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Revision 0

Final 200-ZP-1 Pump-and-Treat Remedy: Results of FY 2010 Groundwater Flow and Contaminant Transport Simulations

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

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Program/Project: S&GRP

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Executive Summary

The *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28) and the *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33) describe the use of pump-and-treat technology as one component of the final groundwater remedy for the 200-ZP-1 Operable Unit (OU). The development of a groundwater flow and contaminant transport model encompassing the Central Plateau, to support remedy design decisions is discussed in the *200-West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses* (DOE/RL-2008-56), which also describes initial applications of the model to simulate a well field for the 200-ZP-1 OU remedy.

The *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78) outlines the schedule for the design, installation, and operation of the remedy set forth in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al., 2008]). The selected remedy combines pump-and-treat, monitored natural attenuation (MNA), flow-path control, and institutional controls. In the *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38), the results of flow and transport simulations are presented to support the design presented in the remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2008-78). DOE/RL-2009-38 describes several simulations performed to estimate likely concentrations over time at individual 200-ZP-1 extraction wells and the combined treatment system influent for all contaminants of concern (COCs), plus uranium. For some COCs, a range of transport properties and initial conditions was simulated to provide an indication of the uncertainty in the calculated influent concentrations.

This document describes simulations performed during fiscal year 2010 to estimate likely concentrations of carbon tetrachloride over time at individual 200-ZP-1 extraction wells and the combined treatment system influent. The simulations completed are similar to those described in DOE/RL-2009-38; the model is used to estimate concentrations at existing and planned extraction wells as they phase into operation as described in the RD/RAWP. However, these simulations reflect new information obtained during fiscal year 2010 and changes to the Central Plateau model that reflect this new information, including the following:

- As-built well locations and screen intervals
- An updated depiction of the extent of carbon tetrachloride that includes data obtained from recent borings
- Revisions to the model structure, with emphasis on the representation of principal water-bearing units
- Calibration of flow model parameters
- Simulation code improvements that stabilize convergence in the presence of rapidly declining water levels.

Assuming the "base" pumping rates described in the RD/RAWP (DOE/RL-2008-78), the simulations suggest that the remedy may extract about 70 to 80 percent of the mass of carbon tetrachloride, and an additional 10 to 20 percent may degrade over the planned period of pumping, with degradation continuing after pumping ceases. These results are generally consistent with simulation presented in support of the RD/RAWP. The ranking of most new extraction wells, in terms of total mass recovered through pumping, are also consistent with those determined from previous analyses. The simulation results reflect no systematic efforts at optimizing the rates and timing of groundwater extraction. However, the results suggest that new wells ranked highest (in terms of mass recovery) may extract several times the mass recovered by the wells ranked lowest, and that recovery at the low-ranking wells falls after 5 to 10 years of pumping. This is consistent with the expectation that, over time, mass recovery at the margins of the carbon tetrachloride plume will decline as concentrations decrease, while recovery in the interior of the contamination will remain high while the wells continue to access areas of high concentrations. This indicates that there are opportunities for optimizing the rates and timing of groundwater extraction (and to a lesser degree, reinjection) to enhance mass recovery. The opportunity for enhancing recovery is reinforced by the results of recent tests (PNNL-18732, *Field Test Report: Preliminary Aquifer Test Characterization Results for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Remedial Design*), which suggest that the capacity of some planned extraction wells may be considerably higher than the 379 L/min (100 gpm) assumed herein and in DOE/RL-2009-38.

Because the results presented here reflect no systematic efforts at optimization, it is concluded that under suitable conditions (and if systematic remedy performance analysis and optimization take place throughout the lifecycle of active pumping) attainment of the mass recovery remedial action objective for carbon tetrachloride is possible. However, the further conditions encountered in the field differ from such suitable conditions (and if systematic remedy performance analysis and optimization are not undertaken), the less likely the remedial action objective can be achieved with the proposed well configuration and rates.

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Terms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC	contaminant of concern
FY	fiscal year
gpm	gallons per minute
HEIS	Hanford Environmental Information System
HWIS	Hanford Well Information System
Kd	distribution coefficient
MNA	monitored natural attenuation
MNW	multi-node well
OU	operable unit
RAO	remedial action objective
RD/RAWP	remedial design/remedial action work plan
ROD	Record of Decision

1 Introduction

1.1 Purpose

Groundwater pump-and-treat is one element of the selected remedy for the 200-ZP-1 Groundwater Operable Unit (OU), located on the Hanford Site's Central Plateau, in Washington State (Figure 1-1). This document describes groundwater flow and contaminant transport simulations completed to estimate the likely concentrations of the principal contaminant of concern (COC), carbon tetrachloride, at individual extraction wells and for the combined treatment system at the 200-ZP-1 OU pump-and-treat remedy that is currently under construction. The flow and transport simulations were performed using the current version of the Central Plateau groundwater flow and contaminant transport model (hereafter referred to as the Central Plateau model), which is described in the environmental calculation brief ECF-HANFORD-10-0371, *Central Plateau Version 3 MODFLOW Model.*

1.2 Background

The *Feasibility Study for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28) and the *Proposed Plan for Remediation of the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-33) describe the use of pump-and-treat technology for the 200-ZP-1 OU as part of the remedy set forth in the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al., 2008) (hereafter referred to as the Record of Decision [ROD]). The selected remedy in the ROD combines pump-and-treat, monitored natural attenuation (MNA), flow-path control, and institutional controls to achieve groundwater cleanup levels for carbon tetrachloride, total chromium (trivalent and hexavalent), nitrate, trichloroethene, iodine-129, technetium-99, and tritium within a timeframe of 125 years.

During fiscal year (FY) 2008, a groundwater flow and contaminant transport model was developed to support remedy design decisions for the 200-ZP-1 OU. This model was primarily developed to provide estimates of influent concentrations and contaminant mass removal rates to support design of the aboveground treatment train. The development of the first version of the Central Plateau model is discussed in *200-West Area Pre-Conceptual Design for Final Extraction/Injection Well Network: Modeling Analyses* (DOE/RL-2008-56), which also includes the initial application of the Central Plateau model to simulate a well field for the 200-ZP-1 remedy, addressing the COCs carbon tetrachloride and technetium-99.

In the *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78), the plan and schedule for the design, installation, and operation are discussed for the remedy set forth in the 200-ZP-1 OU ROD (EPA et al., 2008). In the *Description of Modeling Analyses in Support of the 200-ZP-1 Remedial Design/Remedial Action Work Plan* (DOE/RL-2009-38), the results are provided for groundwater flow and contaminant transport simulations that were completed to provide a basis for the design presented in the remedial design/remedial action work plan (RD/RAWP) (DOE/RL-2008-78). DOE/RL-2009-38 describes several flow and transport simulations performed to estimate likely concentrations over time at individual 200-ZP-1 extraction wells and for the combined treatment system influent for all COCs listed above plus uranium. For some COCs, a range of transport properties and initial conditions was simulated to provide an indication of the uncertainty in the calculated influent concentrations.

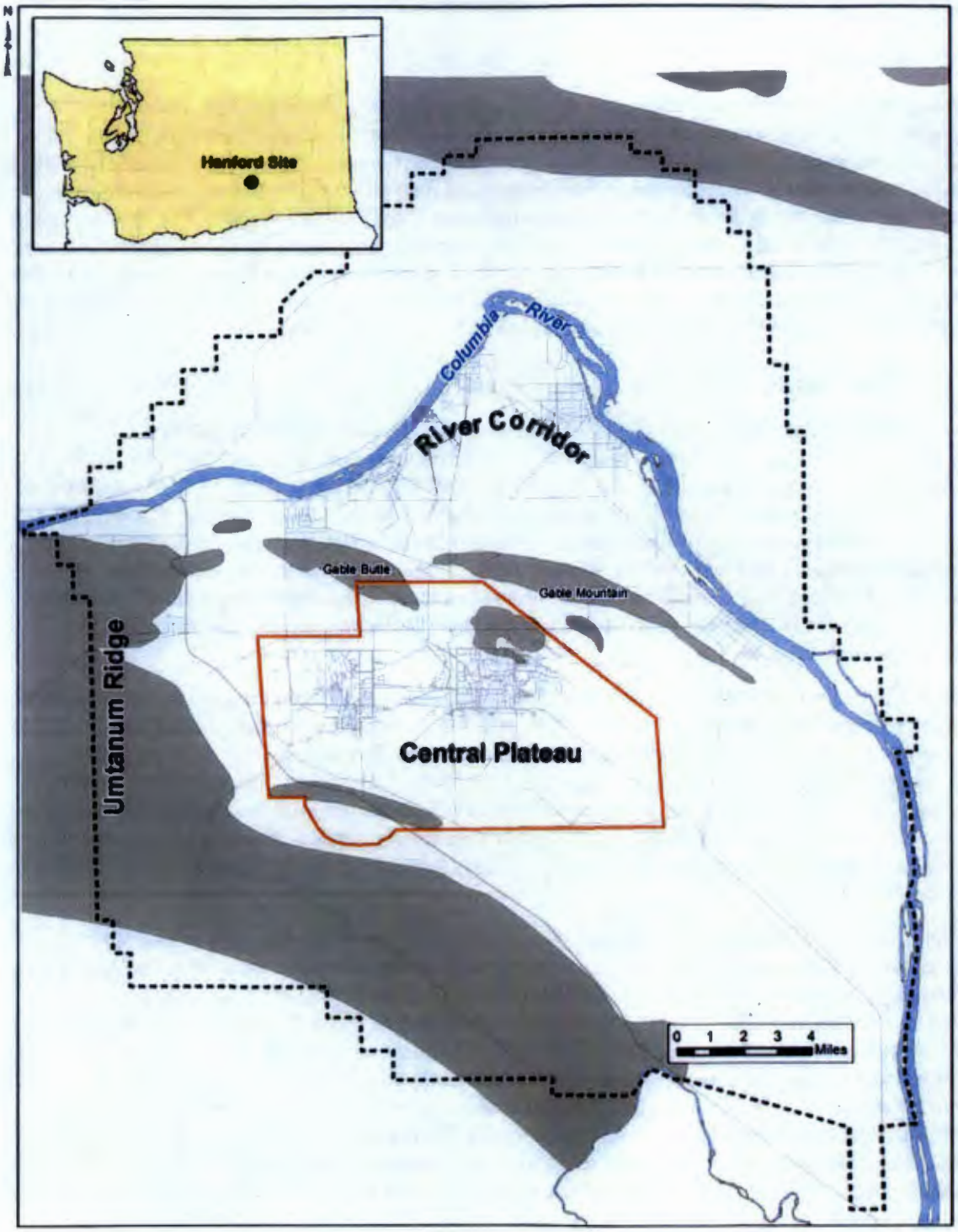


Figure 1-1. Location of the Hanford Site, Richland, Washington

1.3 Objectives

This document describes the results of simulations performed using Version 3 of the Central Plateau model (ECF-HANFORD-10-0371) to estimate influent concentrations of carbon tetrachloride at the 200-ZP-1 groundwater pump-and-treat remedy. The flow and transport simulations completed are similar to those described in DOE/RL-2009-38. The model is used to estimate likely influent concentrations at existing and planned extraction wells as the wells are phased into operation, as described in the RD/RAWP (DOE/RL-2008-78). The simulations described in this document reflect recent changes in the structure and inputs to the Central Plateau model for purposes of simulating the 200-ZP-1 remedy, which are listed below and are described in more detail in the following sections:

- Simulation codes: Simulation code improvements were performed to stabilize the flow and transport solutions in the presence of rapidly declining water tables and in the presence of drying cells.
- Model structure: The Central Plateau model structure was revised, with particular emphasis on improving the lateral boundary conditions and representation of the principal water-bearing units.
- Flow and transport properties: Flow model parameters were updated using focused calibration efforts.
- Initial conditions: Groundwater samples obtained from recent borings and the newly installed extraction and injection wells were included in the construction of a new three-dimensional depiction of the extent of carbon tetrachloride.
- Well locations and screen intervals: As-built extraction and injection well information was incorporated, to the extent that this information was available.

The completed simulations consider eight possible implementations of the proposed remedy that focus on alternate pumped well configurations and/or rates. Each implementation is simulated using two values of the first order decay (degradation) rate coefficient for carbon tetrachloride, which leads to 16 sets of results. As noted above, during preparation of this document, improvements in the representation of the principal water-bearing units in the Central Plateau resulted in a revision to the structure of the model; these revisions are detailed in the calculation brief ECF-HANFORD-10-0371. The superseded Central Plateau model Version N3 Grid G2 comprised five model layers, while the recently approved Version N3 Grid G3 comprises seven model layers (ECF-HANFORD-10-0371). For consistency with results provided throughout FY 2010 using model Version N3 Grid G2, the results obtained using the now superseded Version N3 Grid G2 are presented together with the results obtained using the recently approved Version N3 Grid G3 to illustrate the sensitivity of predicted wellhead and influent concentrations to these improvements in the structure of the model.

This document is structured as follows:

- Chapter 2: Describes the Central Plateau model, including revisions and enhancements to the model during FY 2009 and FY 2010.
- Chapter 3: Includes new data and information on wells and sample concentrations obtained from the 200-ZP-1 OU during FY 2009 and FY 2010.
- Chapter 4: Discusses the definition of initial conditions for the transport model for carbon tetrachloride.

- Chapter 5: Describes the eight alternate implementations of the proposed remedy that were simulated, including the number, locations, and rates of extraction and injection wells; the results of these simulations are also presented. A discussion of the results focuses on the predicted influent carbon tetrachloride concentrations and mass recovery, at the individual extraction wells and for the remedy as a whole.
- Chapter 6: Discusses the results of the simulations and provides recommendations focused on enhancing the mass recovered by the remedy.
- Chapter 7: Provides the references cited in this document.

In addition, six appendices are included. Appendices A through E provide additional data and figures. Appendix F includes a copy of the CH2M HILL Software Installation and Checkout form that was completed for the computer on which the simulations described were executed.

1.4 Role of Modeling in Phased Remedy Implementation

The design, evaluation, and optimization of groundwater remedies should be viewed as a long-term project in which the system design and operation are modified in response to improved understanding of the site (*Alternatives for Ground Water Cleanup* [NRC, 1994]). The methods and tools used to assist in this understanding are also developed over time and with increasing knowledge. The drilling and construction of extraction and injection wells at the 200-ZP-1 OU has been implemented in a phased manner and the remedy itself will be expanded in distinct phases. These phases are described in detail in the RD/RAWP (DOE/RL-2008-78). DOE/RL-2009-38 describes calculations made in support of the first implementation phase, which is the RD/RAWP. This document describes calculations made in support of the second implementation phase (final remedy system construction), during which the existing interim groundwater pump-and-treat remedy will continue to operate to recover and treat contaminants.

1.4.1 Phase 0 – RD/RAWP Design

The modeling steps for Phase 0, RD/RAWP design, are as follows:

1. Develop initial conditions (i.e., COC distributions) for use in predictive simulations of remedy design.
2. Model groundwater flow and particle paths:
   - Particle starting locations defined on the basis of COC distributions and the ROD remedial action objectives (RAOs)/cleanup levels
   - Simulations used to identify initial well locations and rates that will accomplish the RAOs, assuming advective transport.
3. Model groundwater flow and advective/dispersive/reactive contaminant transport to provide initial estimates of the following:
   - Concentration versus time for each COC at each recovery well
   - Total system mass recovery versus time
   - Design basis concentrations for the design of the aboveground treatment train.

1.4.2 Phase I – System Construction (Current Phase)

The modeling steps for Phase I, system construction (through December 2011, which is the current phase), are as follows:

1. Assume that the current interim remedial measure is operational at 1,325 L/min (350 gallons per minute [gpm]).
2. Incorporate new field characterization data (e.g., aquifer tests) into the model.
3. Recalibrate the flow and transport model to operational data, including measured heads, drawdowns, influent concentrations, and mass recovery rates.
4. Repeat steps 1 through 3 from Phase 0, as appropriate.
5. Update well locations and rates required to achieve the RAOs stated in the ROD. These simulations constitute the results presented in this document, although additional simulations will be completed during FY 2011 to systematically evaluate options for enhancing mass recovery
6. Support the identification of suitable monitoring well locations and data quality objectives for monitoring the performance of the remedy operating at the following:
   - 3,785 L/min (1,000 gpm), or other optimized rate (i.e., Phase II)
   - 7,571 L/min (2,000 gpm), or ultimate full operating capacity (i.e., Phase III).

1.4.3 Phase II – System Upgrade and Optimization

The modeling steps for Phase II, system upgrade and optimization (assumed duration of 3 years), are as follows:

1. Assume that the remedy is operational at 3,785 L/min (1,000 gpm), or other optimized rate.
2. Incorporate new field characterization data (e.g., aquifer tests) into the model.
3. Recalibrate the flow and transport model to operational data, including measured heads, drawdowns, influent concentrations, and mass recovery rates.
4. Repeat steps 1 through 3 from Phase 0, as appropriate.
5. Update well locations and rates required to achieve the RAOs stated in the ROD.
6. Re-evaluate suitable monitoring well locations for monitoring performance of the final remedy operating at full operating capacity.

1.4.4 Phase III – Long-Term Operations

The modeling steps for Phase III, long-term operations (assumed duration of 22 years), are as follows:

1. Assume that the remedy is operational at final full capacity.
2. Incorporate new field characterization data (e.g., aquifer tests) into the model.
3. Calibrate the flow and transport model to full operational data, including heads, drawdowns, influent concentrations, and mass recovery rates.
4. Repeat steps 1 through 3 from Phase 0, as appropriate.

5. Update well rates required to achieve the RAOs stated in the ROD.
6. Re-evaluate suitable monitoring well locations for monitoring performance of final remedy operating at full operating capacity.

Modeling will also support evaluations of remedy performance as part of statutory *Comprehensive Environmental Response, Compensation, and Recovery Act of 1980* (CERCLA) 5-year reviews and other regular performance reviews.

1.5 Assumptions and Limitations

Flow and transport modeling provides approximate predictions of groundwater flow, contaminant migration, and the potential effectiveness of the pump-and-treat component of the proposed remedy. The reliability of these predictions can be improved over time by acknowledging the underlying assumptions and limitations and by working to evaluate, address, or mitigate them. This document describes the principal assumptions and limitations of this modeling effort, as well as actions that are currently underway to address or evaluate each of these assumptions and limitations. The design, evaluation, and optimization strategy of the 200-ZP-1 OU groundwater pump-and-treat remedy described in DOE/RL-2008-56 adopts the NRC (1994) recommendation that a pump-and-treat remedy should be viewed as a long-term project in which the system design and operation are modified in response to improved understanding. The methods and tools used to assist in this understanding are also developed over time and with increasing knowledge.

2 Central Plateau Model Design and Simulation Software Applications

DOE/RL-2008-56 and DOE/RL-2009-38 discuss the development and initial applications of the Central Plateau model to simulate a possible well field for the 200-ZP-1 remedy. DOE/RL-2008-56 and DOE/RL-2009-38 provide detailed information on these initial developments and simulations. The Central Plateau model is executed using versions of the common simulators MODFLOW (groundwater flow), MODPATH (path-line analysis) and MT3DMS (contaminant transport), which discussed in this chapter. Open-source versions of these groundwater flow, particle tracking, and contaminant transport simulation programs used to execute the Central Plateau model have been approved for use at the Hanford Site and are described in this chapter. The general structure, boundaries, and inputs to the Central Plateau model are also summarized from the more detailed discussions provided in DOE/RL-2008-56 and DOE/RL-2009-38. This chapter concludes by summarizing the significant Central Plateau model developments during FY 2009 and FY 2010 and summarizes the detailed discussion provided in ECF-HANFORD-10-0371.

2.1 Software Applications

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

2.1.1 Approved Software

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

- CHPRC-00257, Rev. 1, *MODFLOW and Related Codes Functional Requirements Document*
- CHPRC-00258, Rev. 2, *MODFLOW and Related Codes Software Management Plan*
- CHPRC-00259, Rev. 1, *MODFLOW and Related Codes Software Test Plan*
- CHPRC-00260, Rev. 2, *MODFLOW and Related Codes Acceptance Test Report*
- CHPRC-00261, Rev. 1, *MODFLOW and Related Codes Requirements Traceability Matrix*.

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 subsections.

2.1.1.1 MODFLOW (Controlled Calculation Software)

- Software title: MODFLOW-2000 (*MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process* [Harbaugh et al., 2000]); solves transient groundwater flow equations using the finite-difference discretization technique.

- Software version: Version 2.1.18, modified by S.S. Papadopulos and Associates, Inc., for minimum saturated thickness and using the Orthomnin solver; approved as CHPRC Build 0003 using executable "mf2k-mst-0003dp" (compiled to default double precision for real variables).

- Hanford Information Systems Inventory identification number: 2517 (safety software, graded Level C).

- Workstation type and property number (from which software is run): S.S. Papadopulos & Associates, Inc., PC #FE404.

2.1.1.2 MT3DMS (Controlled Calculation Software)

- Software title: MT3DMS (*MT3DMS, A Modular Three-Dimensional Multi-Species Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide* [Zheng and Wang, 1999]; *MT3DMS v5.3: A Modular Three-Dimensional MultiSpecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems – Supplemental User's Guide* [Zheng, 2006]).
- Software version: Version 5.2, modified by S.S. Papadopulos and Associates, Inc., for minimum saturated thickness; approved as CHPRC Build 0003 using executable "mt3d-mst-0003dp" (compiled to default double precision for real variables).
- Hanford Information Systems Inventory identification number: 2518 (safety software, graded Level C).
- Workstation type and property number (from which software is run): S.S. Papadopulos & Associates, Inc., PC #FE404.

2.1.1.3 Support Software

Supporting programs were used to complete the Central Plateau model simulations described in this document. These supporting programs are described in ECF-HANFORD-10-0371 and comprise the following utilities to pre- and post-process the flow and transport model input and output files, respectively:

- ALLOCATEQWELL: Constructs a MODFLOW well package (WEL) or a multi-node well (MNW) package file.
- READ-LST-BUDGET: Tabulates volumetric budget terms for the MODFLOW simulation.
- READ-MT3D-OUT-BUDGET: Tabulates mass budget terms for the MT3DMS simulation.

With the exception of the WEL or MNW input files (see Chapter 6), all other inputs to the Central Plateau model are identical to those described in ECF-HANFORD-10-0371.

2.1.2 Software Installation and Checkout

The software identified above was used consistent with its intended use for CHPRC as identified in CHPRC-00257. The use of this software is a valid for the problem addressed in this application.

The software was used within its limitations, as identified in CHPRC-00257.

2.2 Model Structure and Boundaries

The Central Plateau model was constructed to simulate an area encompassing the 200 East and 200 West Areas of the Central Plateau (Figures 1-1 and 2-1). The simulations described in this document represent further development and application of the Central Plateau model. The model comprises 134 rows and 256 columns. The first versions of the model comprised five layers (DOE/RL-2009-38). This vertical layering was retained into FY 2010 for the version of the Central Plateau model referred to as "Version N3 Grid G2." During 2010, this layering was revised to comprise seven layers during preparation of Central Plateau model Version N3 Grid G3 (ECF-HANFORD-10-0371). All layers of the model are simulated as convertible type. As a result, if the head calculated in the layer exceeds the top of the layer, the layer is simulated as confined (specific storage applies); if the head calculated in

the layer is above the bottom of the layer but below the top of the layer (i.e., within the model cell), the layer is simulated as unconfined (specific yield applies). Development of the Central Plateau model will continue by incorporating new information as it becomes available and new methods where necessary, so the Central Plateau model can complement other methods of analysis throughout the design, implementation, and optimization of the final 200-ZP-1 OU remedy.

2.2.1 Boundary Conditions

Boundary conditions are defined on all sides of the model, both vertically and horizontally. The vertical boundaries are the bottom of the model (which corresponds with the top of basalt) and the top of the model (which corresponds with the water table). The basalt is considered a no-flow lower boundary, while the water table is a recharge boundary. Figure 2-1 illustrates the groundwater flow model domain and lateral boundary conditions, which are assigned as follows (ECF-HANFORD-10-0371):

- Basalt forms the western boundary of the model, as well as part of the northern and southern boundaries. In all cases, the basalt is considered a no-flow boundary.
- The northern boundary of the model includes two gaps in the basalt subcrop/outcrop.
- A northwest gap is located between Gable Butte and Umtanum Ridge. This gap is represented as a time-invariant specified head boundary.
- An eastern gap along the northern model boundary lies between Gable Mountain and Gable Butte. This boundary was defined as a time-varying specified head boundary.
- A basalt subcrop crosses the southern model boundary creating a shallow gap between the subcrop and Yakima Ridge. The southern gap is specified as a no-flow boundary.
- The southeastern model boundary extending from the southern basalt subcrop to the eastern end of the model domain and the eastern model boundary is open, with groundwater flowing toward the Columbia River. These boundaries are treated as Cauchy (general head) boundaries, using the Columbia River stage as the boundary head. The conductance is computed using a process incorporating the flow-path distance to the Columbia River, the intervening aquifer material properties, and scalar multipliers employed for calibration purposes. The details of this calculation are provided in the calculation brief ECF-HANFORD-10-0371.

2.2.2 Stratigraphy

The stratigraphy closely follows that described in *Groundwater Data Package for Hanford Assessments* (PNNL-14753). The principal stratigraphic units (based on PNNL-14753) were used to define the six hydrostratigraphic units listed in Table 2-1. The hydrostratigraphic unit top and bottom elevation and the unit thickness were interpolated onto the model grid using kriging, and the presence or absence of a unit was mapped onto the model grid using a nearest-neighbor interpolation. The top of basalt is used as the bottom of the model throughout the model domain.

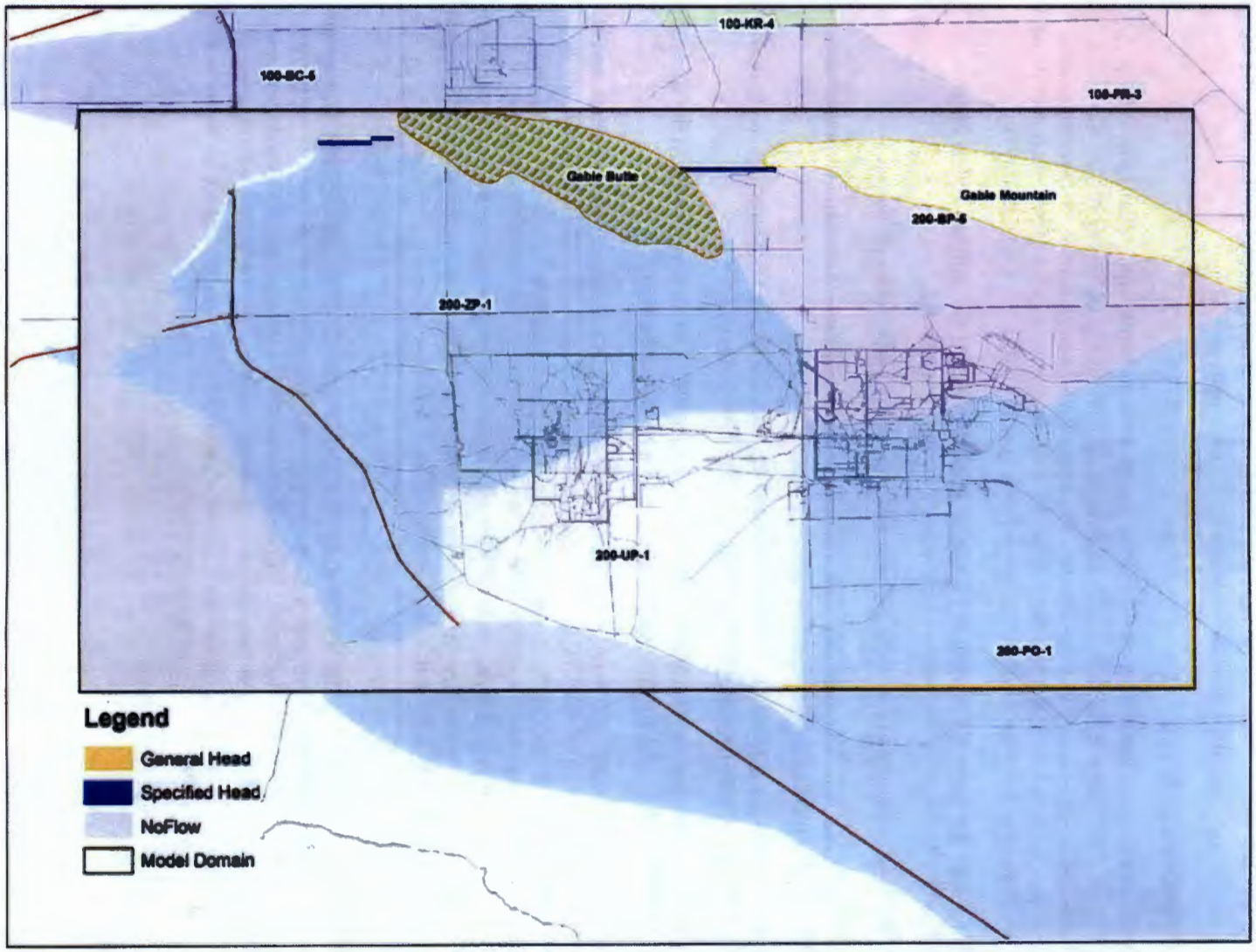


Figure 2-1. Groundwater Flow Model Domain and Lateral Boundary Conditions

Table 2-1. Stratigraphic Units Represented in the Central Plateau Model

Hydrostratigraphic Unit	Description
1	Hanford course-grained unit(s)
2	Hanford fine-grained unit(s)
3	Eastern portion of the Cold Creek unit (i.e., that portion of the Cold Creek unit that lies beneath the water table and is present in the 200 East Area [Unit 3])
4/5	Upper Ringold Unit E (also known as Ringold Units 4 and 5, primarily)
8	Ringold lower mud unit comprising Ringold Units B, C, and D (Unit 8)
9	Ringold Unit A, a gravel and sand facies (also known as Unit 9)

Several revisions were made to the top and bottom elevations and to the mapped unit extents provided in PNNL-14753 prior to constructing the Central Plateau model top and bottom elevations and unit extents; these are described in DOE/RL-2009-38 and ECF-HANFORD-10-0371. In Central Plateau model Version N3 Grid G3, the hydrostratigraphic units listed in Table 2-1 are distributed among the seven layers, so model layers and hydrostratigraphic units do not necessarily correspond (i.e., a model layer may contain and laterally transition between several hydrostratigraphic units) (ECF-HANFORD-10-0371).

2.2.3 Recharge

Recharge in the Central Plateau model comprises contributions from net precipitation that reaches the water table, wastewater discharges, and mountain-front recharge arising from infiltration of snowmelt and runoff from elevated areas, which focus in the areas of the ephemeral Cold Creek and Dry Creek stream beds. The first contribution, net recharge from aerial precipitation, is primarily derived from PNNL-14753. Net groundwater recharge calculated from historic wastewater discharges to the vadose zone was obtained from the analyses of attenuated recharge completed as part of the Sitewide Assessment Capability (ECF-HANFORD-10-0371). Finally, recharge associated with stream flows is a significant contributor west (upgradient) of the Central Plateau (PNNL-17841, *Compendium of Data for the Hanford Site [Fiscal Years 2004 to 2008] Applicable to Estimation of Recharge Rates*); however, it is difficult to obtain direct measurements. As a result, recharge occurring via the Cold Creek and Dry Creek streams was varied during calibration (ECF-HANFORD-10-0371).

2.2.4 Flow Model Temporal Discretization

The flow model component of the analyses comprises two distinct periods: first, a period representing historic conditions simulating from pre-development through to the current timeframe, and second a period representing predictive (future) conditions simulating from about the current timeframe through the phased implementation of the 200-ZP-1 OU pump-and-treat remedy (Table 2-2).

Table 2-2. Temporal Discretization of the Groundwater Flow Model

Model	Stress Period(s)	Duration	Description
Historic	1	Approx. 274 years	Initial transient stress period prior to the calibration period to establish an initial pre-development groundwater condition.
Historic	2 to 66	68 years	Transient annual stress periods span the calibration period (1944 through 2008).
Predictive (future)	67 to 69	3 years	Phase I of the final 200-ZP-1 remedy implementation: these stress periods represent the current remedy operating at about 350 gpm total extraction/injection rate.
Predictive (future)	70 to 72	3 years	Phase II of the final 200-ZP-1 remedy operating at 1,000 gpm.
Predictive (future)	73	22 years	Phase III of the final 200-ZP-1 remedy operating at 2,000 gpm.

gpm = gallons per minute

2.3 Model Development During FY 2009 and FY 2010

Developments and improvements to the Central Plateau model were made throughout FY 2009 and FY 2010. These developments and improvements fall into three main categories (ECF-HANFORD-10-0371):

- Updates to the stratigraphy, layering, recharge, and lateral boundary conditions that define the model structure and lateral boundaries
- Implementation of numerical solvers and computational methods that address the effect of a rapidly changing and, in particular, a diminishing water table in the flow simulator MODFLOW
- Recalibration of the Central Plateau model parameters.

These overarching developments and improvements are documented in ECF-HANFORD-10-0371. The principal developments and improvements include the following:

- Stratigraphy:
  - The Hanford fine-grained and coarse-grained units were treated as a single unit in Version N2 of the Central Plateau model, whereas in Version N3, these are treated as distinct units.
  - The Hanford formation and the eastern portion of the Cold Creek unit were previously combined into a single unit in the Central Plateau model, whereas in Version N3, these are distinct.
- Boundary conditions:
  - Additional calibration multipliers were introduced to help improve the definition of the eastern and southeastern Cauchy (GHB) boundaries, to improve the correspondence between simulated and observed heads in the 200 East Area.

These revisions were made as part of general Central Plateau model refinement and recalibration activities. At the conclusion of the calibration process, the values of the flow model aquifer parameters obtained were those listed in Table 2-3. (Note that the ratio of horizontal to vertical hydraulic conductivity was held constant at 10:1 throughout the calibration [ECF-HANFORD-10-0371].)

In addition to these overarching developments of the Central Plateau model, several improvements and updates to the Central Plateau model were made specifically to improve the reliability of simulations in the 200-ZP-1 OU. These improvements and updates, specific to the 200-ZP-1 OU, are described in Chapter 3.

Table 2-3. Principal Flow Model Parameters Used in Predictive Simulations

Parameter/ Units	Parameter Name	Formation	Value
SY 1(-)	Specific yield (unconfined storage)	Hanford formation	0.1
SY 2(-)	Specific yield (unconfined storage)	Non-Hanford units	0.09
HK1 (m/day)	Hydraulic conductivity	Hanford formation	10,000
HK2 (m/day)	Hydraulic conductivity	Hanford formation	100
HK3 (m/day)	Hydraulic conductivity	Cold Creek unit	106
HK5 (m/day)	Hydraulic conductivity	Ringold Unit E	5
HK8 (m/day)	Hydraulic conductivity	Ringold lower mud unit	0.008
HK9 (m/day)	Hydraulic conductivity	Ringold Unit A	4.8

Notes:

1. The ratio of horizontal to vertical hydraulic conductivity (i.e., vertical anisotropy) was held constant at 10:1 throughout the calibration.
2. The specific yield applies to the formations within which the water table lies.

3 Recent Data and Information

Throughout the 200 West Area in recent years, sampling, drilling, and characterization activities have been extensive in relation to the 200-ZP-1 OU, adjacent OUs, and other facilities. The principal activities in recent months that provided additional information used directly by the Central Plateau model to simulate the 200-ZP-1 OU remedy are discussed in this chapter.

3.1 Extraction/Injection Well Data

During FY 2009 and FY 2010, extensive drilling, installation, development, and testing activities have occurred for the extraction and injection wells that will comprise the final 200-ZP-1 OU groundwater pump-and-treat remedy described in the RD/RAWP (DOE/RL-2008-78). Table 3-1 summarizes the status of new well drilling and construction for the extraction and injection wells of the final 200-ZP-1 OU remedy, which at the time of report preparation including the following:

- Fourteen extraction wells have been drilled to total depth, and several of these have been constructed and developed.
- One extraction well (EW-6) is currently being drilled.
- Two injection wells (IW-5 and IW-6) are currently being drilled.
- Drilling of three additional injection wells (IW-4, IW-11, and IW-13) is scheduled to be completed in 2010.

Table 3-1. Summary of Status of New Well Drilling and Construction

Extraction Well	Well Name	Well No.	Northing (m)	Easting (m)	Total Depth (ft)	Total Depth (m)	Completion Schedule
EW-1	299-W15-225	C7017	136109	566657	410.5	125	FY 2009
EW-2	299-W14-20	C7018	136285	566909	409	125	FY 2009
EW-3	299-W14-73	C7021	136204	567359	507.5	155	FY 2009
EW-4	299-W14-74	C7024	136381	567781	508	155	FY 2010
EW-5	299-W12-2	C7027	136610	568313	505	154	FY 2010
EW-6	299-W11-50	C7020	136757	566966	NA	NA	In progress
EW-7	299-W11-90	C7022	136520	567307	520	158	FY 2010
EW-8	299-W11-96	C7754	136772	567775	480.5	146	FY 2010
EW-9	299-W17-3	C7577	135325	566926	440	134	FY 2010
EW-10	299-W17-2	C7576	135806	566952	470	143	FY 2010
EW-11	NA	NA	NA	NA	NA	NA	Out-years
EW-12	299-W11-49	C7019	135925	567362	433	132	FY 2010
EW-13	NA	NA	NA	NA	NA	NA	Out-years
EW-14	NA	NA	NA	NA	NA	NA	Out-years
EW-15	299-W14-21	C7494	135890	567722	525	160	FY 2010

Table 3-1. Summary of Status of New Well Drilling and Construction

Extraction Well	Well Name	Well No.	Northing (m)	Easting (m)	Total Depth (ft)	Total Depth (m)	Completion Schedule
EW-16	299-W11-92	C7025	136352	566693	405	123	FY 2010
EW-17	NA	NA	NA	NA	NA	NA	Out-years
EW-18	299-W12-3	C7028	136998	568322	496	151	FY 2010
EW-19	299-W12-4	C7029	136364	568327	525.8	160	FY 2010
EW-20	299-W14-22	C7030	136116	568330	NA	NA	FY 2011
IW-1	299-W6-13	C8064	137630	567313	NA	NA	FY 2011
IW-2	299-W6-14	C8065	137389	566940	NA	NA	FY 2011
IW-3	299-W10-36	C8066	NA	NA	NA	NA	FY 2011
IW-4	299-W10-35	C7573	136987	566067	NA	NA	In progress
IW-5	299-W15-226	C7574	136450	566033	448	137	FY 2010
IW-6	299-W15-227	C7575	135966	566034	511	156	FY 2010
IW-7	NA	NA	NA	NA	NA	NA	Out-years
IW-8	NA	NA	NA	NA	NA	NA	Out-years
IW-9	NA	NA	NA	NA	NA	NA	Out-years
IW-10	699-46-68	C8067	137600	569110	NA	NA	FY 2011
IW-11	699-45-67	C7578	137263	569257	400	122	In progress
IW-12	699-44-67	C8068	136894	569338	NA	NA	FY 2011
IW-13	699-43-67	C7579	136560	569370	422	129	In progress
IW-14	699-42-67	C8069	136200	569390	NA	NA	FY 2011
IW-15	699-40-67	C8070	135816	569420	NA	NA	FY 2011
IW-16	NA	NA	NA	NA	NA	NA	Out-years

EW = extraction well
FY = fiscal year
IW = injection well
NA = not available (planned for out-year construction)

As described in the RD/RAWP (DOE/RL-2008-78), drilling for most new extraction and injection wells has continued either to the top of the Ringold lower mud unit or to the top of the basalt unit that comprises the base of the unconfined sedimentary aquifer. Characterization activities during sampling have included frequent collection of sediment samples, compilation of stratigraphic logs, and collection of depth-discrete groundwater samples for analysis of contaminant concentrations. Much of these data are compiled and available through the Hanford Well Information System (HWIS), which is a web-based interface that provides access to a relational database system containing general well information for the Hanford Site.

In addition, pumping and related tests were conducted at new extraction well 299-W15-225 (also designated as EW-1 or well C7017). These tests included interval-rate (step) testing, constant-rate testing, and borehole flow logging. The design, implementation, and analysis of these tests are described in *Field Test Report: Preliminary Aquifer Test Characterization Results for Well 299-W15-225: Supporting Phase I of the 200-ZP-1 Groundwater Operable Unit Remedial Design* (PNNL-18732). This testing suggested the following:

- Well 299-W15-225 is highly efficient (efficiencies between 88 and 97 percent) over the pumping rates observed. The extraction well performance increased about 5 percent following extensive well development.
- A composite multi-well analysis indicates a best-estimate aquifer transmissivity of 438 m^2/day (4,714.6 ft^2/day) (and hydraulic conductivity of 7.91 m/day [25.95 ft/day], assuming an aquifer thickness of 55.4 m [181.2 ft]), which falls within the upper range of similarly derived, large-scale values determined for the area.

The as-built well locations and screen intervals, together with the updated proposed well locations and intervals available as of late May 2010, were incorporated into the Central Plateau model packages that represent the extraction and injection of water, and removal of contaminants for purposes of simulating the 200-ZP-1 OU remedy.

At the time of this report preparation, the results of the well 299-W15-225 aquifer test have not been directly incorporated into the Central Plateau model. However, the transmissivity estimated from Version N3 Grid G3 of the Central Plateau model at the location of well 299-W15-225 ranges from about 350 m^2/day (3,767.4 ft^2/day) above the Ringold lower mud unit up to about 650 m^2/day (6,996.5 ft^2/day) from the water table to the top of the basalt. These values encompass the estimate of 438 m^2/day (4,714.6 ft^2/day) obtained from testing at well 299-W15-225. Although substantial variability is expected in the aquifer properties and the performance of the newly constructed extraction wells, the well test results are encouraging and suggest that the aquifer properties and well capacities will provide opportunities to optimize the final pump-and-treat system operating rates in an effort to enhance mass recovery and to achieve the RAOs.

3.2 Groundwater Sample Data

In addition to regular groundwater sampling at the 200-ZP-1 OU, groundwater samples have been collected on a frequent basis during drilling of the new extraction and injection wells, and following well completion and development. During drilling, samples have generally been collected every 6.1 m (20 ft) (vertical) of drilling above the Ringold lower mud unit where it is encountered, and a single sample is collected 3 m (10 ft) beneath the Ringold lower mud unit where it is encountered. These data are being added to the Hanford Environmental Information System (HEIS) database. In general, sampling has identified high concentrations of carbon tetrachloride throughout much of the 200-ZP-1 OU above the Ringold lower mud unit, as well as considerably lower concentrations below the Ringold lower mud. Groundwater sample data collected through April 2010 were included in the construction of the three-dimensional carbon tetrachloride distribution that was used as the initial condition in the remedy simulations described in Chapter 6.

4 Definition of Initial Conditions for Carbon Tetrachloride

Initial conditions for contaminant transport modeling were mapped in three dimensions using concentration data measured in wells throughout the area. A variety of methods can be used to map point data to create initial conditions for transport modeling. The remedy design modeling described in DOE/RL-2009-38 used initial conditions that were constructed using two methods:

- An ordinary kriging method that produces a single depiction of the likely extent of a contaminant. This method was used to prepare initial conditions for all contaminants.
- A multi-Gaussian (stochastic) sequential simulation approach that produces multiple realizations of the likely extent of a contaminant, each consistent with the spatial statistics of that contaminant. This method was used to prepare initial conditions for the most widespread contaminants (i.e., carbon tetrachloride, technetium-99, and nitrate).

Using these two alternate mapping methods provided an indication of the potential impact of uncertainties in the distribution of the contaminants on predictions made with the Central Plateau model. However, as stated in DOE/RL-2009-38, within the convex hull of the data domain (and for purposes of developing design basis concentrations for the 200-ZP-1 OU remedy), the contaminant depictions prepared using the ordinary kriging method are considered to be the "best estimate" of the contaminant distribution, leading to the corresponding best estimate of the likely influent concentration at each well. The contaminant depictions prepared using the stochastic sequential simulation approach are considered to present an alternate (and typically higher) "potential" contaminant distribution, leading to a corresponding "potential" influent concentration at each well.

For the simulations described in this document, the initial conditions for carbon tetrachloride were prepared using ordinary kriging in a manner analogous to that described in DOE/RL-2009-38. Thus, the simulation results presented in this document are considered to use the best estimate of the initial distribution of carbon tetrachloride within the convex hull of the data. The results presented should be contrasted with those obtained using initial conditions constructed from the ordinary kriging method (as presented in DOE/RL-2009-38) to identify impacts of revisions to the Central Plateau model and of the newly obtained data and information on the model predictions of mass removal. Three-dimensional mapping is discussed below.

4.1 Compilation of Depth-Discrete Concentration Database

A database of depth-discrete concentration data was compiled for use in spatial analysis and geostatistical mapping. The database was originally compiled as part of an effort to analyze the distribution of carbon tetrachloride and technetium-99 detailed in *Spatial Analysis of Contaminants in 200 West Area Groundwater in Support of the 200-ZP-1 Operable Unit Pre-Conceptual Remedy Design* (PNNL-18100). The database includes well sample data, well construction information, water table elevations, fields describing the sources of the concentration data, and data quality flags. The data were drawn from several sources that can be traced back to standard Hanford Site data sources, including the HEIS and HWIS databases (PNNL-18100). The compilation of carbon tetrachloride samples used in mapping for the simulations described here includes data compiled for the *Remedial Investigation Report for the 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2006-24), the feasibility study (DOE/RL-2007-28), and depth-discrete data obtained during drilling. In addition to the three-dimensional, depth-discrete data, the database was supplemented by two-dimensional data sets (*Hanford Site Groundwater Monitoring for Fiscal Year 2007* [DOE/RL-2008-01]).

Since the data compilation is essentially an update to the compilation described in PNNL-18100 and DOE/RL-2008-78, the data set included older data for some locations that have since been resampled. As a result, older data were replaced where new data were available. The updated data set includes recent data collected from drilling at new 200-ZP-1 OU extraction wells EW-1 through EW-5, EW-7 through EW-10, EW-12, EW-15, EW-18, and EW-19 (Table 3-1), resulting in a data set ranging from January 1999 through April 2010. The maximum concentration of carbon tetrachloride in the compiled data set is 4,400 µg/L at well 299-W15-46 from February 2006 sampling.

4.1.1 Treatment of Nondetects and Duplicates

Contaminant concentrations were occasionally below the method reporting limit, which is noted in the laboratory qualifier field in the database. These concentrations were flagged as nondetects. Nondetect concentrations were replaced by half of their stated value, which is a common practice in environmental analysis (*Statistical Methods for Environmental Pollution Monitoring* [Gilbert, 1987]). On occasion, more than a single observation of the concentration was made at a given location (i.e., duplicate samples from a single depth in well, or multiple sample dates). When this occurred, the maximum concentration value above detection was used to represent the concentration at that location. If all data from a given location were less than the detection limit, then the minimum value was used.

4.1.2 Sample Elevations

Representative elevations for the samples were assumed to correspond to the midpoint of the well screen or sampled interval. Because of the falling water table in the 200 West Area and the prevalence of monitoring wells screened at the water table, many monitoring wells have mid-screen elevations above the water table. In these cases, the mid-screen elevation was adjusted toward the screen bottom elevation to place the sample point below the current water table elevation.

4.1.3 Final Data Used for Interpolation

The final point data used to develop initial conditions for carbon tetrachloride are listed in Appendix A. Several criteria were used in the final selection of the contaminant data used in the mapping, including sample date, location relative to the water table, geographic area, and well type. The majority of the data incorporated in the final data set used for mapping represent samples obtained during 2003 or later. Control points were used to supplement the sample data to mitigate extrapolation above the water table, beneath the base of the model (i.e., the bedrock), and into or below the Ringold lower mud unit where data indicated this should not occur. Control points were also used to mitigate lateral extrapolation and to provide continuity in areas of large spatial data separation in the interior of the plume. In these cases, control point concentrations were generally specified as the average of the closest upgradient and downgradient data points along the same groundwater flow path. Control points are also listed in Appendix A following the actual sample data.

4.2 Interpolation

4.2.1 Approach

The point concentration data and control point values tabulated in Appendix A were interpolated to a regular three-dimensional grid by dividing the plume into several kriging zones on the basis of groundwater flow directions, kriging the data lying within each zone, and combining the results to produce a single continuous plume. In each case, the variogram assumed no nugget, and the interpolated results were truncated to the minimum and maximum values of the point sample data. The interpolated plume was masked to eliminate any remaining kriging artifacts that produce hydraulically unreasonable

extensions into areas with no data coverage. The mask is defined as the two-dimensional (i.e., plan view) maximum lateral extent of contamination present at the 3.4 µg/L cleanup level for carbon tetrachloride. Beyond this masking boundary, concentrations were set to zero.

To transfer the interpolated plume from the regular three-dimensional plume shell grid to the irregular three-dimensional Central Plateau model grid, bi-linear interpolation was used to provide the best estimate of the concentration for each node-centered model cell from the concentrations at the surrounding plume shell grid nodes. Model cells lying outside the plume shell grid are assigned a concentration of zero. Since the Central Plateau model has a coarser grid than the plume shell grid, and the mapped water table used to constrain the interpolation differs slightly from the water table simulated by the Central Plateau model, the volume of contaminated groundwater and the dissolved-phase contaminant mass differ slightly between the plume shell grid and the model grid. The plume shell grid interpolation suggests a dissolved mass of approximately 47,820 kg (assuming a porosity of 0.18), which equates to a mass of 39,850 kg, assuming a porosity of 0.15 as used in the Central Plateau model. The estimated mass following transfer to the Central Plateau model grid is about 40,080 kg, assuming a porosity of 0.15. This value differs from the finer plume-shell grid estimate of 39,850 kg by less than 1 percent and lies between the initial dissolved mass estimates of 35,300 kg and 47,100 kg reported in DOE/RL-2009-38 for the same ordinary kriging technique.

4.2.2 Sources of Uncertainty

As is often the case when mapping large sample data sets over wide areas, there is uncertainty associated with defining the extent of contaminants. This includes uncertainty in the point sample data, as well as uncertainties regarding the distribution of contaminants between the point sample data and in locations where there are no sample data. Uncertainties regarding the point sample data include contrasting monitoring well designs, sample collection and analytical methods (i.e., sampling variability), and the presence of relatively long well screens that provide integrated samples throughout the intercepted interval. Uncertainties regarding the spatial distribution of carbon tetrachloride between point sample data and in locations where there are no sample data include changes in groundwater flow direction over time that make it difficult to correlate sample data points spatially.

Despite these uncertainties, the sample data set represents the best available information upon which to base the current carbon tetrachloride distribution. As described in DOE/RL-2009-38 and in Chapters 5 and 6 of this document, since accurate estimation of the dissolved and total (i.e., incorporating sorption and other processes) mass in the subsurface is prone to error, interpretation of the results of the Central Plateau model simulations focuses on the fraction or percentage of the initial mass that is recovered by the remedy rather than the absolute mass recovered.

5 Remedy Simulations

This chapter describes several flow and transport calculations conducted using the Central Plateau model. The purpose of the various simulations is to evaluate the impact of the following on predicted mass recovery using the Central Plateau model:

- Alternate well configurations (eight alternatives) (Table 5-1)
- The value of the first-order degradation (decay) rate for carbon tetrachloride (two alternatives)
- The vertical and stratigraphic discretization of the Central Plateau model, and corresponding alternative methods for representing pumped wells (two alternatives).

Table 5-1. Summary of Eight Alternate Well Configurations Considered

Simulated Case	System Description	Remedy Well Description	
Base Case 1	As described in RD/RAWP* at 2,000 gpm	Phase II: 16 EWs at 100 gpm 12 IWs at 133 gpm	Phase III: 20 EWs at 100 gpm 16 IWs at 125 gpm
Base Case 2	As described in RD/RAWP*, but 2,500 gpm	Phase II: 16 EWs at 125 gpm 12 IWs at 167 gpm	Phase III: 20 EWs at 125 gpm 16 IWs at 156 gpm
Sensitivity Case 1	2,000 gpm	Every other downgradient injection well injects below Ringold lower mud unit only.	
Sensitivity Case 2	2,000 gpm	All downgradient injection wells inject below Ringold lower mud unit only.	
Sensitivity Case 3	2,000 gpm	Employ existing IRM injection wells at nominal rates, divert water from proposed upgradient injection wells.	
Sensitivity Case 4	2,000 gpm	Employ existing IRM injection wells at nominal rates, divert water from proposed downgradient injection wells.	
Sensitivity Case 5	Approx. 2,150 gpm	Supplement base case with extraction at top four IRM EWs: distribute injected water to existing IRM IWs.	
Sensitivity Case 6	Approx. 2,150 gpm	Supplement base case with extraction at top four IRM EWs: distribute injected water to new upgradient IWs.	

* DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan.*

EW = extraction well
gpm = gallons per minute
IRM = interim remedial measure
IW = injection well
RD/RAWP = remedial design/remedial action work plan

As a result, the 32 simulations completed comprise eight possible pumped well configurations, simulated using two degradation rate values for carbon tetrachloride, with each simulation completed using Version N3 Grid G2 of the Central Plateau model (comprising five model layers) and using the recently approved Version N3 Grid G3 of the Central Plateau model (comprising seven model layers). For ease of presentation, the results obtained using the two model grids (superseded Version N3 Grid G2, and the recently approved Version N3 Grid G3) are plotted together, so the results obtained from the eight different well configurations are depicted twice (once for each degradation rate value).

For each of the 16 sets of results, the following is presented:

- Influent concentrations at each recovery well (Appendix C)
- Cumulative mass recovery at each recovery well (Appendix D)
- System-wide mass recovery (this section and Appendix E)
- Ranking of extraction wells by mass recovered (this chapter).

5.1 Flow Model Procedures

5.1.1 Location of Extraction and Injection Wells

The 200-ZP-1 feasibility study (DOE/RL-2007-28) and proposed plan (DOE/RL-2007-33) provide comparative evaluations of alternate pumped well configurations on the basis of semi-analytical groundwater flow modeling and particle tracking. The analyses were used to identify the approximate number and potentially suitable locations for extraction and injection wells. These calculations provided a starting point for the flow and transport simulations described in DOE/RL-2009-38, providing initial locations and rates for the extraction and injection wells simulated in that study. Similarly, the well locations and rates developed during preparation of DOE/RL-2009-38 form a basis for the simulations presented in this document.

DOE/RL-2009-38 identified a base case pumped well configuration for the final remedy, comprising 20 extraction wells and 16 injection wells, implemented in the phases described in Chapter 1. Table 5-1 summarizes the scenarios simulated in the present document. For all of these scenarios, the basic well configuration is similar to that presented in DOE/RL-2009-38 but has been updated to reflect the as-built locations and well construction as of May 2010. However, each scenario reflects one of the following implementation alternatives (complete well lists for each alternative are provided in Appendix B):

- Base Case 1: The configuration is similar to that presented in DOE/RL-2009-38. The final total extraction and injection rate is 7,571 L/min (2,000 gpm).
- Base Case 2: The configuration is similar to that presented in DOE/RL-2009-38. The final total extraction and injection rate is 9,464 L/min (2,500 gpm).
- Sensitivity Case 1: The configuration is similar to that presented in DOE/RL-2009-38; however, every other downgradient injection well injects water below the Ringold lower mud unit only. The final total extraction and injection rate is 7,571 L/min (2,000 gpm).
- Sensitivity Case 2: The configuration is similar to that presented in DOE/RL-2009-38; however, all downgradient injection wells inject water below the Ringold lower mud unit only. The final total extraction and injection rate is 7,571 L/min (2,000 gpm).
- Sensitivity Case 3: The configuration is similar to that presented in DOE/RL-2009-38; however, the existing interim remedy injection wells are used to inject water that is re-directed from several of the new upgradient injection wells. The final total extraction and injection rate is 7,571 L/min (2,000 gpm).
- Sensitivity Case 4: The configuration is similar to that presented in DOE/RL-2009-38; however, the existing interim remedy injection wells are used to inject water that is re-directed uniformly from the new downgradient injection wells. The final total extraction and injection rate is 7,571 L/min (2,000 gpm).

- Sensitivity Case 5: The configuration of all new wells is similar to that presented in DOE/RL-2009-38; however, extraction is also maintained at current extraction wells 299-W15-35, 299-W15-43, 299-W15-45, and 299-W15-46, and injection also takes place at current injection wells 299-W18-36, 299-W18-37, and 299-W18-38. The final total extraction and injection rate is approximately 8,139 L/min (2,150 gpm).
- Sensitivity Case 6: The configuration of all new wells is similar to that presented in DOE/RL-2009-38; however, extraction is also maintained at current extraction wells 299-W15-35, 299-W15-43, 299-W15-45, and 299-W15-46, and injection of this water takes place uniformly across the new upgradient injection wells. The final total extraction and injection rate is approximately 8,139 L/min (2,150 gpm).

Figure 5-1 depicts the configuration of extraction and injection wells under (a) current conditions (i.e., Phase I), (b) Phase II of final remedy implementation, and (c) Phase III of final remedy implementation based upon the information provided in Table 5-1 (Base Case 1).

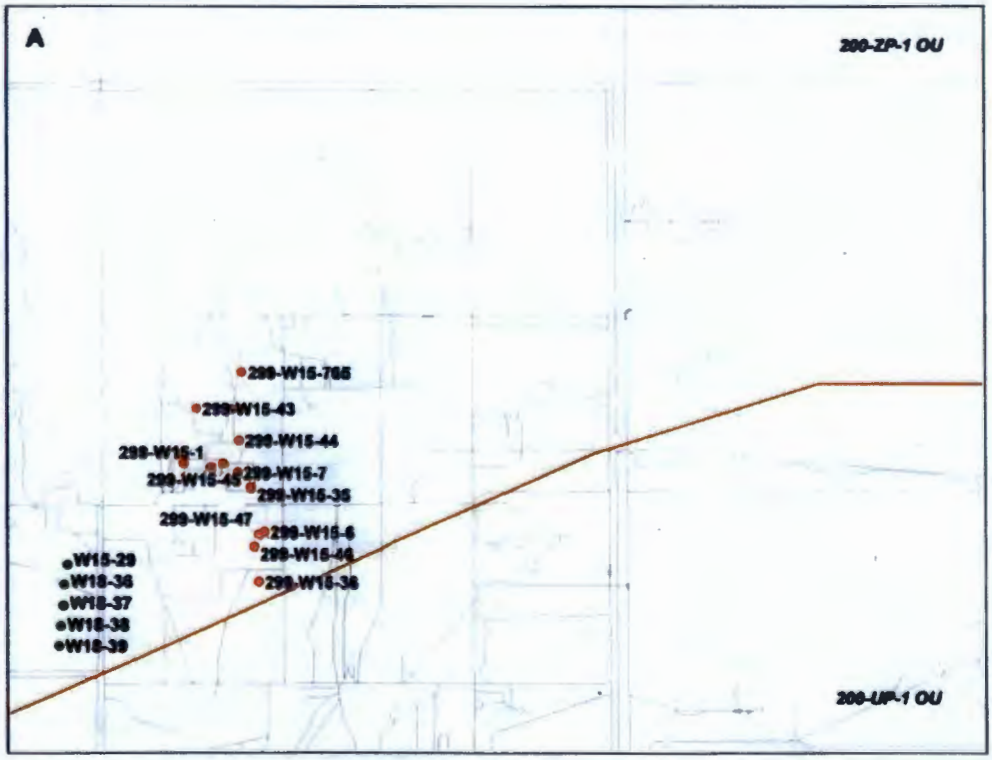


Figure 5-1. Configuration of Extraction and Injection Wells Under (a) Current Conditions (Phase I), (b) Phase II, and (c) Phase III

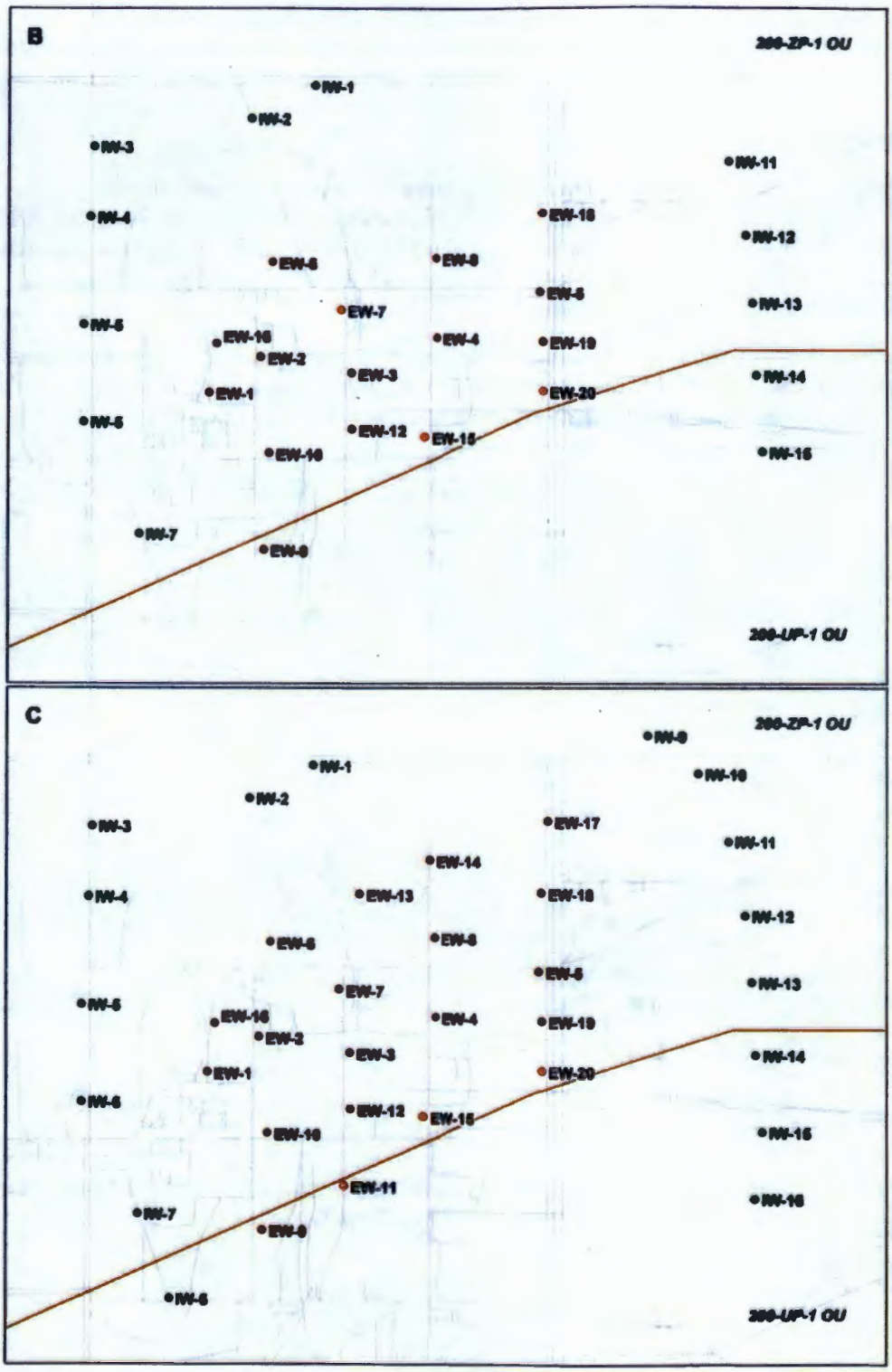


Figure 5-1. Configuration of Extraction and Injection Wells Under (a) Current Conditions (Phase I), (b) Phase II, and (c) Phase III (cont'd.)

5.1.2 Allocation of Extraction and Injection Across Model Layers

In DOE/RL-2009-38, all new recovery and injection wells were assumed to intercept the entire saturated thickness of the aquifer because drilling had not commenced on these wells at that time. As described in DOE/RL-2009-38, in preparing a MODFLOW WEL package input file, it is necessary to appropriately distribute extraction and injection throughout the principal water-bearing units. This was accomplished for DOE/RL-2009-38 using the support program ALLOCATEQWELL (ECF-HANFORD-10-0371), which specifies pumping in each saturated ("wet") layer intercepted by a well according to the saturated thickness of the cell intercepted by the well, as well as the hydraulic conductivity of the cell.

This approach is suitable for representing specified flux boundary conditions under the assumption that the saturated thickness does not change substantially throughout the period of the simulation and, in particular, assuming that no pumped model cells go dry (i.e., the water table drops beneath the bottom of the cell). Although post-processing of simulations performed for DOE/RL-2009-38 suggested this did not occur, during the simulations performed for the current analyses, an alternative method of representing specified fluxes (wells), the MNW was evaluated that mitigates this difficulty, should it occur.

The MNW package differs from the WEL package in that a single pumping rate (the total rate for the well) is specified as input, rather than apportioning this rate across intercepted layers. During the simulation, the MNW package calculates a single water level within the well and, using this head, apportions flow from the layers intercepted by the MNW well accordingly ("Modeling Multiaquifer Wells with MODFLOW" [Neville and Tonkin, 2004]). In settings where the intercepted saturated thickness of the aquifer is constant over time, the MNW package produces a distribution of flow analogous to that produced by the WEL package. However, if the intercepted saturated thickness changes, the MNW calculates the necessary re-apportionment of flow between the model layers so the total specified rate is maintained (*User Guide for the Drawdown-Limited, Multi-Node Well [MNW] Package for the U.S. Geological Survey's Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, Versions MODFLOW-96 and MODFLOW-2000* [Halford and Hanson, 2002]; "Revised Multi-Node Well [MNW2] Package for MODFLOW Ground-Water Flow Model" [Konikow et al., 2009]). An additional advantage of the MNW package is, when undertaking transport simulations using MT3DMS following a MODFLOW simulation that employed the MNW package, the flow-weighted influent concentration, and mass recovery are automatically calculated by MT3DMS.

For the simulations presented here, the Central Plateau model Version N3 Grid G2 simulations were executed using the standard MODFLOW well simulation approach, whereas the Central Plateau model Version N3 Grid G3 simulations were executed using the MODFLOW MNW simulation approach. The results of the two simulations are plotted together in Appendix C (well-specific influent concentrations versus time) and Appendix D (well-specific mass recovery versus time).

5.2 Transport Model Procedures

Contaminant transport simulations were completed using MT3DMS for carbon tetrachloride. Transport terms simulated comprise advection, dispersion, sorption, and degradation (decay). All transport terms were solved using an implicit solution scheme. The simulations were used to evaluate the approximate directions and rates of migration of the contaminants and the approximate time-varying influent concentration of these contaminants at the extraction wells. Consistent with the simulations conducted for the RD/RAWP (DOE/RL-2008-78), contaminant transport modeling considered the migration of contaminants mapped as being present at the current time within the saturated aquifer. As such, it is

assumed that there are no continuing sources of contaminants to groundwater and that the dissolved and sorbed contaminants are in equilibrium.

Parameters defined for the transport of carbon tetrachloride are primarily based on values provided in the feasibility study (DOE/RL-2007-28), *Hanford Contaminant Distribution Coefficient Database and Users Guide* (PNNL-13895), and *Geochemical Data Package for the Hanford Immobilized Low-Activity Tank Waste Performance Assessment (ILAW PA)* (PNNL-13307). The simulations described in DOE/RL-2009-38 considered some transport parameters to be fixed for all simulations and considered a variety of values for three key inputs to the contaminant transport model. The transport parameters considered as fixed were longitudinal dispersivity, transverse dispersivity, vertical dispersivity (assumed to be zero), and bulk density. The transport parameters for which more than value was considered in the simulations described in DOE/RL-2009-38 comprised the following:

- Initial condition (i.e., mapped extent at simulation time zero)
- Mobile porosity (values of 0.13 and 0.18)
- Distribution coefficient (Kd) (values of 0.06 and 0.011 L/kg).

For the simulations described in the current document, however, the following transport parameters were considered fixed for all simulations:

- Longitudinal dispersivity (3.5 m), transverse dispersivity (0.35 m), and vertical dispersivity (assumed to be zero)
- Bulk density (1.90 kg/L)
- Initial condition (i.e., mapped extent at simulation time zero)
- Mobile porosity (0.15)
- Kd (0.003 L/kg).

The only transport parameter that was varied in the current simulations was the first-order decay (degradation) rate, which was ascribed values of about 1.9×10^{-5} per day (corresponding to a half-life of 100 years) and of about 4.6×10^{-5} per day (corresponding to a half-life of 41.3 years).

The single value ascribed for mobile porosity lies between the values simulated in support of the RD/RAWP (DOE/RL-2009-38) and is assumed to provide results approximately intermediate between the values used therein. Together, the values for porosity, Kd, and bulk density result in a retardation rate of about 1.04 for carbon tetrachloride. This relatively low retardation rate is consistent with that ascribed in the *200-UP-1 Remedial Investigation Report; Groundwater Contaminant Fate and Transport Model* (ECF-200UP-10-0373), which was selected to result in conservative (i.e., high-value) estimates of concentrations in the far-field for purposes of long-term impact analyses. As described in DOE/RL-2009-38, it is difficult to obtain a direct estimate of Kd (and other transport parameters) that is applicable at the site scale throughout the lifecycle of the remedy. Estimates may ultimately be obtained indirectly through model calibration, by refining understanding of aquifer properties and the contaminant distribution, and/or by comparing the simulated mass recovery with measured mass recovery. Given the time required for a groundwater system to stabilize following implementation of a large pump-and-treat remedy, and for monitoring data to elucidate patterns enabling inference of the remedy performance, information enabling accurate estimation of transport parameters may require several years to obtain. Therefore, it is recommended in Chapter 6 that the approach adopted in DOE/RL-2009-38 of conducting simulations using multiple transport parameter sets is continued until such time as uncertainty in transport parameter values is mitigated.

5.3 Comparison of Simulated Mass Recovery to Recent Data

The flow parameters of the Central Plateau model (including hydraulic conductivity, storage, recharge, and flow boundary conditions) have been calibrated on the basis of historic water levels (see DOE/RL-2009-38 and ECF-HANFORD-10-0371). However, the transport parameters of the Central Plateau model have not been formally calibrated on the basis of sampled concentration data (i.e., through coupled flow and transport calibration). This substantial effort is often most reliably performed using data obtained from a large pump-and-treat remedy such as the operations that will begin in the 200-ZP-1 OU in FY 2012. As such, it is expected that formal calibration of transport parameters will take place following startup of the final remedy.

However, simulation of recent mass recovery by the active interim pump-and-treat remedy can provide qualitative validation of the reasonableness of predictions of influent concentrations and masses made using the Central Plateau model. A qualitative validation of this type was performed prior to completing the predictive simulations described later in this document. Using the carbon tetrachloride initial condition (described in Chapter 4), and the groundwater extraction and injection rates for the current interim remedy wells for the first stress period of the Central Plateau model predictive simulation (equating to calendar years 2009, 2010, and 2011), the influent concentrations and mass recovery calculated by the Central Plateau model for the current interim remedy were compared with influent concentrations and mass recovery measured from 2009 through summer 2010. This qualitative comparison focuses on the mean and the trend of the simulated and measured concentrations and mass recovery rates since the model simulates annually averaged pumping rates and other stresses, and since the transport model initial condition combines data collected between 1999 and 2010 (with the majority of data obtained after 2003).

Figure 5-2 depicts the simulated and observed mass recovery at each extraction well under recent operating conditions, and Figure 5-3 depicts the simulated and observed mass recovery for the entire remedy under recent operating conditions.

The well-specific plots illustrated in Figure 5-2 suggest that the model matches the concentrations at some wells (e.g., 299-W15-34 and 299-W15-47), over-predicts the concentrations at some wells (e.g., 299-W15-1), and under-predicts the concentrations at other wells (e.g., 299-W15-40). Figure 5-3 indicates that on average (or, in total), the range in the simulated combined, flow-weighted, influent concentration encompasses the combined flow-weighted concentrations calculated using the well data. Figures 5-2 and 5-3 together suggest that for the volume of groundwater recovered by the interim remedy over the simulation period, the actual recoverable mass in groundwater is reasonably well approximated by the initial distribution of carbon tetrachloride (described in Chapter 4), as reflected by the comparable simulated and observed combined concentrations (Figure 5-3). However, the accuracy of the model at reproducing well-specific concentrations varies. The reasons for this likely include the approximate nature of the initial condition based on the interpolation of point data gathered over several years, the annual averaging used in the Central Plateau model, the model discretization that "averages" the concentrations within well cells, and other factors.

Nonetheless, the comparison is encouraging, suggesting that the model provides reasonable estimates of the bulk properties, concentrations, and mass recovery in the 200-ZP-1 OU. The accuracy of simulated well-specific concentrations will improve following development, testing, and sampling of each newly constructed extraction well, and following the integration of these data into the model initial conditions.

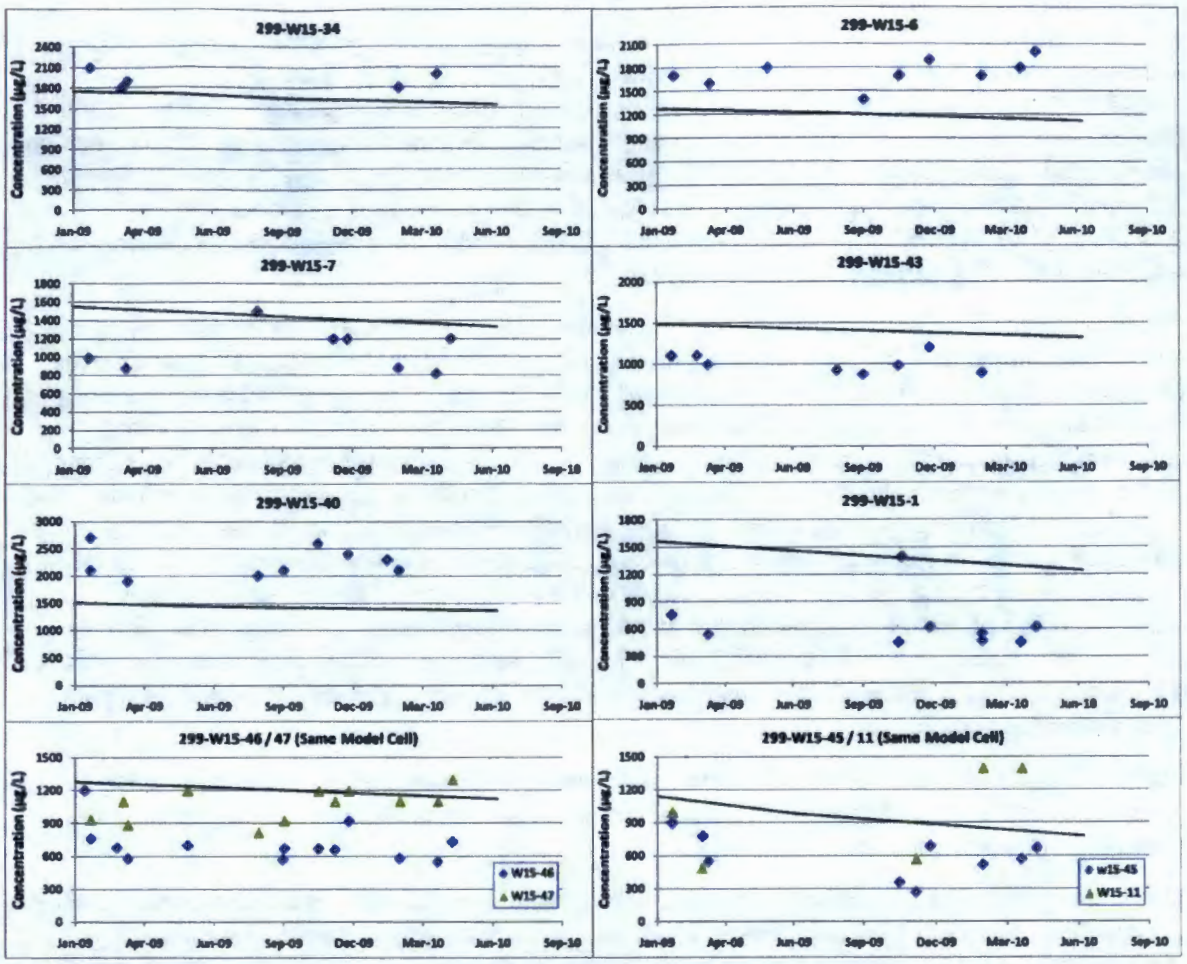


Figure 5-2. Simulated and Observed Influent Concentrations Under Current Conditions at Individual Wells

5.4 Results of Predictive Simulations

Appendix B list the well configurations for current conditions (i.e., Phase I), Phase II, and Phase III of final remedy implementation for each of the eight simulated well configuration alternatives. Figure 5-1 (a, b, and c) depicts the configuration of extraction and injection wells for the base case configuration alternatives, for current conditions (Phase I), Phase II, and Phase III of the final remedy implementation, respectively. As described above, each of the six additional alternatives simulated uses subtly different configurations of the same wells illustrated in Figure 5-1; therefore, additional figures are not presented for these six alternatives.

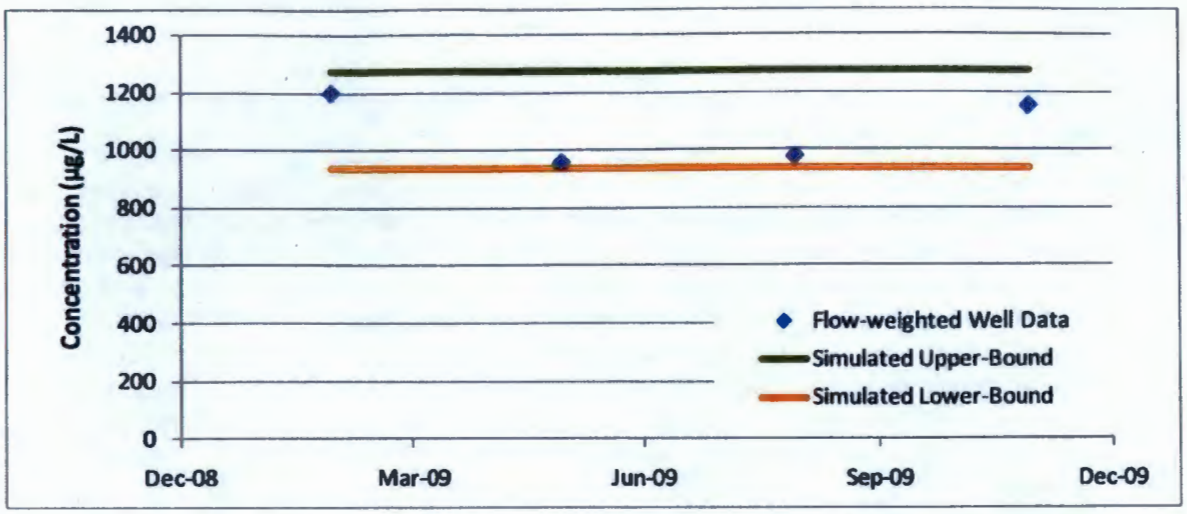


Figure 5-3. Simulated and Observed Combined Influent Concentration Under Current Conditions

5.4.1 Influent Concentrations and Mass Recovery of Carbon Tetrachloride

Because a large number of simulations were completed, and the three implementation phases of the simulated remedy comprise numerous extraction well locations, a large number of plots are required to depict the individual results from each simulation. Composite plots are presented and discussed in this section, and the individual, more detailed plots are provided in the following appendices:

- Appendix C presents the simulated influent concentration at each extraction well, for each of the eight alternate well configurations, for each of the two values of carbon tetrachloride degradation rate, resulting in 16 sets of plots (Figures C-1 through C-16) with each figure including results obtained with the superseded model Version N3 Grid G2 employing the WEL package, and with the approved model Version N3 Grid G3 employing the MNW package.
- Appendix D presents the simulated mass recovery at each extraction well, for each of the eight alternate well configurations for each of the two values of carbon tetrachloride degradation rate, resulting in 16 sets of plots (Figures D-1 through D-16) with each figure including results obtained with the superseded model Version N3 Grid G2 employing the WEL package, and with the approved model Version N3 Grid G3 employing the MNW package.
- Appendix E presents the simulated combined mass recovered by the entire remedy, for each of the eight alternate well configurations for each of the two values of carbon tetrachloride degradation rate, resulting in 16 sets of plots (Figures E-1 through E-16) with each figure including only results obtained with the approved Central Plateau model Version N3 Grid G3 employing the MNW package.

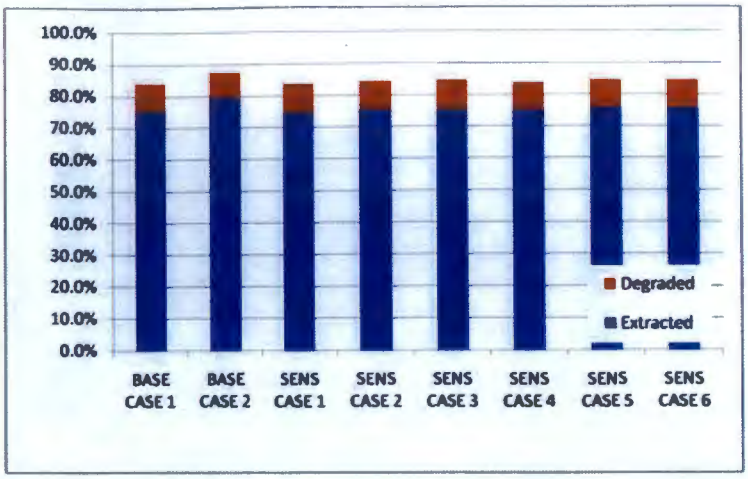
Review of the figures presented in Appendices C and D suggests that, with few exceptions, results obtained using superseded model Version N3 Grid G2 and the approved model Version N3 Grid G3 are similar. For this reason, the summaries that follow focus on the results obtained using model Version N3 Grid G3 and the MNW package. Figures 5-4 and 5-5 present the simulated, cumulative, system-wide mass recovery obtained assuming a half-life of 100 years and of 41.3 years, respectively. Figures 5-4 and 5-5 were prepared by combining the results presented in Appendix E for the model

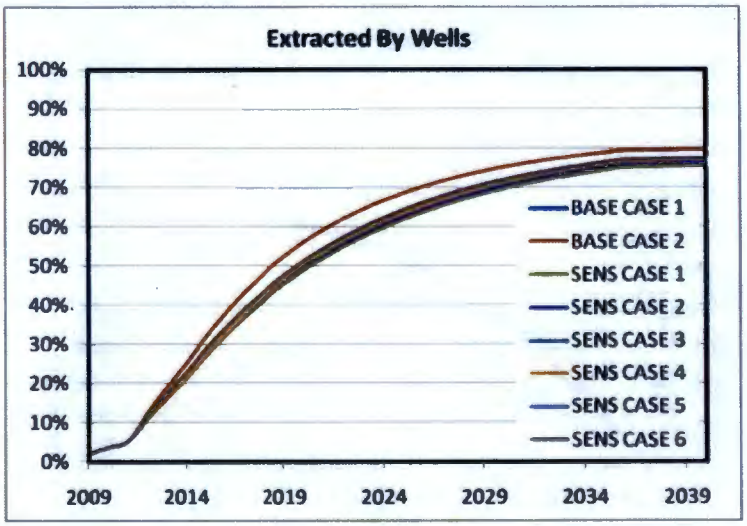
Version N3 Grid G3. As expected, the assumption of a longer half-life leads to greater mass recovery within the operational period (averaging between 75 and 80 percent) with a corresponding reduced loss of mass to degradation (averaging between 8 and 10 percent) (Figure 5-4), while the assumption of a shorter half-life leads less mass recovery (averaging around 70 percent) but increased loss of mass to degradation (averaging close to 20 percent) (Figure 5-5).

Further review of Figures 5-4 and 5-5 indicates that only one implementation alternative stands out clearly from the ensemble in terms of mass recovery rate and total mass recovered (Base Case 2). This might be expected, since Base Case 2 employs the base case well locations and as-built (where available) screened intervals, extracting at a rate that ranges from 1,325 L/min (350 gpm) higher (versus Sensitivity Cases 5 and 6) up to 1,893 L/min (500 gpm) higher (versus Base Case 1 and Sensitivity Cases 1 through 4) than the remaining implementation alternatives. From a total, system-wide recovery perspective, the remaining implementation alternatives appear, for practical purposes, indistinguishable. With regard to Sensitivity Cases 1 through 4, this suggests that, over the simulated timeframe, mass recovery by the extraction wells is relatively insensitive to the relatively small changes in patterns of reinjection represented by these four alternatives. With regard to Sensitivity Cases 5 and 6, this may suggest that although retaining extraction from the most effective current recovery wells leads to mass recovery from those wells, it may do so by reducing mass recovery from nearby new wells (i.e., through competition with other wells).

Tables 5-2 and 5-3 list the current and new extraction wells and their simulated cumulative mass recovery after a simulation time of 28 years (i.e., 25 years, +3 years), assuming a half-life of 100 years and of 41.3 years, respectively. This corresponds with 25 years from the implementation of Phase II of the remedy in accordance with the 200-ZP-1 ROD (EPA et al., 2008) and the RD/RAWP (DOE/RL-2008-78). Note that a combined mass recovery number is presented for some well pairs (e.g., 299-W15-11 and 299-W15-45) that share the same row and column location in the Central Plateau model because it is difficult to distinguish their individual mass recovery.

Review of Tables 5-2 and 5-3 indicates that under either assumption of the degradation rate, a wide disparity exists in the simulated mass recovery at wells, ranging from as little as 40 kg for some existing wells to 3,000 kg or greater for new extraction well EW-4, and close to this value for new well EW-8. As presented in the appendices, plots of influent concentration versus time clearly indicate that at some wells, the influent concentration declines within a few years of commencement of pumping, while for others (e.g., wells EW-4 and EW-8), the influent concentration remains steady and high for many years following commencement of pumping. The patterns in influent concentrations, which for several wells (including the elevated concentrations at wells EW-4 and EW-8, rapidly declining concentrations at well EW-9, and sustained low concentrations at EW-11) are consistent regardless of the simulated implementation alternative, suggests there will be opportunities to optimize the total system-wide mass recovery over time. This would be accomplished by reducing extraction at wells where the influent concentration has declined, and focusing extraction at wells where the influent concentration remains at elevated levels. This opportunity for optimization can be further evaluated by ranking the new extraction wells in terms of their mass recovery.





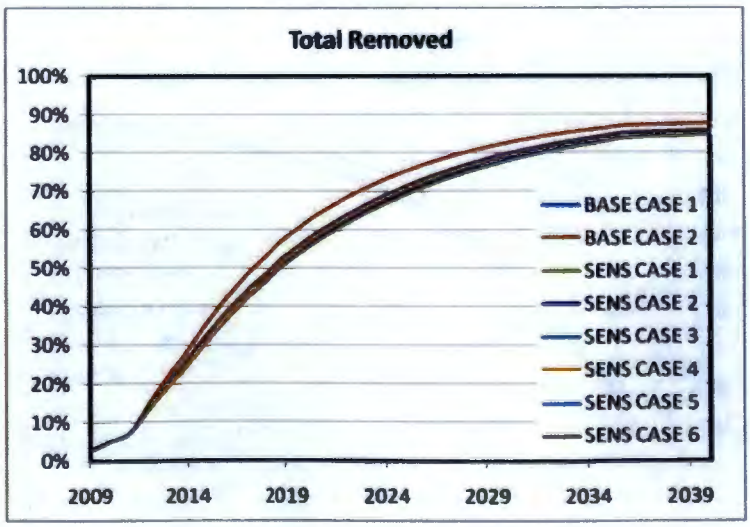


Figure 5-4. Total Mass Recovered and Degraded Assuming 100-Year Half-Life

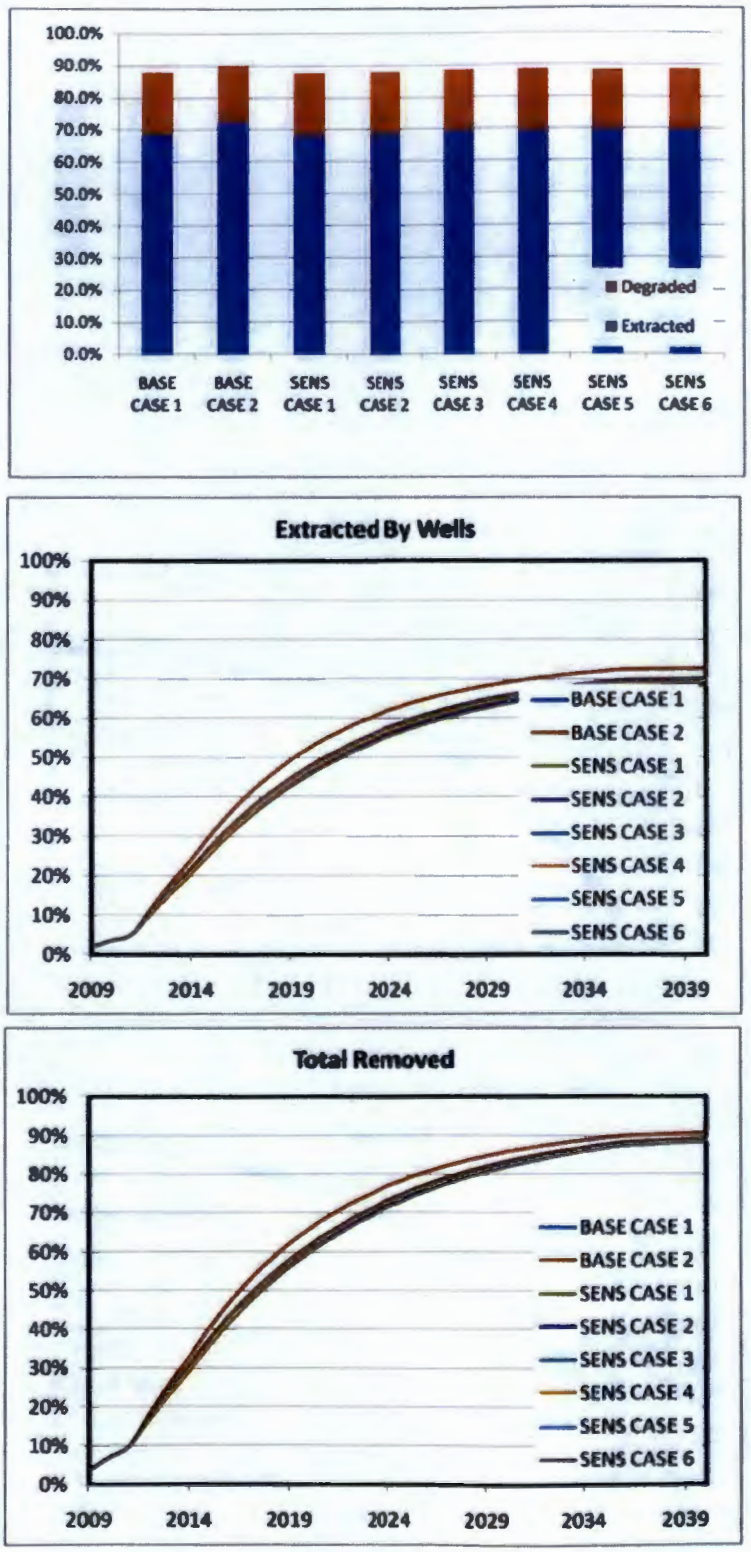


Figure 5-5. Total Mass Recovered and Degraded Assuming 41.3-Year Half-Life

Table 5-2. Summary of Simulated Cumulative Mass Recovery by Extraction Wells at 25 Years (+3 Years) Assuming 100-Year Half-Life

Well	Half-Life = 100 years							
	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
EW-1	1,347	1,417	1,346	1,260	1,321	1,232	1,195	1,178
EW-2	1,676	1,750	1,679	1,534	1,526	1,521	1,596	1,398
EW-3	2,048	2,284	2,054	1,792	1,819	1,799	1,836	1,774
EW-4	3,385	3,959	3,376	2,946	3,040	3,018	3,119	3,031
EW-5	1,583	1,562	1,497	1,349	2,379	2,424	2,161	2,389
EW-6	831	870	831	767	795	794	822	756
EW-7	1,872	1,993	1,874	1,697	1,677	1,655	1,803	1,622
EW-8	2,639	2,913	2,676	2,376	2,248	2,239	2,323	2,168
EW-9	354	382	355	326	374	369	359	309
EW-10	1,090	1,151	1,092	1,015	1,086	1,035	1,042	1,001
EW-11	400	418	401	351	390	392	331	346
EW-12	1,569	1,646	1,574	1,414	1,489	1,478	1,387	1,431
EW-13	624	575	625	566	571	570	555	522
EW-14	964	961	984	884	773	764	789	731
EW-15	1,389	1,524	1,386	1,236	1,250	1,246	1,177	1,231
EW-16	889	921	889	829	862	870	861	767
EW-17	785	729	797	706	1,039	1,038	989	1,038
EW-18	1,287	1,259	1,218	1,087	1,789	1,818	1,644	1,793
EW-19	1,777	1,738	1,783	1,596	2,408	2,480	2,190	2,426
EW-20	1,628	1,646	1,595	1,435	1,822	1,862	1,702	1,829
299-W15-11/ 299-W15-45	375	375	375	371	375	375	375	375
299-W15-34	200	200	200	198	200	200	200	200
299-W15-40	54	54	54	53	54	54	54	54
299-W15-43	267	267	267	263	267	267	267	267
299-W15-46/ 299-W15-47	404	404	404	399	404	404	404	404
299-W15-6	40	40	40	39	40	40	40	40

Table 5-2. Summary of Simulated Cumulative Mass Recovery by Extraction Wells at 25 Years (+3 Years) Assuming 100-Year Half-Life

Well	Half-Life = 100 years							
	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
299-W15-7/ 299-W15-35	494	494	494	487	494	494	494	494
299-W15-44	56	56	56	55	56	56	56	56
299-W15-765	110	110	110	108	110	110	110	110

EW = extraction well

Table 5-3. Summary of Simulated Cumulative Mass Recovery by Extraction Wells at 25 Years (+3 Years) Assuming 41.3-Year Half-Life

Well	Half-Life = 41.3 years							
	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
EW-1	1,261	1,334	1,260	1,262	1,239	1,158	1,123	1,109
EW-2	1,532	1,614	1,534	1,529	1,403	1,400	1,459	1,288
EW-3	1,788	2,015	1,792	1,788	1,606	1,590	1,615	1,566
EW-4	2,953	3,473	2,946	2,986	2,675	2,655	2,739	2,669
EW-5	1,424	1,421	1,349	1,465	2,084	2,123	1,903	2,093
EW-6	766	809	767	766	736	735	758	701
EW-7	1,695	1,823	1,697	1,690	1,532	1,512	1,638	1,485
EW-8	2,345	2,610	2,376	2,333	2,025	2,017	2,087	1,957
EW-9	326	354	326	324	343	340	329	286
EW-10	1,013	1,077	1,015	1,009	1,012	966	969	934
EW-11	351	368	351	347	343	345	292	305
EW-12	1,410	1,493	1,414	1,404	1,345	1,338	1,255	1,294
EW-13	566	525	566	564	519	519	506	476
EW-14	867	870	884	878	704	695	717	666
EW-15	1,238	1,368	1,236	1,250	1,123	1,120	1,062	1,106

Table 5-3. Summary of Simulated Cumulative Mass Recovery by Extraction Wells at 25 Years (+3 Years) Assuming 41.3-Year Half-Life

Well	Half-Life = 41.3 years							
	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
EW-16	829	864	829	828	806	813	802	718
EW-17	700	656	706	695	920	920	877	920
EW-18	1,146	1,137	1,087	1,088	1,576	1,603	1,454	1,581
EW-19	1,592	1,579	1,596	1,609	2,120	2,182	1,939	2,134
EW-20	1,465	1,498	1,435	1,535	1,627	1,663	1,527	1,633
299-W15-11/ 299-W15-45	371	371	371	371	371	371	371	371
299-W15-34	198	198	198	198	198	198	198	198
299-W15-40	53	53	53	53	53	53	53	53
299-W15-43	263	263	263	263	263	263	263	263
299-W15-46/ 299-W15-47	399	399	399	399	399	399	399	399
299-W15-6	39	39	39	39	39	39	39	39
299-W15-7/ 299-W15-35	487	487	487	487	487	487	487	487
299-W15-44	55	55	55	55	55	55	55	55
299-W15-765	108	108	108	108	108	108	108	108

EW = extraction well

Table 5-4 presents the rank of each new extraction well in terms of the total mass recovered after 25 years (+3 years) of operation under each of the eight simulated scenarios, assuming a half-life of 100 years and 41.3 years, respectively. Table 5-4 illustrates that some extraction wells are predicted to ultimately recover considerably more mass than other wells. As identified from Tables 5-2 and 5-3, it is evident that some new extraction wells are consistently highly ranked, while others are consistently ranked low. For example, well EW-4 ranks the highest regardless of the simulated implementation, while well EW-9 ranks the lowest in all but a single simulated implementation alternative. For some wells, such as wells EW-3 and EW-5, however, their ranking changes considerably depending on the simulated implementation alternative. This may occur as a result of their changed extraction rate in different simulations, or as a result of their location relative to other extraction and injection wells.

Table 5-4. Ranking of New Extraction Wells by Mass Recovery Assuming (a) 100-Year Half-Life and (b) 41.3-Year Half-Life

Well	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
Half-Life = 100 years								
EW-1	11	11	11	10	11	12	11	12
EW-2	6	5	6	6	9	9	9	10
EW-3	3	3	3	3	6	7	5	7
EW-4	1	1	1	1	1	1	1	1
EW-5	8	9	9	9	3	3	4	3
EW-6	16	16	16	16	16	16	16	16
EW-7	4	4	4	4	8	8	6	8
EW-8	2	2	2	2	4	4	2	4
EW-9	20	20	20	20	20	20	19	20
EW-10	13	13	13	13	13	14	13	14
EW-11	19	19	19	19	19	19	20	19
EW-12	9	7	8	8	10	10	10	9
EW-13	18	18	18	18	18	18	18	18
EW-14	14	14	14	14	17	17	17	17
EW-15	10	10	10	11	12	11	12	11
EW-16	15	15	15	15	15	15	15	15
EW-17	17	17	17	17	14	13	14	13
EW-18	12	12	12	12	7	6	8	6
EW-19	5	6	5	5	2	2	3	2
EW-20	7	8	7	7	5	5	7	5
Half-Life = 41.3 years								
EW-1	10	11	10	10	11	11	11	11
EW-2	6	5	6	7	9	9	8	10
EW-3	3	3	3	3	6	7	6	7
EW-4	1	1	1	1	1	1	1	1
EW-5	8	9	9	8	3	3	4	3
EW-6	16	16	16	16	16	16	16	16

Table 5-4. Ranking of New Extraction Wells by Mass Recovery Assuming (a) 100-Year Half-Life and (b) 41.3-Year Half-Life

Well	Base Case 1	Base Case 2	Sensitivity Case 1	Sensitivity Case 2	Sensitivity Case 3	Sensitivity Case 4	Sensitivity Case 5	Sensitivity Case 6
EW-7	4	4	4	4	8	8	5	8
EW-8	2	2	2	2	4	4	2	4
EW-9	20	20	20	20	19	20	19	20
EW-10	13	13	13	13	13	13	13	13
EW-11	19	19	19	19	20	19	20	19
EW-12	9	8	8	9	10	10	10	9
EW-13	18	18	18	18	18	18	18	18
EW-14	14	14	14	14	17	17	17	17
EW-15	11	10	11	11	12	12	12	12
EW-16	15	15	15	15	15	15	15	15
EW-17	17	17	17	17	14	14	14	14
EW-18	12	12	12	12	7	6	9	6
EW-19	5	6	5	5	2	2	3	2
EW-20	7	7	7	6	5	5	7	5

EW = extraction well

5.4.2 Ranking of Wells Based on Mass Recovery

Table 5-5 provides the average and mode rankings for the new wells, in terms of mass recovered after 28 years (i.e., 25 years, +3 years) of operation, for all scenarios simulated in this study, including both assumed half-lives. For comparison purposes, the rank is shown for each well that was calculated on the basis of the simulations completed in support of the RD/RAWP (DOE/RL-2008-78), the change between the average new rank (this document), and average previous rank (DOE/RL-2009-38). Once again, the ranking for some wells (EW-4 ranked #1, and EW-11 ranked #19) are consistent between the various analyses, while the ranking for other wells (EW-1 and EW-7) have changed. In some cases, the change between the previous ranking and those calculated here are understandable. For example, during drilling of well EW-1, extensive characterization was completed, and the sample data obtained from the well were directly integrated into the initial condition for carbon tetrachloride used in this study. For other wells, the variability in ranking between analyses requires further investigation prior to attempting remedy optimization.

Table 5-5. Summary of Well Rankings from this Document and Previous Reports

Well	RD/RAWP* Rank	Average New Rank	Change	Mode New Rank
EW-1	18.50	10.88	7.63	11
EW-2	11.00	7.50	3.50	6
EW-3	5.50	4.69	0.81	3
EW-4	1.00	1.00	0.00	1
EW-5	6.50	5.94	0.56	3
EW-6	15.50	16.00	-0.50	16
EW-7	10.00	5.69	4.31	4
EW-8	3.00	2.75	0.25	2
EW-9	18.50	19.81	-1.31	20
EW-10	13.50	13.13	0.38	13
EW-11	19.00	19.19	-0.19	19
EW-12	6.50	9.00	-2.50	10
EW-13	17.00	18.00	-1.00	18
EW-14	13.00	15.50	-2.50	14
EW-15	7.00	11.13	-4.13	11
EW-16	10.50	15.00	-4.50	15
EW-17	16.50	15.38	1.13	17
EW-18	11.00	9.44	1.56	12
EW-19	2.00	3.75	-1.75	5
EW-20	4.50	6.25	-1.75	7

* DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan.*

EW = extraction well

RD/RAWP = remedial design/remedial action work plan

5.5 Principal Assumptions Underlying the Modeling Analysis

Some of the assumptions that underlie the analyses described in this document are listed below. These assumptions are listed in order of the likely magnitude of potential impact on the results presented. This list is not all inclusive, but it is intended provide direction for actions to refine and update the estimates presented in this document:

1. Contaminant distribution: The simulations described address the current mapped extent of contaminants in the groundwater and, using an instantaneous reversible linear sorption isotherm, their current extent sorbed on the aquifer materials:

   a. There is/are assumed to be no continuing source(s) to groundwater for any of the COCs.

   b. Contamination that may lie outside of the current mapped extent is not addressed (although hydraulic capture extends beyond the mapped plume in some areas).

   c. Contaminants that may be sorbed to materials that express a higher effective Kd than the model-wide value used in the simulations are not represented.

2. Aquifer properties: Although all principal water-bearing units documented in PNNL-14753 that lie within the model domain are simulated, homogeneity is assumed within each water-bearing unit.

   The modeling completed in support of the RD/RAWP (DOE/RL-2009-38) cited three additional assumptions and limitations that are re-iterated below but are now considered secondary as a result of revisions and improvements to the Central Plateau model described in Chapters 3 and 4.

3. Recharge: DOE/RL-2009-38 indicated that the Central Plateau model was being revised to incorporate spatially variable net recharge from aerial precipitation (after PNNL-14753), historic wastewater discharges in the 200 West and 200 East Areas, and mountain-front recharge via the ephemeral Dry Creek and Cold Creek unit (after PNNL-14753) prior to recalibration for the 30 percent design simulations. This has been completed.

4. Well screen intervals: DOE/RL-2009-38 indicated that the recovery wells were considered to penetrate from the water table to the top of the basalt, which forms the base of the model. Final screened intervals available for new extraction wells were incorporated into the Central Plateau model for the current study, where available.

5. Boundary conditions: DOE/RL-2009-38 indicated that the Central Plateau model assumed the southeastern boundary was a no-flow boundary, forcing flow to be parallel (directly east) to this boundary. The Central Plateau model has been revised to treat this boundary as a general head boundary that is defined on the basis of two controlling head conditions: the first of these comprising the Columbia River, and the second comprising a relatively static head condition between the Rattlesnake Mountain and Yakima Ridge anticlines.

6 Discussion and Recommendations

6.1 Discussion

This document presents the results of 32 flow and transport simulations, comprising eight alternate well configurations and two alternate assumptions for the degradation half-life of carbon tetrachloride, and employing two alternate approaches to simulate wells. The first approach uses the standard MODFLOW WEL package with the superseded Central Plateau model Version N3 Grid G2 (comprising five layers), and the second approach uses the MODFLOW MNW package with the recently approved Central Plateau model Version N3 Grid G3 (comprising seven layers). No additional perturbations of parameters or assumptions were made in this suite of simulations. The simulations considered carbon tetrachloride only, and the fate of contaminants not captured was not evaluated since the focus was on the impact of recent characterization data and improvements to the Central Plateau model on predictions of mass recovery.

6.1.1 Projected Mass Recovery

The Central Plateau model has been used to simulate the approximate fate of carbon tetrachloride in the 200-ZP-1 OU for a variety of alternative implementations of the remedy. Assuming the base pumping rates described in the RD/RAWP (DOE/RL-2008-78), the simulations suggest that the remedy may extract about 70 to 80 percent of the total mass of carbon tetrachloride during the planned period of active pumping, and an additional 10 to 20 percent will degrade over the planned period of active pumping, with degradation continuing after cessation of pumping. In general, the results presented in this document are consistent with those presented in support of the RD/RAWP (DOE/RL-2009-38). In particular, the ranking of most new extraction wells, in terms of total mass recovered throughout the lifecycle of active pumping, across the range of scenarios presented (Tables 5-4 and 5-5) are consistent with those obtained in previous analyses.

The simulation results reflect no systematic efforts at optimizing the rates and timing of groundwater extraction. The simulations presented here typically reflect a uniform distribution of pumping across the planned extraction wells, with some exceptions (e.g., Sensitivity Cases 5 and 6). However, the simulation results suggest a wide range in the expected cumulative mass recovery at each of the new extraction wells. For example, it is projected that the new wells ranked highest in terms of mass recovery extract over three to five times the mass of the wells ranked lowest, and that the highest ranked wells continue to recover mass at a significant rate after many years of operation, while recovery at the lowest ranked wells approaches an asymptote after as little as 5 to 10 years of active pumping. This pattern is consistent with the expectation that over time, mass recovery rates at the margins of the carbon tetrachloride plume will decline as concentrations in the aquifer are reduced, while mass recovery rates at wells located interior to the contamination will remain high since these wells will continue to access areas of higher concentrations within the plume for many years.

This pattern indicates that clear opportunities exist for optimizing the relative rates and timing of groundwater extraction (and, to a lesser degree, reinjection) to enhance mass recovery and aquifer cleanup. The opportunity for optimization to enhance recovery is reinforced by the findings of recent aquifer tests (PNNL-18732), which suggest that the operating capacities of some of the planned extraction wells may be considerably higher than the 379 L/min (100 gpm) assumed as part of analyses conducted here and in DOE/RL-2009-38.

As a result, since the results presented here reflect no efforts at systematic optimization, it is concluded that under suitable conditions (and assuming that remedy performance analysis and optimization take place throughout the remedy lifecycle), attainment of the mass recovery RAO for carbon tetrachloride

(recovering a mass of carbon tetrachloride equivalent to 95 percent of the corresponding initial estimate of the dissolved mass after 25 years of active pumping) may be possible. However, the simulations presented here and in DOE/RL-2009-38 suggest that the further the conditions encountered in the field differ from such suitable conditions and, if remedy performance analysis and optimization are not systematically performed, the less likely the RAOs can be achieved with the proposed well configuration and rates.

Finally, the simulations presented here and in DOE/RL-2009-38 suggested that significant variables that might affect both the mass recovery rates and the attainment of the mass-recovery RAO for carbon tetrachloride include the following:

- Degradation rate (half-life) (this document)
- Kd and retardation rate (DOE/RL-2009-38)
- Initial distribution of contaminants (DOE/RL-2009-38).

Furthermore, although not explicitly considered in simulations to date, the presence of continuing sources of contaminants would significantly impact the attainment of RAOs.

6.1.2 Injection Well Completion

Two remedy implementation scenarios were simulated (Sensitivity Cases 1 and 2) to evaluate the possible impact of injecting some fraction of treated water below the Ringold lower mud unit. This possible implementation may lead to improved long-term injection well efficiency since the unconfined aquifer above the Ringold lower mud unit is of limited thickness, and well rehabilitation and development methods are most effective for saturated screen intervals. Comparison of the simulated alternatives suggests that there is little impact to the mass recovered over the lifecycle of active pumping. Thus, in terms of this single metric, these implementation alternatives appear as viable as reinjection above the Ringold lower mud unit. However, an additional objective of the active pumping is hydraulic control (both hydraulic capture and flow path control) of the contaminants within the unconfined aquifer. Since the sampling and characterization data obtained to date indicate that the bulk of the contaminants lie above the Ringold lower mud unit, it appears prudent that extraction and reinjection are focused above the Ringold lower mud unit until evidence contradicts this current depiction of the distribution of contaminants. It is noted that significant uncertainties impacting the sensitivity of the mass recovery predictions to the reinjection implementation alternatives include the following:

- Distribution of contaminants beneath the Ringold lower mud unit
- Continuity and competency of the Ringold lower mud unit
- Transmissivity beneath the Ringold lower mud unit.

6.1.3 Continued Operation of Selected Interim Remedy Wells

Two remedy implementation scenarios were simulated (Sensitivity Cases 3 and 4) to evaluate the possible impact of injecting some fraction of treated water using existing interim remedy injection wells. These wells are located upgradient (southwest) of the planned remedy expansion, in the vicinity of the new planned injection wells IW-7 and IW-8. This possible implementation may lead to improved long-term total injection well capacity and flexibility in the distribution of reinjected water, since these existing injection wells have a proven record of receiving relatively high rates of discharge. Furthermore, these wells are located in an area that is targeted for reinjection to provide upgradient hydraulic control of contaminants. Comparison of the simulated alternatives suggests that there is little impact to the mass recovered over the lifecycle of active pumping; thus, in terms of this single metric, these implementation alternatives appear as viable as reinjection above the Ringold lower mud unit. Since these wells already

exist, it is recommended that this option be further considered and that any actions that might prohibit this option from being exercised in future (e.g., well abandonment) be carefully considered before being undertaken.

Two remedy implementation scenarios were simulated (Sensitivity Cases 5 and 6) to evaluate the possible impact of supplementing extraction at the newly installed recovery wells with extraction at existing, high-performing recovery wells. The four wells considered are 299-W15-35, 299-W15-43, 299-W15-45, and 299-W15-46. This possible implementation may lead to improved mass recovery and possibly improved hydraulic control of areas exhibiting high concentrations, since these wells have a proven record of recovering significant contaminant mass. Furthermore, these wells are located in an area that is targeted for focused mass recovery in the final remedy. However, comparison of the simulated alternatives suggests that there is little impact to the mass recovered over the lifecycle of active pumping, despite the fact that some of the existing extraction wells may continue to recover significant mass of carbon tetrachloride for a number of years. Thus, in terms of this single metric, these implementation alternatives do not appear to offer substantial benefits. The reasons for this have not been rigorously investigated but may result from competition between these wells and newly installed wells for mass present in the vicinity of each. Since these wells already exist, it is recommended that this option be further considered, and that any actions that might prohibit this option from being exercised in future (e.g., well abandonment) be carefully considered before being undertaken.

6.2 Recommendations

This document and DOE/RL-2009-38 present numerous simulations of the likely performance of the final 200-ZP-1 OU pump-and-treat remedy over 25 years of active operation. Collectively, these simulations suggest that the remedy, as currently designed (i.e., assuming the base pumping rates described in the RD/RAWP [DOE/RL-2008-78] without systematic optimization), may come close to achieving the mass recovery RAO for carbon tetrachloride, but that mass recovery at several existing and planned extraction wells approaches an asymptote after fewer than 10 years of operation, which is reflected in a corresponding reduced system-wide mass recovery rate. As a result of this consistent inference from simulations of the 200-ZP-1 pump-and-treat remedy completed to date (and noting that information on actual mass recovery will be obtained soon after expanded remedy pumping commences), it is recommended that efforts in FY 2011 focus on continued integration of newly obtained data to the Central Plateau model (as was undertaken in FY 2010) and on a more systematic optimization of the remedy implementation to the extent that this is possible with the information available.

To accomplish this, the following general course of activities is recommended:

- Ongoing integration of characterization data gathered through spring 2011 into the Central Plateau model 200-ZP-1 OU simulations to accurately represent these elements. This includes water quality samples used to define initial conditions, as-built well construction and performance data used to specify pumping, hydrostratigraphic data used to define the model structure and parameterization, and water-level data used for calibration.

- Evaluation of contaminant transport parameters and simulation techniques used in simulating carbon tetrachloride and other COCs to provide best-estimate and bounding values for use in predictive simulations to bound the likely remedy performance. Although, as noted in DOE/RL-2009-38, it is difficult to obtain direct estimates for Kd and other transport parameters that are applicable throughout the longevity of the site, the results presented here and in DOE/RL-2009-38 suggest that remedy optimization can be implemented relatively soon by focusing on relative mass recovery (rather than absolute mass recovery), without detailed knowledge of these parameters.

- Implementation of a more systematic remedy optimization approach that attempts to maximize the recovery of carbon tetrachloride and attainment of the other RAOs within reasonable constraints set by well capacities, treatment system capacity, and other practical limitations about which knowledge is becoming available. Based on the results presented here, this optimization process should consider the possibility of varying extraction/injection patterns on intervals of 5 to 10 years and retaining beneficial elements of the implementation alternatives described earlier (i.e., Base Case 2 with increased extraction; Sensitivity Cases 1 through 4 with alternative reinjection; and Sensitivity Cases 5 and 6 with supplementary extraction). Such an optimization process would necessarily need to consider the sensitivity of predicted remedy performance with respect to key model inputs.

If an improved understanding of any primary variables deviates substantially from the assumptions made during the remedy design (e.g., significantly higher transmissivity, substantially poorer well performance, and/or a much larger distribution of contaminants), this may indicate that the remedy requires substantial revision. It may also indicate that the likelihood of achieving the RAOs is sufficiently undermined by the new information and understanding that further remedy implementation should be reconsidered. If model predictions are based on assumptions that are contradicted by new data, it may become evident that the remedy may be either over-designed (i.e., more wells may be installed than required to meet RAOs) or under-designed (i.e., fewer wells may be installed than required to meet RAOs).

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Appendix A

Sample Data Used to Map Initial Conditions for Transport Simulations

Table

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area A-1

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
1	566663.1	136734.57	134.9	1400	299-W10-1	7/16/2009
2	565998.65	136599.87	136.1	1.00	299-W10-13	3/12/2002
3	566017.19	136608.9	81.1	0.5	299-W10-14	3/12/2009
4	566317.42	137030.18	135.2	6.20	299-W10-19	9/8/2003
5	566249.69	136866.61	135.2	13.00	299-W10-20	3/16/2006
6	566584	137154.72	134.6	350	299-W10-21	9/19/2005
7	566832.61	136883.05	134.7	500	299-W10-22	10/27/2009
8	566823.73	136815.34	133.3	1500	299-W10-23	2/3/2009
9	566885.43	136798.78	133.4	1700	299-W10-24	1/26/2010
10	566082.98	136828.74	132.3	36	299-W10-29	3/12/2009
11	566082.78	136739.33	132.4	6.7	299-W10-30	3/12/2009
12	566266.44	136968.34	131.9	120	299-W10-31	5/1/2009
13	566772.75	136610.18	131.7	1300	299-W10-33	7/6/2007
14	566772.75	136610.18	130.0	1700	299-W10-33	7/10/2007
15	566772.75	136610.18	124.7	1500	299-W10-33	7/11/2007
16	566772.75	136610.18	122.2	1200	299-W10-33	7/12/2007
17	566772.75	136610.18	119.8	1600	299-W10-33	7/16/2007
18	566772.75	136610.18	116.8	600	299-W10-33	7/17/2007
19	566772.75	136610.18	113.7	2.7	299-W10-33	7/24/2007
20	566772.75	136610.18	109.8	230	299-W10-33	7/27/2007
21	566772.75	136610.18	107.6	280	299-W10-33	7/31/2007
22	566772.75	136610.18	104.6	1100	299-W10-33	8/1/2007
23	566772.75	136610.18	101.2	1200	299-W10-33	8/2/2007
24	566772.75	136610.18	99.4	110	299-W10-33	8/3/2007
25	566772.75	136610.18	95.4	65	299-W10-33	8/6/2007
26	566772.75	136610.18	92.4	14	299-W10-33	8/8/2007
27	566772.75	136610.18	89.0	8.1	299-W10-33	8/13/2007
28	566772.75	136610.19	84.1	0.5	299-W10-33	1/28/2010
29	566772.75	136610.18	80.2	2.5	299-W10-33	8/24/2007
30	566772.75	136610.18	77.2	0.5	299-W10-33	8/29/2007
31	566734.64	136578.08	134.6	1300	299-W10-4	2/9/2010
32	566578.6	136474.83	136.0	1300	299-W10-5	11/16/2009
33	566848.81	136811.22	134.6	320	299-W10-8	8/25/2005
34	568147.51	136610.04	133.0	530	299-W11-10	9/13/2009
35	566927.13	136604.02	132.9	83	299-W11-12	1/24/2005
36	567099.36	136424.03	106.9	350	299-W11-13	6/22/2009
37	567457.94	136913.97	132.9	240	299-W11-14	6/21/2006
38	567181.92	137161.48	134.2	600	299-W11-18	8/17/2009
39	566912.31	136774.77	130.2	890	299-W11-25B	2/8/2005
40	566912.31	136774.77	124.1	1400	299-W11-25B	2/8/2005
41	566912.31	136774.77	118.0	1146	299-W11-25B	2/16/2005
42	566912.31	136774.77	111.9	1500	299-W11-25B	2/17/2005
43	566912.31	136774.77	105.8	1200	299-W11-25B	2/23/2005
44	566912.31	136774.77	99.7	1341	299-W11-25B	2/24/2005
45	566912.31	136774.77	93.9	998	299-W11-25B	3/4/2005
46	566912.31	136774.77	87.8	1050	299-W11-25B	3/7/2005
47	566912.31	136774.77	84.9	884	299-W11-25B	3/8/2005
48	567641.72	136663.9	132.5	280	299-W11-3	6/22/2009

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
49	567187.69	136849.2	131.8	1600	299-W11-34P	1/6/2010
50	567635.18	137018	133.6	320	299-W11-37	7/31/2009
51	566908.38	136779.92	132.5	1100	299-W11-39	1/28/2010
52	566926.84	136709.67	132.5	190	299-W11-40	1/28/2010
53	566935.5	136677.78	134.6	99	299-W11-41	9/26/2005
54	566920.44	136745.67	133.6	850	299-W11-42	1/28/2010
55	567269.75	136971.05	125.9	900	299-W11-43	6/1/2005
56	567269.75	136971.05	116.8	980	299-W11-43	6/7/2005
57	567269.75	136971.05	105.8	450	299-W11-43	6/9/2005
58	567269.75	136971.05	89.3	310	299-W11-43	6/16/2005
59	567269.74	136971.04	85.8	1100	299-W11-43	1/6/2010
60	567269.75	136971.05	79.9	1100	299-W11-43	6/21/2005
61	566992.84	136775.64	129.5	790	299-W11-45	10/4/2005
62	566992.84	136775.64	125.7	1400	299-W11-45	3/3/2010
63	566992.84	136775.64	123.3	1200	299-W11-45	10/11/2005
64	566992.84	136775.64	117.2	1370	299-W11-45	10/17/2005
65	566992.84	136775.64	111.4	1175	299-W11-45	10/20/2005
66	566992.84	136775.64	105.4	891	299-W11-45	10/26/2005
67	566992.84	136775.64	99.3	63	299-W11-45	10/28/2005
68	566992.84	136775.64	93.1	363	299-W11-45	11/1/2005
69	566992.84	136775.64	87.0	2.4	299-W11-45	11/7/2005
70	566992.84	136775.64	80.9	77	299-W11-45	11/10/2005
71	566914.86	136773.27	127.6	1200	299-W11-46	3/3/2010
72	566933.82	136680.7	122.2	1200	299-W11-47	7/27/2009
73	566933.82	136680.70	119.4	341.2757974	299-W11-47	2/28/2006
74	566933.82	136680.70	116.7	1700	299-W11-47	3/3/2006
75	566933.82	136680.70	110.6	1389.02439	299-W11-47	3/6/2006
76	566933.82	136680.70	104.5	701.6885553	299-W11-47	3/8/2006
77	566933.82	136680.70	98.4	606.0037523	299-W11-47	3/10/2006
78	566933.82	136680.70	92.3	35.08442777	299-W11-47	3/14/2006
79	566933.82	136680.70	86.2	10.52532833	299-W11-47	3/16/2006
80	566881.97	136846.18	132.1	850	299-W11-48	4/10/2007
81	566881.97	136846.18	127.5	1200	299-W11-48	4/11/2007
82	566881.97	136846.18	122.9	650	299-W11-48	4/13/2007
83	566881.97	136846.18	119.6	1100	299-W11-48	4/17/2007
84	566881.97	136846.18	116.8	1300	299-W11-48	4/25/2007
85	566881.97	136846.18	111.4	980	299-W11-48	1/8/2010
86	566881.97	136846.18	109.5	1200	299-W11-48	5/17/2007
87	566881.97	136846.18	107.4	190	299-W11-48	5/21/2007
88	566881.97	136846.18	104.4	780	299-W11-48	5/22/2007
89	566881.97	136846.18	101.3	58	299-W11-48	5/23/2007
90	566881.97	136846.18	99.6	140	299-W11-48	5/25/2007
91	566881.97	136846.18	95.2	77	299-W11-48	5/25/2007
92	566881.97	136846.18	92.5	6.2	299-W11-48	5/29/2007
93	566881.97	136846.18	89.7	6.2	299-W11-48	6/1/2007
94	566881.97	136846.18	87.3	0.5	299-W11-48	6/5/2007
95	567362	135925	128.5	7	299-W11-49	2/5/2010
96	567362	135925	125.4	55	299-W11-49	2/8/2010
97	567362	135925	119.3	12	299-W11-49	2/9/2010
98	567362	135925	113.2	2200	299-W11-49	2/10/2010
99	567362	135925	107.1	1400	299-W11-49	2/12/2010

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
100	567362	135925	101.0	1300	299-W11-49	2/17/2010
101	567362	135925	94.9	1200	299-W11-49	2/25/2010
102	567362	135925	84.0	1200	299-W11-49	3/26/2010
103	567481.62	136492.84	132.3	370	299-W11-6	12/3/2009
104	567260.88	136675.33	134.3	1400	299-W11-7	6/3/2009
105	568143.53	136610.04	127.0	1433	299-W11-86	6/30/2006
106	568143.53	136610.04	120.0	1200	299-W11-86	7/7/2006
107	568143.53	136610.04	111.4	780	299-W11-86	7/10/2006
108	568143.53	136610.04	106.2	2300	299-W11-86	7/12/2006
109	568143.53	136610.04	97.1	1292	299-W11-86	7/17/2006
110	568143.53	136610.04	89.5	260	299-W11-86	7/25/2006
111	568143.53	136610.04	81.6	160	299-W11-86	7/31/2006
112	568143.53	136610.04	73.6	68	299-W11-86	8/4/2006
113	568141.08	136608.7	105.0	2200	299-W11-87	11/16/2009
114	567874.67	137113.09	124.8	1100	299-W11-88	11/29/2007
115	567874.67	137113.09	115.0	1100	299-W11-88	11/29/2007
116	567874.67	137113.09	109.6	1600	299-W11-88	12/3/2007
117	567874.67	137113.09	103.5	1700	299-W11-88	12/5/2007
118	567874.67	137113.09	94.3	850	299-W11-88	12/6/2007
119	567874.67	137113.09	88.2	23	299-W11-88	12/11/2007
120	567874.67	137113.09	85.3	570	299-W11-88	2/6/2008
121	567874.67	137113.09	80.1	0.5	299-W11-88	11/16/2009
122	567874.67	137113.09	75.0	450	299-W11-88	2/13/2008
123	567307	136520	127.5	150	299-W11-90	1/13/2010
124	567307	136520	124.5	180	299-W11-90	1/14/2010
125	567307	136520	118.4	890	299-W11-90	1/15/2010
126	567307	136520	112.3	1400	299-W11-90	1/19/2010
127	567307	136520	106.2	1100	299-W11-90	2/12/2010
128	567307	136520	100.1	1900	299-W11-90	2/16/2010
129	567307	136520	94.0	2400	299-W11-90	2/22/2010
130	567307	136520	87.9	2000	299-W11-90	2/23/2010
131	567307	136520	81.8	1900	299-W11-90	3/1/2010
132	567307	136520	75.7	1800	299-W11-90	3/2/2010
133	567307	136520	69.0	1800	299-W11-90	3/4/2010
134	567307	136520	62.6	1500	299-W11-90	3/8/2010
135	567307	136520	57.4	2250	299-W11-90	3/8/2010
136	567776	136778	129.1	84	299-W11-93	10/19/2009
137	567776	136778	123.0	330	299-W11-93	10/20/2009
138	567776	136778	116.9	580	299-W11-93	10/21/2009
139	567776	136778	110.8	1300	299-W11-93	10/22/2009
140	567776	136778	104.7	540	299-W11-93	10/23/2009
141	567776	136778	98.6	2400	299-W11-93	10/26/2009
142	567776	136778	92.5	1400	299-W11-93	10/27/2009
143	567776	136778	86.5	1100	299-W11-93	10/29/2009
144	567776	136778	78.8	57	299-W11-93	11/17/2009
145	567776	136778	74.2	19	299-W11-93	11/18/2009
146	567776	136778	68.1	2	299-W11-93	11/19/2009
147	568331.25	137206.12	133.3	35	299-W12-1	6/22/2009
148	568313	136610	130.1	52	299-W12-2	8/17/2009
149	568313	136610	125.5	52	299-W12-2	8/17/2009
150	568313	136610	123.8	280	299-W12-2	8/18/2009
151	568313	136610	117.6	360	299-W12-2	8/19/2009
152	568313	136610	111.6	930	299-W12-2	8/20/2009
153	568313	136610	105.7	1800	299-W12-2	8/21/2009

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
154	568313	136610	98.7	1300	299-W12-2	8/24/2009
155	568313	136610	91.7	790	299-W12-2	8/26/2009
156	568313	136610	86.3	1100	299-W12-2	8/27/2009
157	568313	136610	79.8	510	299-W12-2	9/1/2009
158	568313	136610	75.5	240	299-W12-2	9/10/2009
159	568313	136610	74.2	190	299-W12-2	9/8/2009
160	568325	137000	129.1	50	299-W12-3	9/18/2009
161	568325	137000	122.7	190	299-W12-3	9/22/2009
162	568325	137000	116.8	510	299-W12-3	9/24/2009
163	568325	137000	109.6	360	299-W12-3	9/29/2009
164	568325	137000	103.8	470	299-W12-3	9/30/2009
165	568325	137000	97.4	200	299-W12-3	10/1/2009
166	568325	137000	91.4	220	299-W12-3	10/2/2009
167	568325	137000	84.6	170	299-W12-3	10/5/2009
168	568325	137000	79.5	240	299-W12-3	10/6/2009
169	568325	137000	72.8	160	299-W12-3	10/8/2009
170	568329	136363	125.6	28	299-W12-4	8/12/2009
171	568329	136363	122.5	28	299-W12-4	8/13/2009
172	568329	136363	116.5	11	299-W12-4	8/20/2009
173	568329	136363	110.4	120	299-W12-4	8/21/2009
174	568329	136363	104.6	360	299-W12-4	9/25/2009
175	568329	136363	99.4	900	299-W12-4	9/28/2009
176	568329	136363	93.1	1100	299-W12-4	9/29/2009
177	568329	136363	86.4	850	299-W12-4	10/2/2009
178	568329	136363	80.5	1200	299-W12-4	10/5/2009
179	568329	136363	73.6	1200	299-W12-4	10/7/2009
180	568329	136363	67.8	1100	299-W12-4	10/9/2009
181	568148.75	136048.59	128.6	119.4668821	299-W13-1	12/3/2003
182	568148.75	136048.59	116.4	344.3457189	299-W13-1	12/4/2003
183	568148.75	136048.59	110.9	557.5121163	299-W13-1	12/5/2003
184	568148.74	136048.6	99.1	1500	299-W13-1	11/16/2009
185	568148.75	136048.59	92.1	2900	299-W13-1	12/12/2003
186	568148.75	136048.59	83.2	1506.219709	299-W13-1	12/19/2003
187	568148.75	136048.59	74.1	1194.668821	299-W13-1	12/20/2003
188	568148.75	136048.59	62.2	309.2084006	299-W13-1	12/22/2003
189	566901.69	136287.63	129.1	26	299-W14-11	4/18/2005
190	566901.69	136287.63	123.0	410	299-W14-11	4/20/2005
191	566901.69	136287.63	116.9	920	299-W14-11	4/20/2005
192	566901.69	136287.63	110.8	690	299-W14-11	4/25/2005
193	566901.69	136287.63	104.7	1200	299-W14-11	4/26/2005
194	566901.69	136287.63	98.6	530	299-W14-11	4/27/2005
195	566872.92	136275.45	133.0	110.00	299-W14-13	8/2/2006
196	566898.39	136181.05	134.0	900	299-W14-14	8/13/2009
197	567001.33	136318.48	132.8	590	299-W14-16	4/27/2009
198	566909	136285	127.8	210	299-W14-20	4/16/2009
199	566909	136285	122.8	370	299-W14-20	6/19/2009
200	566909	136285	115.8	870	299-W14-20	6/24/2009
201	566909	136285	109.7	940	299-W14-20	6/29/2009
202	566909	136285	103.6	680	299-W14-20	7/6/2009
203	566909	136285	97.2	820	299-W14-20	7/9/2009
204	566909	136285	91.2	180	299-W14-20	7/13/2009
205	566909	136285	85.2	35	299-W14-20	7/17/2009
206	566909	136285	79.2	170	299-W14-20	7/21/2009

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
207	566909	136285	70.2	0.5	299-W14-20	07/29/09
208	567721	135887	129.9	5	299-W14-21	9/22/2009
209	567721	135887	124.5	25	299-W14-21	9/23/2009
210	567721	135887	117.7	110	299-W14-21	10/2/2009
211	567721	135887	113.8	130	299-W14-21	10/6/2009
212	567721	135887	105.6	190	299-W14-21	10/7/2009
213	567721	135887	99.1	300	299-W14-21	10/8/2009
214	567721	135887	93.3	380	299-W14-21	10/9/2009
215	567721	135887	87.1	1000	299-W14-21	10/12/2009
216	567721	135887	80.9	990	299-W14-21	10/14/2009
217	567721	135887	74.8	1300	299-W14-21	10/16/2009
218	567721	135887	69.0	880	299-W14-21	10/19/2009
219	567721	135887	61.7	1100	299-W14-21	10/22/2009
220	566899.19	136100.83	133.7	164.00	299-W14-6	1/21/2005
221	567733.43	135567.81	128.7	230.023753	299-W14-71	9/19/2006
222	567733.43	135567.81	120.5	222.0427553	299-W14-71	9/22/2006
223	567733.43	135567.81	112.8	310.6888361	299-W14-71	9/27/2006
224	567733.43	135567.81	106.8	259.3824228	299-W14-71	10/5/2006
225	567733.43	135567.81	97.9	877.9097387	299-W14-71	10/9/2006
226	567733.43	135567.81	91.9	1300.0	299-W14-71	6/3/2009
227	567733.43	135567.81	85.9	863.6579572	299-W14-71	10/13/2006
228	567733.43	135567.81	76.3	533.0166271	299-W14-71	11/29/2006
229	567328.44	135941.28	126.1	86.7	299-W14-72	10/2/2006
230	567328.44	135941.28	121.2	71	299-W14-72	10/4/2006
231	567328.44	135941.28	113.3	52.8	299-W14-72	10/9/2006
232	567328.44	135941.28	107.5	628	299-W14-72	10/11/2006
233	567328.44	135941.28	98.3	731	299-W14-72	10/12/2006
234	567328.44	135941.28	87.9	1000	299-W14-72	6/5/2009
235	567328.44	135941.28	82.5	988	299-W14-72	10/24/2006
236	567359	136204	127.4	170	299-W14-73	4/7/2009
237	567359	136204	121.4	27	299-W14-73	4/10/2009
238	567359	136204	115.4	180	299-W14-73	4/15/2009
239	567359	136204	109.4	140	299-W14-73	4/20/2009
240	567359	136204	103.4	140	299-W14-73	4/22/2009
241	567359	136204	96.4	67	299-W14-73	4/27/2009
242	567359	136204	91.4	110	299-W14-73	4/29/2009
243	567359	136204	84.7	690	299-W14-73	5/4/2009
244	567359	136204	79.2	140	299-W14-73	5/8/2009
245	567359	136204	73.1	420	299-W14-73	05/15/09
246	567359	136204	66.4	90	299-W14-73	05/27/09
247	567781	136383	128.1	610	299-W14-74	8/12/2009
248	567781	136383	125.0	590	299-W14-74	8/14/2009
249	567781	136383	118.6	840	299-W14-74	8/17/2009
250	567781	136383	112.9	1100	299-W14-74	8/18/2009
251	567781	136383	106.8	740	299-W14-74	8/20/2009
252	567781	136383	100.7	620	299-W14-74	8/24/2009
253	567781	136383	94.6	1600	299-W14-74	8/27/2009
254	567781	136383	88.5	1100	299-W14-74	8/28/2009
255	567781	136383	82.4	1200	299-W14-74	8/31/2009
256	567781	136383	76.3	1400	299-W14-74	9/2/2009
257	567781	136383	70.2	1100	299-W14-74	9/3/2009
258	567031.75	135650.69	79.5	258	299-W14-9	2/14/2005
259	566554.31	135942.94	134.6	620	299-W15-1	12/21/2009
260	566554.31	135942.94	133.2	1042	299-W15-1	2/4/2005

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
261	566554.31	135942.94	131.7	1350	299-W15-1	2/7/2005
262	566554.31	135942.94	129.9	1947	299-W15-1	2/7/2005
263	566554.31	135942.94	127.7	3321	299-W15-1	2/8/2005
264	566554.31	135942.94	123.5	4152	299-W15-1	2/8/2005
265	566412.3	136000.72	134.7	1400	299-W15-11	2/25/2010
266	566412.31	136000.72	131.1	2100	299-W15-11	1/26/2005
267	566412.31	136000.72	127.8	2600	299-W15-11	1/27/2005
268	566412.31	136000.72	124.4	2700	299-W15-11	1/27/2005
269	566412.31	136000.72	121.7	3100	299-W15-11	2/1/2005
270	566088.81	135751.5	135.2	1.2	299-W15-15	7/11/2007
271	566309.4	135550	132.6	30	299-W15-152	2/1/2010
272	566309.38	135550.00	121.9	95	299-W15-152	9/19/2005
273	566309.38	135550.00	110.0	190	299-W15-152	9/19/2005
274	566309.38	135550.00	100.3	390	299-W15-152	9/20/2005
275	566278.24	135726.73	135.2	610.00	299-W15-16	1/13/2004
276	566306.89	135718.96	79.5	2.6	299-W15-17	2/10/2010
277	566093.76	136336.24	136.0	39	299-W15-2	11/16/2009
278	566307.89	135926.08	132.1	38	299-W15-224	2/10/2010
279	566657	136109	128.7	2200	299-W15-225	3/9/2009
280	566657	136109	121.8	270	299-W15-225	3/27/2009
281	566657	136109	114.2	2400	299-W15-225	4/21/2009
282	566657	136109	108.1	1500	299-W15-225	4/22/2009
283	566657	136109	102.0	1800	299-W15-225	4/23/2009
284	566657	136109	95.9	1500	299-W15-225	4/24/2009
285	566657	136109	89.8	1100	299-W15-225	4/27/2009
286	566657	136109	83.7	1100	299-W15-225	4/28/2009
287	566657	136109	77.9	850	299-W15-225	4/29/2009
288	566657	136109	62.7	5	299-W15-225	5/8/2009
289	566304.62	135748.94	135.8	94	299-W15-30	2/10/2010
290	566377.11	135856.1	135.4	120	299-W15-31A	8/17/2009
291	566773.43	135635	135.2	1300	299-W15-32	5/6/2008
292	566433.3	135966.7	134.7	950	299-W15-33	5/6/2008
293	566613.41	135960.44	134.0	1800	299-W15-34	2/25/2010
294	566739.26	135853.07	133.6	1700	299-W15-35	2/25/2010
295	566773.9	135429.59	132.0	350	299-W15-36	5/27/2009
296	566716.47	135248.32	132.7	120.0	299-W15-37	3/2/2010
297	566812.92	135672.9	134.3	700	299-W15-38	8/12/2008
298	566790.38	135546.08	134.3	220.00	299-W15-39	8/31/2007
299	566652.5	136204.97	134.0	2100	299-W15-40	2/25/2010
300	566757.59	136031.68	134.0	940	299-W15-41	2/10/2010
301	566581.83	135627.02	130.3	300	299-W15-42	3/5/2009
302	566490.13	136210.03	133.2	890	299-W15-43	2/25/2010
303	566685.02	136066.47	133.6	2400	299-W15-44	12/21/2009
304	566432.94	135961.16	129.1	520	299-W15-45	2/25/2010
305	566752.25	135586.67	133.2	330	299-W15-46	9/14/2004
306	566752.25	135586.67	132.0	1600	299-W15-46	9/28/2004
307	566752.23	135586.67	128.2	580	299-W15-46	2/25/2010
308	566752.25	135586.67	125.1	120	299-W15-46	10/11/2004
309	566752.25	135586.67	122.1	4400	299-W15-46	2/1/2006
310	566752.25	135586.67	121.8	825	299-W15-46	10/12/2004
311	566752.25	135586.67	119.0	3800	299-W15-46	10/14/2004
312	566752.25	135586.67	114.5	2918	299-W15-46	10/19/2004
313	566752.25	135586.67	113.9	2200	299-W15-46	10/19/2004

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
314	566752.25	135586.67	112.8	286	299-W15-46	10/25/2004
315	566752.25	135586.67	112.2	270	299-W15-46	10/25/2004
316	566752.25	135586.67	106.1	110	299-W15-46	10/28/2004
317	566752.25	135586.67	100.1	32	299-W15-46	11/2/2004
318	566752.25	135586.67	100.0	29	299-W15-46	11/2/2004
319	566752.25	135586.67	94.7	258	299-W15-46	11/8/2004
320	566752.25	135586.67	91.7	1300	299-W15-46	11/10/2004
321	566752.25	135586.67	88.6	472	299-W15-46	11/15/2004
322	566752.25	135586.67	87.8	470	299-W15-46	11/15/2004
323	566752.25	135586.67	81.6	8.7	299-W15-46	11/23/2004
324	566752.25	135586.67	75.8	206	299-W15-46	11/30/2004
325	566752.25	135586.67	75.2	190	299-W15-46	11/30/2004
326	566776.45	135642.37	128.0	1100	299-W15-47	2/25/2010
327	566307.2	135972.91	131.9	150	299-W15-49	11/16/2009
328	566793.50	135790.72	127.8	1724.137931	299-W15-50	1/25/2005
329	566793.47	135790.72	123.7	2400	299-W15-50	11/16/2009
330	566793.50	135790.72	120.8	2000	299-W15-50	1/31/2005
331	566793.50	135790.72	115.6	1659.482759	299-W15-50	2/2/2005
332	566793.50	135790.72	105.6	1576.508621	299-W15-50	2/7/2005
333	566793.50	135790.72	99.8	887.9310345	299-W15-50	2/9/2005
334	566801.50	135654.39	133.8	550	299-W15-6	5/19/2005
335	566801.50	135654.39	132.0	1000	299-W15-6	5/19/2005
336	566801.50	135654.39	124.1	1100	299-W15-6	5/23/2005
337	566801.50	135654.39	115.8	1000	299-W15-6	5/23/2005
338	566801.50	135654.39	107.9	1700	299-W15-6	5/23/2005
339	566801.50	135654.39	99.7	2300	299-W15-6	5/24/2005
340	566801.50	135654.39	95.1	1700	299-W15-6	5/25/2005
341	566801.50	135654.39	89.9	834	299-W15-6	11/14/2005
342	566801.50	135654.39	89.3	1478	299-W15-6	11/19/2005
343	566801.51	135654.4	84.9	1700	299-W15-6	2/25/2010
344	566801.50	135654.39	78.3	1003	299-W15-6	11/14/2005
345	566801.50	135654.39	77.7	1266	299-W15-6	11/14/2005
346	566675.88	135920.20	132.6	2358	299-W15-7	2/21/2005
347	566675.88	135920.20	130.8	2601	299-W15-7	2/21/2005
348	566675.88	135920.20	127.1	2665	299-W15-7	2/21/2005
349	566675.88	135920.2	123.2	880	299-W15-7	2/25/2010
350	566675.88	135920.20	117.7	2639	299-W15-7	2/22/2005
351	566675.88	135920.20	112.8	2564	299-W15-7	2/22/2005
352	566809.21	136028.76	133.1	920	299-W15-763	10/20/2009
353	566897.02	136373.06	132.9	2200	299-W15-765	2/25/2010
354	566304.52	135826.24	132.4	41	299-W15-83	3/16/2009
355	566307.58	135640.34	132.6	75	299-W15-94	2/1/2010
356	565310.68	135038.74	134.1	2	299-W17-1	7/31/2009
357	565310.69	135038.73	120.2	1	299-W17-1	11/17/2003
358	565310.69	135038.73	112.3	1	299-W17-1	11/18/2003
359	565310.69	135038.73	106.1	1	299-W17-1	11/19/2003
360	566925.96	135324.9	130.5	48	299-W17-3	3/19/2010
361	566925.96	135324.9	125.3	160	299-W17-3	3/23/2010
362	566925.96	135324.9	118.9	170	299-W17-3	3/24/2010
363	566925.96	135324.9	112.8	160	299-W17-3	3/25/2010
364	566925.96	135324.9	106.4	200	299-W17-3	3/26/2010
365	566925.96	135324.9	100.3	150	299-W17-3	3/31/2010
366	566925.96	135324.9	93.9	200	299-W17-3	04/02/10
367	566926	135325	87.8	230	299-W17-3	04/07/10

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
368	566925.96	135324.9	81.7	150	299-W17-3	04/12/10
369	566925.96	135324.9	75.6	63	299-W17-3	04/15/10
370	566925.96	135324.9	69.5	63	299-W17-3	04/16/10
371	566926	135325	55.8	2.5	299-W17-3	04/20/10
372	566421.50	135465.20	134.8	160	299-W18-1	5/16/2005
373	566421.50	135465.20	132.4	250	299-W18-1	5/17/2005
374	566421.50	135465.20	125.0	84	299-W18-1	5/17/2005
375	566421.50	135465.20	117.1	89	299-W18-1	5/17/2005
376	566421.52	135465.21	113.8	50	299-W18-1	11/19/2009
377	566421.50	135465.20	108.9	57	299-W18-1	5/18/2005
378	566421.50	135465.20	101.0	57	299-W18-1	5/18/2005
379	566421.50	135465.20	97.3	56	299-W18-1	5/18/2005
380	566380.03	134733.48	130.7	110.0	299-W18-15	7/31/2009
381	566605.05	135425.69	131.8	240	299-W18-16	11/19/2009
382	566605.06	135425.69	119.5	222	299-W18-16	12/1/2004
383	566605.06	135425.69	108.8	137	299-W18-16	12/9/2004
384	566605.06	135425.69	108.5	850	299-W18-16	12/9/2004
385	566605.06	135425.69	104.3	2.6	299-W18-16	12/15/2004
386	566097.7	134978.69	136.9	2.3	299-W18-21	2/10/2010
387	566088.63	134990.16	73.2	0.0	299-W18-22	2/10/2010
388	566084.53	135342.44	137.0	0.021	299-W18-23	4/22/2008
389	566342.07	135339.44	135.2	6.60	299-W18-24	8/22/2002
390	566061.43	135219.67	135.2	4.60	299-W18-27	1/15/2003
391	566870.76	135193.62	136.0	200.0	299-W18-30	7/23/2009
392	566692.75	135068.31	134.6	97.00	299-W18-31	2/13/2003
393	566694.53	134804.27	134.4	78.00	299-W18-33	9/2/2005
394	566276.8	135408.91	132.7	11.00	299-W18-4	8/21/2002
395	566694.5	134989.55	130.9	160.00	299-W18-40	2/26/2003
396	567939.14	135014.07	129.6	120.0	299-W19-101	3/2/2010
397	567939.14	135014.07	106.7	69	299-W19-101	8/22/2005
398	567939.14	135014.07	97.6	120	299-W19-101	8/23/2005
399	568007.74	135206.88	129.0	118	299-W19-104	3/28/2006
400	568007.74	135206.88	125.1	156	299-W19-104	3/29/2006
401	567565.15	134745.44	129.8	120.0	299-W19-105	3/2/2010
402	567565.13	134745.44	118.5	24	299-W19-105	1/12/2006
403	567565.13	134745.44	109.3	19	299-W19-105	1/13/2006
404	567565.13	134745.44	97.1	1	299-W19-105	1/16/2006
405	567997.87	135205.66	120.5	200.0	299-W19-107	3/2/2010
406	567997.89	135205.66	106.9	212	299-W19-107	4/5/2006
407	567997.89	135205.66	94.7	115	299-W19-107	4/7/2006
408	567997.89	135205.66	86.5	20.6	299-W19-107	4/10/2006
409	566868.33	135052.59	129.5	120.00	299-W19-12	2/13/2003
410	567360.65	135012.36	125.9	63.0	299-W19-18	3/2/2010
411	567873.94	134901.08	133.1	39	299-W19-20	8/22/2002
412	567665.88	134924.47	133.1	1	299-W19-30	1/17/2001
413	567673.64	135012.25	113.3	130.0	299-W19-34A	8/3/2009
414	567662.88	135010.65	87.6	190.0	299-W19-34B	8/22/2008
415	567992.1	135015.16	133.8	40.0	299-W19-35	12/3/2009
416	567634.74	135017.05	133.8	270.0	299-W19-36	8/3/2009
417	567723.85	134950.35	134.3	30.0	299-W19-37	3/19/2008
418	567872.89	134879.89	131.5	68.00	299-W19-39	2/22/2007
419	567949.93	135350.79	98.3	100.0	299-W19-4	9/13/2009
420	567945.01	134840.53	133.1	9.00	299-W19-40	1/25/2006
421	566867.73	134997.65	133.4	77.00	299-W19-41	2/19/2003

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GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
422	566868.01	135116.03	133.0	180.00	299-W19-42	3/12/2003
423	567699.15	135004.02	131.4	130.0	299-W19-43	8/3/2009
424	566868.15	135035.11	131.1	55.00	299-W19-44	2/19/2003
425	566868.85	135080.79	132.0	550.00	299-W19-45	2/18/2003
426	567782.67	134842.46	131.0	70.0	299-W19-46	3/2/2010
427	567782.69	134842.45	121.9	98	299-W19-46	11/20/2002
428	567782.69	134842.45	109.8	46	299-W19-46	11/20/2002
429	567782.69	134842.45	103.7	0.075	299-W19-46	11/21/2002
430	567782.69	134842.45	98.2	75	299-W19-46	11/21/2002
431	567822.93	134925.99	127.6	120.0	299-W19-48	3/2/2010
432	567822.94	134925.98	123.7	37	299-W19-48	11/30/2004
433	567822.94	134925.98	120.7	72	299-W19-48	12/9/2004
434	567822.94	134925.98	107.0	87	299-W19-48	12/9/2004
435	567822.94	134925.98	89.6	100	299-W19-48	12/14/2004
436	567822.94	134925.98	82.9	40	299-W19-48	12/16/2004
437	567568.04	134894.38	129.8	270.0	299-W19-49	3/19/2010
438	567568.06	134894.38	116.5	130	299-W19-49	9/1/2005
439	567568.06	134894.38	106.7	120	299-W19-49	9/2/2005
440	567568.06	134894.38	97.6	100	299-W19-49	9/6/2005
441	567939.25	135011.84	128.4	35	299-W19-50	8/8/2005
442	567939.25	135011.84	122.3	89	299-W19-50	8/9/2005
443	567939.25	135011.84	115.6	120	299-W19-50	8/11/2005
444	568124.39	134573.79	130.2	26.0	299-W21-2	12/3/2009
445	568124.38	134573.80	127.3	16	299-W21-2	11/29/2004
446	568124.38	134573.80	119.9	6.5	299-W21-2	11/29/2004
447	568124.38	134573.80	112.3	6.4	299-W21-2	12/1/2004
448	568124.38	134573.80	107.8	13	299-W21-2	12/2/2004
449	568124.38	134573.80	101.7	16	299-W21-2	12/6/2004
450	568124.38	134573.80	98.0	13	299-W21-2	12/7/2004
451	567593.09	133879.25	130.3	0.5	299-W22-20	8/26/2009
452	567205.19	134465.23	132.5	41.0	299-W22-26	3/26/2009
453	566945.16	134292.51	134.4	42.0	299-W22-45	3/11/2009
454	566875.05	134121.02	134.4	13.00	299-W22-46	3/18/2003
455	566908.75	134076.28	130.1	62.00	299-W22-47	12/14/2005
456	566908.75	134076.28	123.5	145	299-W22-47	1/12/2005
457	566908.75	134076.28	117.8	90	299-W22-47	1/13/2005
458	566908.75	134076.28	111.7	3.4	299-W22-47	1/19/2005
459	566908.75	134076.28	105.6	5.2	299-W22-47	1/20/2005
460	566908.75	134076.28	99.5	3.9	299-W22-47	1/21/2005
461	566996.64	134425.1	134.4	18.0	299-W22-48	12/1/2009
462	566904.38	134201.63	134.4	81.0	299-W22-49	12/1/2009
463	566904.25	134139.75	133.7	20.00	299-W22-50	10/9/2000
464	566904.25	134139.75	130.7	5.6	299-W22-50	11/29/1999
465	566904.25	134139.75	125.5	0.94	299-W22-50	12/14/1999
466	566904.25	134139.75	108.7	1.5	299-W22-50	12/15/1999
467	566904.25	134139.75	84.4	5.6	299-W22-50	12/17/1999
468	566904.25	134139.75	69.7	0.89	299-W22-50	12/22/1999
469	566904.25	134139.75	38.0	0.23	299-W22-50	1/1/1999
470	567179.6	134347.83	130.1	11.0	299-W22-69	3/25/2009
471	567179.60	134347.83	118.9	1	299-W22-69	2/1/2006
472	567179.60	134347.83	110.8	1	299-W22-69	2/2/2006
473	567179.60	134347.83	92.4	11	299-W22-69	2/8/2006
474	567237.37	134207.08	130.5	12.0	299-W22-72	12/2/2009
475	567237.37	134207.08	125.0	1	299-W22-72	2/23/2006

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GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
476	567237.37	134207.08	119.0	1	299-W22-72	2/24/2006
477	567237.37	134207.08	112.9	1	299-W22-72	2/27/2006
478	567237.37	134207.08	109.8	4.4	299-W22-72	2/28/2006
479	567237.37	134207.08	98.3	7.1	299-W22-72	2/28/2006
480	567009.08	134092.55	132.7	93.0	299-W22-83	12/2/2009
481	567186.74	134041.31	130.5	70.0	299-W22-86	12/2/2009
482	567186.74	134041.31	124.3	15	299-W22-86	3/14/2006
483	567186.74	134041.31	117.3	1	299-W22-86	3/14/2006
484	567186.74	134041.31	115.8	1	299-W22-86	3/15/2006
485	567186.74	134041.31	111.2	1	299-W22-86	3/14/2006
486	567186.74	134041.31	108.2	1	299-W22-86	3/15/2006
487	567186.74	134041.31	99.0	2.5	299-W22-86	3/16/2006
488	567541.75	134539.88	130.4	12.0	299-W22-87	8/26/2009
489	567541.75	134539.88	119.8	6.4	299-W22-87	12/21/2005
490	567541.75	134539.88	110.7	1	299-W22-87	12/22/2005
491	567541.75	134539.88	95.5	1	299-W22-87	12/27/2005
492	568046.48	134390.53	129.0	6.4	299-W22-88	3/3/2009
493	568046.48	134390.53	120.3	9.8	299-W22-88	2/15/2008
494	568046.48	134390.53	108.1	14.0	299-W22-88	2/20/2008
495	568046.48	134390.53	98.1	22.0	299-W22-88	2/27/2008
496	568046.48	134390.53	80.4	8.8	299-W22-88	2/28/2008
497	566570.38	134256.33	134.6	41.00	299-W23-10	2/27/2006
498	566794	134127.23	135.1	130.0	299-W23-15	9/13/2009
499	566707.74	134293.99	132.9	140.0	299-W23-21	3/19/2010
500	566628.19	134391.88	134.6	23	299-W23-4	6/21/2006
501	566628.19	134391.88	133.8	211	299-W23-4	11/12/2005
502	566628.22	134391.88	129.9	150.0	299-W23-4	3/2/2010
503	566628.19	134391.88	127.7	232	299-W23-4	11/21/2005
504	566613.2	134267.8	132.6	12.00	299-W23-9	9/18/2007
505	566424.39	133293.6	132.8	4.6	299-W26-13	6/22/2009
506	566682.69	133539.21	132.0	4.2	299-W26-14	6/17/2009
507	566296.68	133235.65	134.4	0.075	299-W26-7	6/12/2003
508	566908.27	133670.35	82.1	6.9	299-W27-2	1/6/2009
509	567384.51	137446.07	133.1	200.00	299-W6-10	9/1/2005
510	567089.37	137292.15	85.9	1.10	299-W6-3	7/17/2002
511	567289.92	137631.73	86.2	0.68	299-W6-6	1/22/2002
512	567282.48	137631.81	133.1	33.00	299-W6-7	4/16/2002
513	566012.05	137629.31	135.6	0.045	299-W7-12	9/23/2005
514	566292.03	137638.64	66.1	0.5	299-W7-3	3/26/2009
515	566380	137301.27	134.0	81.00	299-W7-4	9/24/2007
516	566447.25	137628.7	135.2	0.53	299-W7-5	3/17/2005
517	566537.97	137629.08	134.6	0.075	299-W7-7	9/9/2003
518	566732.6	137629.67	134.6	0.165	299-W7-8	3/13/2002
519	565749.42	137646.64	135.7	1.1	299-W8-1	6/5/2009
520	569990.98	132739.19	91.6	0.5	699-30-66	12/2/2009
521	567942.68	133362.61	66.7	0.5	699-32-72A	4/6/2009
522	566683.94	133137.73	130.2	0.5	699-32-76	3/3/2010
523	566683.01	133138.74	118.7	0.5	699-32-76	12/11/2007
524	566683.01	133138.74	110.6	0.5	699-32-76	12/12/2007
525	566683.01	133138.74	97.5	0.5	699-32-76	12/14/2007
526	567472.65	133552.16	129.8	11.0	699-33-74	3/3/2010
527	567472.65	133552.16	127.5	6.1	699-33-74	3/18/2008
528	567472.65	133552.16	118.3	2.0	699-33-74	3/18/2008
529	567472.65	133552.16	109.2	0.5	699-33-74	3/21/2008

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
530	567472.65	133552.16	97.0	2.1	699-33-74	3/24/2008
531	566907.78	133662.48	130.4	26.0	699-33-75	3/3/2010
532	566907.78	133662.48	123.5	43.0	699-33-75	1/17/2008
533	566907.78	133662.48	113.8	35.0	699-33-75	1/18/2008
534	566907.78	133662.48	101.9	12.0	699-33-75	1/22/2008
535	566621.21	133600.43	130.9	4.3	699-33-76	3/3/2010
536	566621.21	133600.43	120.7	3.6	699-33-76	3/4/2008
537	566621.21	133600.43	111.6	3.5	699-33-76	3/5/2008
538	566621.21	133600.43	99.6	6.8	699-33-76	3/6/2008
539	567859.97	133785.33	129.2	1.1	699-34-72	3/3/2010
540	567859.97	133785.33	118.5	0.5	699-34-72	2/29/2008
541	567859.97	133785.33	105.9	1.4	699-34-72	3/4/2008
542	567859.97	133785.33	93.6	3.4	699-34-72	3/5/2008
543	567859.97	133785.33	79.0	0.5	699-34-72	3/10/2008
544	569857.86	134099.24	133.8	2.0	699-35-66A	8/28/2009
545	568566.48	133987.58	135.2	2.2	699-35-70	3/16/2008
546	566063.59	134271.27	132.0	8.4	699-35-78A	9/20/2009
547	569731.34	134469.01	126.4	2.0	699-36-66B	9/30/2008
548	569250.58	134418.18	131.0	6	699-36-67	9/6/2007
549	568466.68	134308.84	132.2	6.0	699-36-70A	8/28/2009
550	568427.79	134625.98	129.4	12.0	699-36-70B	11/23/2009
551	568427.81	134625.98	121.5	1.1	699-36-70B	9/1/2004
552	568427.81	134625.98	110.9	0.5	699-36-70B	9/9/2004
553	568427.81	134625.98	100.2	8.5	699-36-70B	9/14/2004
554	568427.81	134625.98	86.5	0.5	699-36-70B	9/23/2004
555	569730.32	134797.15	126.0	0.5	699-37-66	9/30/2008
556	569244.75	134622.65	128.2	8	699-37-68	9/6/2007
557	570061.23	135032.99	117.9	0.49	699-38-65	3/21/2002
558	569180.31	134931.6	132.0	9.7	699-38-68A	8/14/2009
559	568472.06	135082.34	120.9	20.00	699-38-70	7/2/2007
560	568469.13	135331.05	126.1	64	699-38-70B	2/4/2004
561	568469.13	135331.05	115.8	309	699-38-70B	2/5/2004
562	568469.13	135331.05	107.8	311	699-38-70B	2/6/2004
563	568469.1	135331.04	96.3	560.0	699-38-70B	11/23/2009
564	568469.13	135331.05	88.0	428	699-38-70B	2/11/2004
565	568469.13	135331.05	76.0	14	699-38-70B	2/27/2004
566	569084.13	135325.58	125.7	25	699-38-70C	2/18/2004
567	569084.13	135325.58	114.7	28	699-38-70C	2/19/2004
568	569084.11	135325.58	103.8	22.0	699-38-70C	11/23/2009
569	569084.13	135325.58	98.5	31	699-38-70C	2/20/2004
570	565862.15	135404.99	131.8	0.075	699-39-79	1/16/2003
571	571164.26	135764.42	120.9	0.5	699-40-62	8/14/2009
572	570057.5	135881.16	120.9	1	699-40-65	12/18/2003
573	570057.5	135881.16	90.1	1	699-40-65	12/31/2003
574	568967.03	136488.48	124.7	5	699-43-69	3/12/2008
575	568967.03	136488.48	118.6	0.5	699-43-69	3/14/2008
576	568967.03	136488.48	116.5	0.5	699-43-69	3/18/2008
577	568967.03	136488.48	102.4	240	699-43-69	3/26/2008
578	568967.03	136488.48	100.0	260	699-43-69	11/23/2009
579	568967.03	136488.48	95.1	150	699-43-69	4/1/2008
580	568967.03	136488.48	88.7	140	699-43-69	4/2/2008
581	568967.03	136488.48	81.4	72	699-43-69	4/4/2008
582	568967.03	136488.48	74.7	53	699-43-69	4/9/2008
583	570390.65	136897.43	106.7	8.1	699-44-64	5/8/2009

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Sample Elevation (m amsl)	CTET Concentration (µg/L)	Sample Location	Sample Date
584	568729.3	137182.68	124.6	6	699-45-69A	2/10/2009
585	568947.12	137233.81	124.7	2.4	699-45-69C	8/10/2007
586	568947.12	137233.81	122.3	1.6	699-45-69C	8/15/2007
587	568947.12	137233.81	108.4	37	699-45-69C	11/23/2009
588	568947.12	137233.81	102.8	15	699-45-69C	9/6/2007
589	568947.12	137233.81	90.9	0.5	699-45-69C	9/12/2007
590	568947.12	137233.81	83.6	1	699-45-69C	10/1/2007
591	571474.38	137968.73	118.5	0.5	699-47-60	4/29/2009
592	568387.91	138056.94	128.4	93	699-48-71	1/7/2010
593	566413.23	137968.86	135.8	1.3	699-48-77A	10/26/2009
594	566468.95	138086.8	114.4	0.5	699-48-77C	10/26/2009
595	566433.3	138119.27	133.1	0.5	699-48-77D	10/26/2009
596	565771.12	138271.11	130.0	0.5	699-49-79	2/4/2009
597	567359.50	138646.73	132.1	0.5	699-50-74	7/14/2005
598	567359.52	138646.73	128.0	0.5	699-50-74	9/20/2009
599	567359.50	138646.73	122.0	0.5	699-50-74	7/15/2005
600	567359.50	138646.73	115.6	0.5	699-50-74	7/18/2005
601	567359.50	138646.73	106.8	0.5	699-50-74	7/19/2005
602	567359.50	138646.73	97.3	0.5	699-50-74	7/21/2005
603	564130.2	138669.32	99.9	0.5	699-50-85	5/8/2009
604	566978.08	138906.29	111.2	0.5	699-51-75	2/4/2009
605	566951.59	135806.14	129.4	20	299-W17-2	04/01/10
606	566951.59	135806.14	123.6	160	299-W17-2	04/01/10
607	566951.59	135806.14	117.2	120	299-W17-2	04/06/10
608	566951.59	135806.14	110.2	950	299-W17-2	04/08/10
609	566951.59	135806.14	104.1	2500	299-W17-2	04/09/10
610	566951.59	135806.14	98.3	1900	299-W17-2	04/15/10
611	566951.59	135806.14	92.2	2100	299-W17-2	04/16/10
612	566951.59	135806.14	86.1	1400	299-W17-2	04/19/10
613	566951.59	135806.14	80.6	1800	299-W17-2	04/21/10
614	566951.59	135806.14	63.1	2.5	299-W17-2	04/26/10

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
615	566885.4	136798.8	53.4	0	299-W10-24	Basalt
616	566663.1	136734.6	140.4	0	299-W10-1	WT
617	565998.7	136599.9	65.6	0	299-W10-13	Mud Bot
618	565998.7	136599.9	76.5	0	299-W10-13	Mud Top
619	566017.2	136608.9	47.9	0	299-W10-14	Basalt
620	566017.2	136608.9	141.6	0	299-W10-14	WT
621	566584.0	137154.7	56.3	0	299-W10-21	Basalt
622	566584.0	137154.7	140.0	0	299-W10-21	WT
623	566823.7	136815.3	140.2	0	299-W10-23	WT
624	566885.4	136798.8	140.1	0	299-W10-24	WT
625	566083.0	136828.7	53.8	0	299-W10-29	Basalt
626	566083.0	136828.7	67.7	0	299-W10-29	Mud Bot
627	566083.0	136828.7	78.2	0	299-W10-29	Mud Top
628	566082.8	136739.3	66.8	0	299-W10-30	Mud Bot
629	566082.8	136739.3	77.8	0	299-W10-30	Mud Top
630	566266.4	136968.3	141.2	0	299-W10-31	WT
631	566772.8	136610.2	50.0	0	299-W10-33	Basalt
632	566772.8	136610.2	73.7	0	299-W10-33	Mud Bot
633	566772.8	136610.2	140.2	0	299-W10-33	WT
634	566578.6	136474.8	49.4	0	299-W10-5	Basalt
635	566848.8	136811.2	140.2	0	299-W10-8	WT
636	568147.5	136610.0	138.5	0	299-W11-10	WT
637	566927.1	136604.0	140.1	0	299-W11-12	WT
638	567457.9	136914.0	139.4	0	299-W11-14	WT
639	566912.3	136774.8	85.1	0	299-W11-25B	Mud Top
640	566912.3	136774.8	140.1	0	299-W11-25B	WT
641	567016.3	136556.8	50.6	0	299-W11-26	Basalt
642	567641.7	136663.9	56.2	0	299-W11-3	Basalt
643	567641.7	136663.9	139.3	0	299-W11-3	WT
644	567187.7	136849.2	58.9	0	299-W11-34P	Basalt
645	567635.2	137018.0	139.1	0	299-W11-37	WT
646	566935.5	136677.8	140.1	0	299-W11-41	WT
647	566920.4	136745.7	140.1	0	299-W11-42	WT
648	567269.8	136971.0	58.9	0	299-W11-43	Basalt
649	567269.8	136971.0	139.7	0	299-W11-43	WT
650	566992.8	136775.6	77.8	0	299-W11-45	Mud Top
651	566992.8	136775.6	140.0	0	299-W11-45	WT
652	566933.8	136680.7	76.8	0	299-W11-47	Mud Top
653	566933.8	136680.7	140.1	0	299-W11-47	WT
654	566882.0	136846.2	83.0	0	299-W11-48	Mud Top
655	566882.0	136846.2	140.1	0	299-W11-48	WT
656	567361.7	135924.6	77.0	0	299-W11-49	Mud Bot
657	567361.7	135924.6	79.1	0	299-W11-49	Mud Top
658	567361.7	135924.6	131.6	0	299-W11-49	WT
659	567481.6	136492.8	54.5	0	299-W11-6	Basalt
660	567260.9	136675.3	55.9	0	299-W11-7	Basalt
661	567260.9	136675.3	139.8	0	299-W11-7	WT
662	568143.5	136610.0	70.4	0	299-W11-86	Basalt
663	568143.5	136610.0	64.0	0	299-W11-86	Below Basalt
664	568143.5	136610.0	138.6	0	299-W11-86	WT

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
665	567874.7	137113.1	62.5	0	299-W11-88	Basalt
666	567874.7	137113.1	56.0	0	299-W11-88	Below Basalt
667	567874.7	137113.1	138.8	0	299-W11-88	WT
668	567306.7	136519.6	54.0	0	299-W11-90	Basalt
669	567306.7	136519.6	138.6	0	299-W11-90	WT
670	567776.4	136778.0	60.8	0	299-W11-93	Basalt
671	567776.4	136778.0	54.0	0	299-W11-93	Below Basalt
672	567776.4	136778.0	137.1	0	299-W11-96	WT
673	568313.0	136610.0	71.6	0	299-W12-2	Basalt
674	568313.0	136610.0	65.0	0	299-W12-2	Below Basalt
675	568313.0	136610.0	59.0	0	299-W12-2	Below Basalt
676	568313.0	136610.0	137.4	0	299-W12-2	WT
677	568324.8	137000.0	69.0	0	299-W12-3	Basalt
678	568324.8	137000.0	63.0	0	299-W12-3	Below Basalt
679	568324.8	137000.0	57.0	0	299-W12-3	Below Basalt
680	568324.8	137000.0	137.2	0	299-W12-3	WT
681	568329.0	136363.4	64.3	0	299-W12-4	Basalt
682	568329.0	136363.4	58.0	0	299-W12-4	Below Basalt
683	568329.0	136363.4	52.0	0	299-W12-4	Below Basalt
684	568329.0	136363.4	137.6	0	299-W12-4	WT
685	568148.8	136048.6	58.1	0	299-W13-1	Basalt
686	568148.8	136048.6	52.0	0	299-W13-1	Below Basalt
687	568148.8	136048.6	138.7	0	299-W13-1	WT
688	566901.7	136287.6	140.0	0	299-W14-11	WT
689	566898.4	136181.0	45.7	0	299-W14-14	Basalt
690	566898.4	136181.0	140.0	0	299-W14-14	WT
691	566909.2	136284.6	73.1	0	299-W14-20	Mud Bot
692	566909.2	136284.6	76.4	0	299-W14-20	Mud Top
693	566909.2	136284.6	138.8	0	299-W14-20	WT
694	567721.4	135886.8	55.6	0	299-W14-21	Basalt
695	567721.4	135886.8	139.2	0	299-W14-21	WT
696	566899.2	136100.8	139.8	0	299-W14-6	WT
697	567733.4	135567.8	63.0	0	299-W14-71	Basalt
698	567733.4	135567.8	57.0	0	299-W14-71	Below Basalt
699	567733.4	135567.8	79.0	0	299-W14-71	Mud Bot
700	567733.4	135567.8	82.2	0	299-W14-71	Mud Top
701	567733.4	135567.8	139.4	0	299-W14-71	WT
702	567328.4	135941.3	54.0	0	299-W14-72	Basalt
703	567328.4	135941.3	75.3	0	299-W14-72	Mud Bot
704	567328.4	135941.3	78.9	0	299-W14-72	Mud Top
705	567328.4	135941.3	139.7	0	299-W14-72	WT
706	567359.1	136204.2	54.3	0	299-W14-73	Basalt
707	567359.1	136204.2	138.4	0	299-W14-73	WT
708	567780.9	136383.0	55.6	0	299-W14-74	Basalt
709	567780.9	136383.0	49.0	0	299-W14-74	Below Basalt
710	567780.9	136383.0	137.3	0	299-W14-74	WT
711	567031.8	135650.7	48.0	0	299-W14-9	Basalt
712	567031.8	135650.7	64.2	0	299-W14-9	Mud Bot
713	567031.8	135650.7	72.5	0	299-W14-9	Mud Top
714	567031.8	135650.7	139.7	0	299-W14-9	WT
715	566554.3	135942.9	45.9	0	299-W15-1	Basalt
716	566554.3	135942.9	140.1	0	299-W15-1	WT
717	566412.3	136000.7	42.1	0	299-W15-11	Basalt
718	566412.0	136000.0	63.7	0	299-W15-11	Mud Bot
719	566412.0	136000.0	74.1	0	299-W15-11	Mud Top
720	566412.3	136000.7	140.2	0	299-W15-11	WT
721	566088.8	135751.5	142.4	0	299-W15-15	WT
722	566309.4	135550.0	41.2	0	299-W15-152	Basalt
723	566309.4	135550.0	60.0	0	299-W15-152	Mud Bot

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
724	566309.4	135550.0	71.8	0	299-W15-152	Mud Top
725	566309.4	135550.0	141.5	0	299-W15-152	WT
726	566306.9	135719.0	41.3	0	299-W15-17	Basalt
727	566306.9	135719.0	61.6	0	299-W15-17	Mud Bot
728	566306.9	135719.0	73.1	0	299-W15-17	Mud Top
729	566306.9	135719.0	141.3	0	299-W15-17	WT
730	566093.8	136336.2	45.8	0	299-W15-2	Basalt
731	566093.8	136336.2	63.8	0	299-W15-2	Mud Bot
732	566093.8	136336.2	72.6	0	299-W15-2	Mud Top
733	566093.8	136336.2	141.5	0	299-W15-2	WT
734	566657.3	136108.9	65.7	0	299-W15-225	Mud Bot
735	566657.3	136108.9	75.4	0	299-W15-225	Mud Top
736	566657.3	136108.9	138.4	0	299-W15-225	WT
737	566304.6	135748.9	141.3	0	299-W15-30	WT
738	566377.1	135856.1	140.9	0	299-W15-31A	WT
739	566613.4	135960.4	139.5	0	299-W15-34	WT
740	566739.3	135853.1	139.5	0	299-W15-35	WT
741	566773.9	135429.6	140.0	0	299-W15-36	WT
742	566716.5	135248.3	140.9	0	299-W15-37	WT
743	566652.5	136205.0	45.3	0	299-W15-40	Basalt
744	566652.5	136205.0	139.5	0	299-W15-40	WT
745	566757.6	136031.7	65.7	0	299-W15-41	Mud Bot
746	566757.6	136031.7	74.9	0	299-W15-41	Mud Top
747	566581.8	135627.0	48.0	0	299-W15-42	Basalt
748	566581.8	135627.0	140.7	0	299-W15-42	WT
749	566490.1	136210.0	45.3	0	299-W15-43	Basalt
750	566490.1	136210.0	66.3	0	299-W15-43	Mud Bot
751	566490.1	136210.0	74.7	0	299-W15-43	Mud Top
752	566490.1	136210.0	140.0	0	299-W15-43	WT
753	566685.0	136066.5	139.5	0	299-W15-44	WT
754	566432.9	135961.2	140.1	0	299-W15-45	WT
755	566723.4	135579.8	45.9	0	299-W15-46	Basalt
756	566723.4	135579.8	63.3	0	299-W15-46	Mud Bot
757	566723.4	135579.8	72.2	0	299-W15-46	Mud Top
758	566752.3	135586.7	140.1	0	299-W15-46	WT
759	566776.5	135642.4	139.5	0	299-W15-47	WT
760	566307.2	135972.9	141.1	0	299-W15-49	WT
761	566706.2	135504.9	46.0	0	299-W15-5	Basalt
762	566706.2	135504.9	62.3	0	299-W15-5	Mud Bot
763	566706.2	135504.9	70.8	0	299-W15-5	Mud Top
764	566793.5	135790.7	139.7	0	299-W15-50	WT
765	566801.5	135654.4	45.8	0	299-W15-6	Basalt
766	566801.5	135654.4	64.5	0	299-W15-6	Mud Bot
767	566801.5	135654.4	72.2	0	299-W15-6	Mud Top
768	566801.5	135654.4	139.5	0	299-W15-6	WT
769	566675.9	135920.2	139.6	0	299-W15-7	WT
770	566809.2	136028.8	65.9	0	299-W15-763	Mud Bot
771	566809.2	136028.8	75.2	0	299-W15-763	Mud Top
772	566697.0	136373.1	72.3	0	299-W15-765	Mud Bot
773	566697.0	136373.1	75.9	0	299-W15-765	Mud Top
774	566697.0	136373.1	140.0	0	299-W15-765	WT
775	565310.7	135038.7	25.0	0	299-W17-1	Basalt
776	565310.7	135038.7	54.4	0	299-W17-1	Mud Bot
777	565310.7	135038.7	72.5	0	299-W17-1	Mud Top
778	565310.7	135038.7	142.9	0	299-W17-1	WT
779	566951.6	135806.1	47.3	0	299-W17-2	Basalt
780	566951.6	135806.1	66.8	0	299-W17-2	Mud Bot
781	566951.6	135806.1	73.1	0	299-W17-2	Mud Top
782	566951.6	135806.1	73.2	0	299-W17-2	Mud Top

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
783	566951.6	135806.1	139.0	0	299-W17-2	WT
784	566926.0	135324.9	44.5	0	299-W17-3	Basalt
785	566926.0	135324.9	59.1	0	299-W17-3	Mud Bot
786	566926.0	135324.9	66.5	0	299-W17-3	Mud Top
787	566926.0	135324.9	139.4	0	299-W17-3	WT
788	566421.5	135465.2	42.0	0	299-W18-1	Basalt
789	566421.5	135465.2	60.4	0	299-W18-1	Mud Bot
790	566421.5	135465.2	71.8	0	299-W18-1	Mud Top
791	566421.5	135465.2	141.3	0	299-W18-1	WT
792	566380.0	134733.5	37.1	0	299-W18-15	Basalt
793	566380.0	134733.5	56.8	0	299-W18-15	Mud Bot
794	566380.0	134733.5	67.5	0	299-W18-15	Mud Top
795	566380.0	134733.5	141.5	0	299-W18-15	WT
796	566605.1	135425.7	45.0	0	299-W18-16	Basalt
797	566605.1	135425.7	61.4	0	299-W18-16	Mud Bot
798	566605.1	135425.7	68.6	0	299-W18-16	Mud Top
799	566605.1	135425.7	141.0	0	299-W18-16	WT
800	566097.7	134978.7	141.5	0	299-W18-21	WT
801	566088.6	134990.2	36.4	0	299-W18-22	Basalt
802	566061.4	135219.7	36.7	0	299-W18-27	Basalt
803	566061.4	135219.7	58.6	0	299-W18-27	Mud Bot
804	566061.4	135219.7	69.8	0	299-W18-27	Mud Top
805	566694.5	134804.3	40.0	0	299-W18-33	Basalt
806	566694.5	134804.3	57.4	0	299-W18-33	Mud Bot
807	566694.5	134804.3	66.5	0	299-W18-33	Mud Top
808	566694.5	134804.3	140.0	0	299-W18-33	WT
809	566694.5	134989.6	40.9	0	299-W18-40	Basalt
810	566694.5	134989.6	58.0	0	299-W18-40	Mud Bot
811	566694.5	134989.6	65.7	0	299-W18-40	Mud Top
812	567939.1	135014.1	139.1	0	299-W19-101	WT
813	568007.7	135206.9	139.1	0	299-W19-104	WT
814	567565.2	134745.4	70.8	0	299-W19-105	Mud Bot
815	567565.2	134745.4	77.2	0	299-W19-105	Mud Top
816	567565.2	134745.4	139.5	0	299-W19-105	WT
817	567997.9	135205.7	62.0	0	299-W19-107	Basalt
818	567997.9	135205.7	56.0	0	299-W19-107	Below Basalt
819	567997.9	135205.7	76.6	0	299-W19-107	Mud Bot
820	567997.9	135205.7	82.4	0	299-W19-107	Mud Top
821	567997.9	135205.7	139.1	0	299-W19-107	WT
822	567360.6	135012.4	48.4	0	299-W19-18	Basalt
823	567360.6	135012.4	67.6	0	299-W19-18	Mud Bot
824	567360.6	135012.4	74.0	0	299-W19-18	Mud Top
825	567360.6	135012.4	139.0	0	299-W19-18	WT
826	567662.9	135010.7	54.3	0	299-W19-34B	Basalt
827	567662.9	135010.7	71.8	0	299-W19-34B	Mud Bot
828	567662.9	135010.7	78.2	0	299-W19-34B	Mud Top
829	566868.0	135116.0	42.7	0	299-W19-42	Basalt
830	566868.0	135116.0	58.6	0	299-W19-42	Mud Bot
831	566868.0	135116.0	66.3	0	299-W19-42	Mud Top
832	567782.7	134842.5	139.3	0	299-W19-46	WT
833	567822.9	134926.0	58.7	0	299-W19-48	Basalt
834	567822.9	134926.0	52.0	0	299-W19-48	Below Basalt
835	567822.9	134926.0	73.6	0	299-W19-48	Mud Bot
836	567822.9	134926.0	78.8	0	299-W19-48	Mud Top
837	567822.9	134926.0	139.3	0	299-W19-48	WT
838	567568.0	134894.4	139.5	0	299-W19-49	WT
839	567939.3	135011.8	139.1	0	299-W19-50	WT
840	567534.9	135213.4	50.8	0	299-W19-8	Basalt
841	568124.4	134573.8	57.0	0	299-W21-2	Basalt

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
842	568124.4	134573.8	51.0	0	299-W21-2	Below Basalt
843	568124.4	134573.8	70.8	0	299-W21-2	Mud Bot
844	568124.4	134573.8	77.9	0	299-W21-2	Mud Top
845	568124.4	134573.8	138.8	0	299-W21-2	WT
846	567593.1	133879.2	139.0	0	299-W22-20	WT
847	567122.9	134489.9	33.5	0	299-W22-27	Basalt
848	566908.8	134076.3	140.4	0	299-W22-47	WT
849	566904.3	134139.8	29.6	0	299-W22-50	Basalt
850	566904.3	134139.8	53.8	0	299-W22-50	Mud Bot
851	566904.3	134139.8	63.1	0	299-W22-50	Mud Top
852	566904.3	134139.8	140.4	0	299-W22-50	WT
853	567179.6	134347.8	58.4	0	299-W22-69	Mud Bot
854	567179.6	134347.8	67.5	0	299-W22-69	Mud Top
855	567179.6	134347.8	139.9	0	299-W22-69	WT
856	567237.4	134207.1	41.6	0	299-W22-72	Basalt
857	567237.4	134207.1	139.8	0	299-W22-72	WT
858	567186.7	134041.3	139.9	0	299-W22-86	WT
859	567541.8	134539.9	46.4	0	299-W22-87	Basalt
860	567541.8	134539.9	63.0	0	299-W22-87	Mud Bot
861	567541.8	134539.9	71.5	0	299-W22-87	Mud Top
862	567541.8	134539.9	139.5	0	299-W22-87	WT
863	568046.5	134390.5	55.6	0	299-W22-88	Basalt
864	568046.5	134390.5	69.5	0	299-W22-88	Mud Bot
865	568046.5	134390.5	76.0	0	299-W22-88	Mud Top
866	568046.5	134390.5	138.8	0	299-W22-88	WT
867	566570.4	134256.3	141.0	0	299-W23-10	WT
868	566794.0	134127.2	140.6	0	299-W23-15	WT
869	566707.7	134294.0	30.0	0	299-W23-21	Basalt
870	566628.2	134391.9	30.5	0	299-W23-4	Basalt
871	566628.2	134391.9	55.0	0	299-W23-4	Mud Bot
872	566628.2	134391.9	63.9	0	299-W23-4	Mud Top
873	566628.2	134391.9	141.0	0	299-W23-4	WT
874	566613.2	134267.8	54.4	0	299-W23-9	Mud Bot
875	566613.2	134267.8	63.3	0	299-W23-9	Mud Top
876	566296.7	133235.7	26.0	0	299-W26-7	Basalt
877	566296.7	133235.7	141.5	0	299-W26-7	WT
878	566908.3	133670.4	51.4	0	299-W27-2	Mud Bot
879	566908.3	133670.4	61.9	0	299-W27-2	Mud Top
880	567384.5	137446.1	139.0	0	299-W6-10	WT
881	567089.4	137292.2	62.4	0	299-W6-3	Basalt
882	567289.9	137631.7	66.5	0	299-W6-6	Basalt
883	567282.5	137631.8	139.0	0	299-W6-7	WT
884	566380.0	137301.3	57.9	0	299-W7-4	Basalt
885	566732.6	137629.7	140.0	0	299-W7-8	WT
886	569991.0	132739.2	76.5	0	699-30-66	Basalt
887	564354.4	132992.4	7.6	0	699-31-84A	Basalt
888	566683.9	133137.7	140.3	0	699-32-76	WT
889	567472.7	133552.2	42.5	0	699-33-74	Basalt
890	567472.7	133552.2	139.0	0	699-33-74	WT
891	566907.8	133662.5	140.1	0	699-33-75	WT
892	566621.2	133600.4	26.9	0	699-33-76	Basalt
893	566621.2	133600.4	140.5	0	699-33-76	WT
894	567860.0	133785.3	138.9	0	699-34-72	WT
895	568566.5	133987.6	64.8	0	699-35-70	Basalt
896	568566.5	133987.6	73.0	0	699-35-70	Mud Bot
897	568566.5	133987.6	79.9	0	699-35-70	Mud Top
898	568566.5	133987.6	137.5	0	699-35-70	WT
899	566063.6	134271.3	53.9	0	699-35-78A	Mud Bot
900	566063.6	134271.3	67.5	0	699-35-78A	Mud Top

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
901	566063.6	134271.3	141.5	0	699-35-78A	WT
902	566018.9	134272.4	30.5	0	699-35-78B	Basalt
903	569731.3	134469.0	70.8	0	699-36-66B	Basalt
904	569731.3	134469.0	64.0	0	699-36-66B	Below Basalt
905	569731.3	134469.0	58.0	0	699-36-66B	Below Basalt
906	569731.3	134469.0	88.7	0	699-36-66B	Mud Bot
907	569731.3	134469.0	96.0	0	699-36-66B	Mud Top
908	569731.3	134469.0	132.0	0	699-36-66B	WT
909	569250.6	134418.2	66.3	0	699-36-67	Basalt
910	569250.6	134418.2	60.0	0	699-36-67	Below Basalt
911	569250.6	134418.2	82.5	0	699-36-67	Mud Bot
912	569250.6	134418.2	90.3	0	699-36-67	Mud Top
913	569250.6	134418.2	136.5	0	699-36-67	WT
914	568437.8	134302.0	62.0	0	699-36-70A	Basalt
915	568437.8	134302.0	56.0	0	699-36-70A	Below Basalt
916	568437.0	134302.0	74.6	0	699-36-70A	Mud Bot
917	568437.8	134302.0	83.5	0	699-36-70A	Mud Top
918	568466.7	134308.8	137.5	0	699-36-70A	WT
919	568427.8	134626.0	63.0	0	699-36-70B	Basalt
920	568427.8	134626.0	57.0	0	699-36-70B	Below Basalt
921	568427.8	134626.0	76.6	0	699-36-70B	Mud Bot
922	568427.8	134626.0	81.9	0	699-36-70B	Mud Top
923	568427.8	134626.0	138.3	0	699-36-70B	WT
924	569730.3	134797.2	66.4	0	699-37-66	Basalt
925	569730.3	134797.2	60.0	0	699-37-66	Below Basalt
926	569730.3	134797.2	54.0	0	699-37-66	Below Basalt
927	569730.3	134797.2	87.9	0	699-37-66	Mud Bot
928	569730.3	134797.2	95.2	0	699-37-66	Mud Top
929	569730.3	134797.2	132.0	0	699-37-66	WT
930	569244.8	134622.6	66.2	0	699-37-68	Basalt
931	569244.8	134622.6	60.0	0	699-37-68	Below Basalt
932	569244.8	134622.6	87.9	0	699-37-68	Mud Bot
933	569244.8	134622.6	95.2	0	699-37-68	Mud Top
934	569244.8	134622.6	136.5	0	699-37-68	WT
935	564681.2	134736.0	7.0	0	699-37-83	Basalt
936	564681.2	134736.0	50.0	0	699-37-83	Mud Bot
937	564681.2	134736.0	73.0	0	699-37-83	Mud Top
938	570061.2	135033.0	71.3	0	699-38-65	Basalt
939	570061.2	135033.0	65.0	0	699-38-65	Below Basalt
940	570061.2	135033.0	59.0	0	699-38-65	Below Basalt
941	570061.2	135033.0	94.1	0	699-38-65	Mud Bot
942	570061.2	135033.0	101.8	0	699-38-65	Mud Top
943	569180.3	134931.6	66.9	0	699-38-68A	Basalt
944	569180.3	134931.6	60.0	0	699-38-68A	Below Basalt
945	569180.3	134931.6	87.9	0	699-38-68A	Mud Bot
946	569180.3	134931.6	94.7	0	699-38-68A	Mud Top
947	568472.1	135082.3	64.4	0	699-38-70	Basalt
948	568472.1	135082.3	58.0	0	699-38-70	Below Basalt
949	568472.1	135082.3	76.7	0	699-38-70	Mud Bot
950	568472.1	135082.3	83.6	0	699-38-70	Mud Top
951	568469.1	135331.0	67.4	0	699-38-70B	Basalt
952	568469.1	135331.0	61.0	0	699-38-70B	Below Basalt
953	568469.1	135331.0	55.0	0	699-38-70B	Below Basalt
954	568469.1	135331.0	79.7	0	699-38-70B	Mud Bot
955	568469.1	135331.0	84.9	0	699-38-70B	Mud Top
956	568469.1	135331.0	138.3	0	699-38-70B	WT
957	569084.1	135325.6	66.9	0	699-38-70C	Basalt
958	569084.1	135325.6	60.0	0	699-38-70C	Below Basalt
959	569084.1	135325.6	87.0	0	699-38-70C	Mud Bot

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
960	569084.1	135325.6	93.4	0	699-38-70C	Mud Top
961	569084.1	135325.6	137.2	0	699-38-70C	WT
962	565862.2	135405.0	38.0	0	699-39-79	Basalt
963	565862.2	135405.0	57.6	0	699-39-79	Mud Bot
964	565862.2	135405.0	72.2	0	699-39-79	Mud Top
965	570057.5	135881.2	70.7	0	699-40-65	Basalt
966	570057.5	135881.2	64.0	0	699-40-65	Below Basalt
967	570057.5	135881.2	58.0	0	699-40-65	Below Basalt
968	570057.5	135881.2	101.8	0	699-40-65	Mud Bot
969	570057.5	135881.2	110.5	0	699-40-65	Mud Top
970	570057.5	135881.2	132.0	0	699-40-65	WT
971	568967.0	136488.5	68.7	0	699-43-69	Basalt
972	568967.0	136488.5	62.0	0	699-43-69	Below Basalt
973	568967.0	136488.5	56.0	0	699-43-69	Below Basalt
974	568967.0	136488.5	106.5	0	699-43-69	Mud Bot
975	568967.0	136488.5	112.5	0	699-43-69	Mud Top
976	568967.0	136488.5	136.8	0	699-43-69	WT
977	570390.7	136897.4	77.3	0	699-44-64	Basalt
978	570390.7	136897.4	71.0	0	699-44-64	Below Basalt
979	570390.7	136897.4	65.0	0	699-44-64	Below Basalt
980	570390.7	136897.4	59.0	0	699-44-64	Below Basalt
981	568729.3	137182.7	82.1	0	699-45-69A	Basalt
982	568729.3	137182.7	76.0	0	699-45-69A	Below Basalt
983	568729.3	137182.7	70.0	0	699-45-69A	Below Basalt
984	568947.1	137233.8	81.1	0	699-45-69C	Basalt
985	568947.1	137233.8	75.0	0	699-45-69C	Below Basalt
986	568947.1	137233.8	69.0	0	699-45-69C	Below Basalt
987	568947.1	137233.8	114.4	0	699-45-69C	Mud Bot
988	568947.1	137233.8	119.1	0	699-45-69C	Mud Top
989	568947.1	137233.8	135.9	0	699-45-69C	WT
990	565999.1	137038.2	53.3	0	699-45-78	Basalt
991	564010.8	137382.4	30.5	0	699-46-85B	Basalt
992	571474.4	137968.7	69.6	0	699-47-60	Basalt
993	568387.9	138056.9	68.9	0	699-48-71	Basalt
994	568387.9	138056.9	62.0	0	699-48-71	Below Basalt
995	568387.9	138056.9	56.0	0	699-48-71	Below Basalt
996	568387.9	138056.9	137.5	0	699-48-71	WT
997	566384.5	137961.8	67.1	0	699-48-77A	Basalt
998	566469.0	138086.8	69.4	0	699-48-77C	Basalt
999	567359.5	138646.7	76.7	0	699-50-74	Basalt
1000	567359.5	138646.7	138.7	0	699-50-74	WT
1001	566949.3	138899.2	80.0	0	699-51-75	Basalt
1002	566694.6	140218.7	114.3	0	699-55-76	Basalt
1003	567317.0	135329.0	139.0	0	below ditch	WT
1004	567333.0	135671.0	126.0	195	below ditch	
1005	567333.0	135671.0	118.0	171	below ditch	
1006	567333.0	135671.0	111.0	630	below ditch	
1007	567333.0	135671.0	105.0	1379	below ditch	
1008	567333.0	135671.0	98.0	1388	below ditch	
1009	567333.0	135671.0	92.0	1700	below ditch	
1010	567333.0	135671.0	86.0	1131	below ditch	
1011	567333.0	135671.0	76.0	0	below ditch	
1012	567317.0	135329.0	129.0	83	below ditch	
1013	567317.0	135329.0	125.0	158	below ditch	
1014	567317.0	135329.0	118.0	185	below ditch	
1015	567317.0	135329.0	107.0	206	below ditch	
1016	567317.0	135329.0	99.0	125	below ditch	
1017	567317.0	135329.0	90.0	172	below ditch	
1018	567317.0	135329.0	80.0	41	below ditch	

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
1019	567362.0	135925.0	72.0	0	below mud blank	
1020	567362.0	135925.0	67.0	0	below mud blank	
1021	567362.0	135925.0	62.0	0	below mud blank	
1022	567362.0	135925.0	57.0	0	below mud blank	
1023	567360.0	135012.0	62.0	0	below mud blank	
1024	567360.0	135012.0	57.0	0	below mud blank	
1025	567360.0	135012.0	52.0	0	below mud blank	
1026	567333.0	135671.0	72.0	0	below mud blank	
1027	567333.0	135671.0	67.0	0	below mud blank	
1028	567333.0	135671.0	62.0	0	below mud blank	
1029	567333.0	135671.0	57.0	0	below mud blank	
1030	567317.0	135329.0	72.0	0	below mud blank	
1031	567317.0	135329.0	67.0	0	below mud blank	
1032	567317.0	135329.0	62.0	0	below mud blank	
1033	567317.0	135329.0	57.0	0	below mud blank	
1034	566909.0	136285.0	62.0	0	below mud blank	
1035	566909.0	136285.0	57.0	0	below mud blank	
1036	566909.0	136285.0	52.0	0	below mud blank	
1037	566899.0	136100.0	76.0	0	below mud blank	
1038	566899.0	136100.0	72.0	0	below mud blank	
1039	566899.0	136100.0	67.0	0	below mud blank	
1040	566899.0	136100.0	62.0	0	below mud blank	
1041	566899.0	136100.0	57.0	0	below mud blank	
1042	566899.0	136100.0	52.0	0	below mud blank	
1043	566927.0	136604.0	76.0	0	below mud blank	
1044	566927.0	136604.0	72.0	0	below mud blank	
1045	566927.0	136604.0	67.0	0	below mud blank	
1046	566927.0	136604.0	62.0	0	below mud blank	
1047	566927.0	136604.0	57.0	0	below mud blank	
1048	566927.0	136604.0	52.0	0	below mud blank	
1049	568941.0	136884.0	125.0	3.7	downgrad from 11-86	
1050	568941.0	136884.0	120.0	1	downgrad from 11-86	
1051	568941.0	136884.0	116.0	0	downgrad from 11-86	
1052	568941.0	136884.0	111.0	0	downgrad from 11-86	
1053	568941.0	136884.0	105.0	143.5	downgrad from 11-86	
1054	568941.0	136884.0	99.0	82.5	downgrad from 11-86	
1055	568941.0	136884.0	93.0	82.5	downgrad from 11-86	
1056	568941.0	136884.0	86.0	36.2	downgrad from 11-86	
1057	568941.0	136884.0	79.0	27	downgrad from 11-86	
1058	568941.0	136884.0	75.5	0	downgrad from 11-86	
1059	568941.0	136884.0	69.0	0	downgrad from 11-86	
1060	568941.0	136884.0	63.0	0	downgrad from 11-86	
1061	568969.0	135930.0	136.5	0	downgrad from 13-1	WT
1062	568969.0	135930.0	104.0	0	downgrad from 13-1	
1063	568969.0	135930.0	97.0	0	downgrad from 13-1	
1064	568969.0	135930.0	68.0	0	downgrad from 13-1	
1065	568969.0	135930.0	62.0	0	downgrad from 13-1	
1066	568969.0	135930.0	125.0	25	downgrad from 13-1	
1067	568969.0	135930.0	117.0	28	downgrad from 13-1	
1068	568969.0	135930.0	110.0	22	downgrad from 13-1	
1069	568969.0	135930.0	93.0	260	downgrad from 13-1	
1070	568969.0	135930.0	89.0	150	downgrad from 13-1	
1071	568969.0	135930.0	85.0	140	downgrad from 13-1	
1072	568969.0	135930.0	79.0	72	downgrad from 13-1	
1073	568969.0	135930.0	73.0	53	downgrad from 13-1	
1074	568969.0	135930.0	56.0	0	downgrad from 13-1	
1075	570390.0	136697.0	132.0	0	east bound	WT
1076	570312.0	137706.0	132.0	0	east bound	WT
1077	569583.0	138257.0	132.0	0	east bound	WT

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
1078	569583.0	138257.0	123.0	5	east bound	
1079	570312.0	137706.0	123.0	5	east bound	
1080	570390.0	136897.0	120.0	0	east bound	
1081	570390.0	136897.0	113.0	0	east bound	
1082	570390.0	136897.0	99.0	8.1	east bound	
1083	565904.0	135065.0	141.5	0	Z1 Bound	WT
1084	565661.0	137010.0	135.0	0	Z1 Bound	
1085	565661.0	137010.0	125.0	0	Z1 Bound	
1086	565661.0	137010.0	115.0	0	Z1 Bound	
1087	565661.0	137010.0	105.0	0	Z1 Bound	
1088	565661.0	137010.0	95.0	0	Z1 Bound	
1089	565661.0	137010.0	85.0	0	Z1 Bound	
1090	565694.0	136459.0	135.0	0	Z1 Bound	
1091	565694.0	136459.0	125.0	0	Z1 Bound	
1092	565694.0	136459.0	115.0	0	Z1 Bound	
1093	565694.0	136459.0	105.0	0	Z1 Bound	
1094	565694.0	136459.0	95.0	0	Z1 Bound	
1095	565694.0	136459.0	85.0	0	Z1 Bound	
1096	565840.0	135989.0	135.0	0	Z1 Bound	
1097	565840.0	135989.0	125.0	0	Z1 Bound	
1098	565840.0	135989.0	115.0	0	Z1 Bound	
1099	565840.0	135989.0	105.0	0	Z1 Bound	
1100	565840.0	135989.0	95.0	0	Z1 Bound	
1101	565840.0	135989.0	85.0	0	Z1 Bound	
1102	565942.0	135567.0	135.0	0	Z1 Bound	
1103	565942.0	135567.0	125.0	0	Z1 Bound	
1104	565942.0	135567.0	115.0	0	Z1 Bound	
1105	565942.0	135567.0	105.0	0	Z1 Bound	
1106	565942.0	135567.0	95.0	0	Z1 Bound	
1107	565942.0	135567.0	85.0	0	Z1 Bound	
1108	565904.0	135065.0	135.0	0	Z1 Bound	
1109	565904.0	135065.0	125.0	0	Z1 Bound	
1110	565904.0	135065.0	115.0	0	Z1 Bound	
1111	565904.0	135065.0	105.0	0	Z1 Bound	
1112	565904.0	135065.0	95.0	0	Z1 Bound	
1113	565904.0	135065.0	85.0	0	Z1 Bound	
1114	566012.0	137629.0	125.0	0	Z2 bound	
1115	566012.0	137629.0	115.0	0	Z2 bound	
1116	566012.0	137629.0	105.0	0	Z2 bound	
1117	566012.0	137629.0	95.0	0	Z2 bound	
1118	566012.0	137629.0	85.0	0	Z2 bound	
1119	567152.0	137966.0	135.0	0	Z2 bound	
1120	567152.0	137966.0	125.0	0	Z2 bound	
1121	567152.0	137966.0	115.0	0	Z2 bound	
1122	567152.0	137966.0	105.0	0	Z2 bound	
1123	567152.0	137966.0	95.0	0	Z2 bound	
1124	567152.0	137966.0	85.0	0	Z2 bound	
1125	567946.0	138371.0	135.0	0	Z2 bound	
1126	567946.0	138371.0	125.0	0	Z2 bound	
1127	567946.0	138371.0	115.0	0	Z2 bound	
1128	567946.0	138371.0	105.0	0	Z2 bound	
1129	567946.0	138371.0	95.0	0	Z2 bound	
1130	567946.0	138371.0	85.0	0	Z2 bound	
1131	568902.0	138630.0	135.0	0	Z2 bound	
1132	568902.0	138630.0	125.0	0	Z2 bound	
1133	568902.0	138630.0	115.0	0	Z2 bound	
1134	568902.0	138630.0	105.0	0	Z2 bound	
1135	568902.0	138630.0	95.0	0	Z2 bound	
1136	568902.0	138630.0	85.0	0	Z2 bound	

Table A-1. 2010 Carbon Tetrachloride Plume Shell Data Set, 200 West Area

GMS ID	Easting (m)	Northing (m)	Elevation (m amsl)	Concentration (ug/L)	Location	Type
1137	566637.0	135072.0	130.5	48	299-W17-3 copied west	
1138	566637.0	135072.0	125.3	160	299-W17-3 copied west	
1139	566637.0	135072.0	118.9	170	299-W17-3 copied west	
1140	566637.0	135072.0	112.8	160	299-W17-3 copied west	
1141	566637.0	135072.0	106.4	200	299-W17-3 copied west	
1142	566637.0	135072.0	100.3	150	299-W17-3 copied west	
1143	566637.0	135072.0	93.9	200	299-W17-3 copied west	
1144	566637.0	135072.0	87.8	230	299-W17-3 copied west	
1145	566637.0	135072.0	81.7	150	299-W17-3 copied west	
1146	566637.0	135072.0	75.6	63	299-W17-3 copied west	
1147	566637.0	135072.0	69.5	63	299-W17-3 copied west	

Appendix B

Well Configurations for Simulated Alternatives

Tables

Table B-1. Well Locations and Rates: Base Case 1 ..... B-1
Table B-2. Well Locations and Rates: Base Case 2 ..... B-2
Table B-3. Well Locations and Rates: Sensitivity Case 1 ..... B-3
Table B-4. Well Locations and Rates: Sensitivity Case 2 ..... B-4
Table B-5. Well Locations and Rates: Sensitivity Case 3 ..... B-5
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Table B-7. Well Locations and Rates: Sensitivity Case 5 ..... B-7
Table B-8. Well Locations and Rates: Sensitivity Case 6 ..... B-8

Table B-1. Well Locations and Rates: Base Case 1

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	0.0	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	0.0	Fully penetr.
EW-14	567752	137164	0.0	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	0.0	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566664	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	726.8	Fully penetr.
IW-7	566311	135410	726.8	Fully penetr.
IW-8	566471	134987	0.0	Fully penetr.
IW-9	568862	137789	0.0	Fully penetr.
IW-10	569110	137600	0.0	Fully penetr.
IW-11	569257	137263	726.8	Fully penetr.
IW-12	569338	136894	726.8	Fully penetr.
IW-13	569370	136560	726.8	Fully penetr.
IW-14	569390	136200	726.8	Fully penetr.
IW-15	569420	135816	726.8	Fully penetr.
IW-16	569386	135483	0.0	Fully penetr.

Total	Injection	Extraction
m^3/d	8,721	-8,722
gpm	1,600	-1,600

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	681.4	Fully penetr.
IW-7	566311	135410	681.4	Fully penetr.
IW-8	566471	134987	681.4	Fully penetr.
IW-9	568862	137789	681.4	Fully penetr.
IW-10	569110	137600	681.4	Fully penetr.
IW-11	569257	137263	681.4	Fully penetr.
IW-12	569338	136894	681.4	Fully penetr.
IW-13	569370	136560	681.4	Fully penetr.
IW-14	569390	136200	681.4	Fully penetr.
IW-15	569420	135816	681.4	Fully penetr.
IW-16	569386	135483	681.4	Fully penetr.

Total	Injection	Extraction
m^3/d	10,902	-10,902
gpm	2,000	-2,000

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-2. Well Locations and Rates: Base Case 2

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-681.4	As built
EW-2	566909	136285	-681.4	As built
EW-3	567359	136204	-681.4	As built
EW-4	567781	136383	-681.4	As built
EW-5	568313	136610	-681.4	As built
EW-6	566966	136757	-681.4	Fully penetr.
EW-7	567307	136520	-681.4	As built
EW-8	567776	136778	-681.4	As built
EW-9	566926	135325	-681.4	Fully penetr.
EW-10	566952	135806	-681.4	Fully penetr.
EW-11	567332	135545	0.0	Fully penetr.
EW-12	567362	135925	-681.4	Fully penetr.
EW-13	567406	136996	0.0	Fully penetr.
EW-14	567752	137164	0.0	Fully penetr.
EW-15	567721	135887	-681.4	As built
EW-16	566693	136352	-681.4	Fully penetr.
EW-17	568356	137358	0.0	Fully penetr.
EW-18	568325	137000	-681.4	As built
EW-19	568329	136363	-681.4	As built
EW-20	568330	136116	-681.4	Fully penetr.
IW-1	567178	137639	908.5	Fully penetr.
IW-2	566864	137477	908.5	Fully penetr.
IW-3	566082	137339	908.5	Fully penetr.
IW-4	566067	136987	908.5	Fully penetr.
IW-5	566033	136450	908.5	Fully penetr.
IW-6	566034	135966	908.5	Fully penetr.
IW-7	566311	135410	908.5	Fully penetr.
IW-8	566471	134987	0.0	Fully penetr.
IW-9	568862	137789	0.0	Fully penetr.
IW-10	569110	137600	0.0	Fully penetr.
IW-11	569257	137263	908.5	Fully penetr.
IW-12	569338	136894	908.5	Fully penetr.
IW-13	569370	136560	908.5	Fully penetr.
IW-14	569390	136200	908.5	Fully penetr.
IW-15	569420	135816	908.5	Fully penetr.
IW-16	569386	135483	0.0	Fully penetr.

Total	Injection	Extraction
m^3/d	10,902	-10,902
gpm	2,000	-2,000

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-681.4	As built
EW-2	566909	136285	-681.4	As built
EW-3	567359	136204	-681.4	As built
EW-4	567781	136383	-681.4	As built
EW-5	568313	136610	-681.4	As built
EW-6	566966	136757	-681.4	Fully penetr.
EW-7	567307	136520	-681.4	As built
EW-8	567776	136778	-681.4	As built
EW-9	566926	135325	-681.4	Fully penetr.
EW-10	566952	135806	-681.4	Fully penetr.
EW-11	567332	135545	-681.4	Fully penetr.
EW-12	567362	135925	-681.4	Fully penetr.
EW-13	567406	136996	-681.4	Fully penetr.
EW-14	567752	137164	-681.4	Fully penetr.
EW-15	567721	135887	-681.4	As built
EW-16	566693	136352	-681.4	Fully penetr.
EW-17	568356	137358	-681.4	Fully penetr.
EW-18	568325	137000	-681.4	As built
EW-19	568329	136363	-681.4	As built
EW-20	568330	136116	-681.4	Fully penetr.
IW-1	567178	137639	851.7	Fully penetr.
IW-2	566864	137477	851.7	Fully penetr.
IW-3	566082	137339	851.7	Fully penetr.
IW-4	566067	136987	851.7	Fully penetr.
IW-5	566033	136450	851.7	Fully penetr.
IW-6	566034	135966	851.7	Fully penetr.
IW-7	566311	135410	851.7	Fully penetr.
IW-8	566471	134987	851.7	Fully penetr.
IW-9	568862	137789	851.7	Fully penetr.
IW-10	569110	137600	851.7	Fully penetr.
IW-11	569257	137263	851.7	Fully penetr.
IW-12	569338	136894	851.7	Fully penetr.
IW-13	569370	136560	851.7	Fully penetr.
IW-14	569390	136200	851.7	Fully penetr.
IW-15	569420	135816	851.7	Fully penetr.
IW-16	569386	135483	851.7	Fully penetr.

Total	Injection	Extraction
m^3/d	13,627	-13,627
gpm	2,500	-2,500

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-3. Well Locations and Rates: Sensitivity Case 1

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	0.0	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	0.0	Fully penetr.
EW-14	567752	137164	0.0	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	0.0	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566864	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	726.8	Fully penetr.
IW-7	566311	135410	726.8	Fully penetr.
IW-8	566471	134987	0.0	Fully penetr.
IW-9	568862	137789	0.0	Below mud
IW-10	569110	137600	0.0	Below mud
IW-11	569257	137263	726.8	Below mud
IW-12	569338	136894	726.8	Below mud
IW-13	569370	136560	726.8	Below mud
IW-14	569390	136200	726.8	Below mud
IW-15	569420	135816	726.8	Below mud
IW-16	569386	135483	0.0	Below mud

Total	Injection	Extraction
m^3/d	8,722	-8,722
gpm	1,600	-1,600

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	681.4	Fully penetr.
IW-7	566311	135410	681.4	Fully penetr.
IW-8	566471	134987	681.4	Fully penetr.
IW-9	568862	137789	681.4	Below mud
IW-10	569110	137600	681.4	Below mud
IW-11	569257	137263	681.4	Below mud
IW-12	569338	136894	681.4	Below mud
IW-13	569370	136560	681.4	Below mud
IW-14	569390	136200	681.4	Below mud
IW-15	569420	135816	681.4	Below mud
IW-16	569386	135483	681.4	Below mud

Total	Injection	Extraction
m^3/d	10,902	-10,902
gpm	2,000	-2,000

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-4. Well Locations and Rates: Sensitivity Case 2

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	0.0	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	0.0	Fully penetr.
EW-14	567752	137164	0.0	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	0.0	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566864	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	726.8	Fully penetr.
IW-7	566311	135410	726.8	Fully penetr.
IW-8	566471	134987	0.0	Fully penetr.
IW-9	568862	137789	0.0	Below mud
IW-10	569110	137600	0.0	Below mud
IW-11	569257	137263	726.8	Below mud
IW-12	569338	136894	726.8	Below mud
IW-13	569370	136560	726.8	Below mud
IW-14	569390	136200	726.8	Below mud
IW-15	569420	135816	726.8	Below mud
IW-16	569386	135483	0.0	Below mud

Total	Injection	Extraction
m^3/d	8,722	-8,722
gpm	1,600	-1,600

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568356	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	681.4	Fully penetr.
IW-7	566311	135410	681.4	Fully penetr.
IW-8	566471	134987	681.4	Fully penetr.
IW-9	568862	137789	681.4	Below mud
IW-10	569110	137600	681.4	Below mud
IW-11	569257	137263	681.4	Below mud
IW-12	569338	136894	681.4	Below mud
IW-13	569370	136560	681.4	Below mud
IW-14	569390	136200	681.4	Below mud
IW-15	569420	135816	681.4	Below mud
IW-16	569386	135483	681.4	Below mud

Total	Injection	Extraction
m^3/d	10,902	-10,902
gpm	2,000	-2,000

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-5. Well Locations and Rates: Sensitivity Case 3

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/day	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
W15-29	565920	135506	244.3	As built
W18-36	565907	135419	285.5	As built
W18-37	565903	135323	257.0	As built
W18-38	565891	135233	256.3	As built
W18-39	565884	135141	318.0	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566864	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	92.5	Fully penetr.
IW-11	569257	137263	726.8	Fully penetr.
IW-12	569338	136894	726.8	Fully penetr.
IW-13	569370	136560	726.8	Fully penetr.
IW-14	569390	136200	726.8	Fully penetr.
IW-15	569420	135816	726.8	Fully penetr.

Total	Injection	Extraction
m^3/day	8,722	-8,722
gpm	1,600	-1,600

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
W15-29	565920	135506	244.3	As built
W18-36	565907	135419	285.5	As built
W18-37	565903	135323	257.0	As built
W18-38	565891	135233	256.3	As built
W18-39	565884	135141	318.0	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568357	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	682.0	Fully penetr.
IW-9	568862	137789	682.0	Fully penetr.
IW-10	569110	137600	681.4	Fully penetr.
IW-11	569257	137263	681.4	Fully penetr.
IW-12	569338	136894	681.4	Fully penetr.
IW-13	569370	136560	681.4	Fully penetr.
IW-14	569390	136200	681.4	Fully penetr.
IW-15	569420	135816	681.4	Fully penetr.
IW-16	569386	135483	681.4	Fully penetr.

Total	Injection	Extraction
m^3/day	10,902	-10,902
gpm	2,000	-2,000

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-6. Well Locations and Rates: Sensitivity Case 4

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/day	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
W15-29	565920	135506	244.3	As built
W18-36	565907	135419	285.5	As built
W18-37	565903	135323	257	As built
W18-38	565891	135233	256.3	As built
W18-39	565884	135141	318	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566864	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	726.8	Fully penetr.
IW-7	566311	135410	726.8	Fully penetr.
IW-11	569257	137263	726.8	Fully penetr.
IW-12	569338	136894	726.8	Fully penetr.
IW-13	569370	136560	726.8	Fully penetr.
IW-14	569390	136200	92.5	Fully penetr.

Total	Injection	Extraction
m^3/day	8,722	-8,722
gpm	1,600	-1,600

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
W15-29	565920	135506	244.3	As built
W18-36	565907	135419	285.5	As built
W18-37	565903	135323	257.0	As built
W18-38	565891	135233	256.3	As built
W18-39	565884	135141	318.0	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568357	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	681.4	Fully penetr.
IW-7	566311	135410	681.4	Fully penetr.
IW-8	566471	134987	681.4	Fully penetr.
IW-9	568862	137789	681.4	Fully penetr.
IW-10	569110	137600	681.4	Fully penetr.
IW-11	569257	137263	681.4	Fully penetr.
IW-12	569338	136894	681.4	Fully penetr.
IW-13	569370	136560	682.0	Fully penetr.
IW-14	569390	136200	682.0	Fully penetr.

Total	Injection	Extraction
m^3/day	8,856	-10,902
gpm	1,625	-2,000

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-7. Well Locations and Rates: Sensitivity Case 5

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-35	566738	135853	-224.0	As built
299-W15-43	566489	136210	-142.0	As built
299-W15-45	566432	135961	-140.0	As built
299-W15-46	566752	135587	-294.0	As built
W18-36	565907	135419	285.7	As built
W18-37	565903	135323	257.7	As built
W18-38	565891	135233	256.6	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	726.8	Fully penetr.
IW-2	566864	137477	726.8	Fully penetr.
IW-3	566082	137339	726.8	Fully penetr.
IW-4	566067	136987	726.8	Fully penetr.
IW-5	566033	136450	726.8	Fully penetr.
IW-6	566034	135966	726.8	Fully penetr.
IW-7	566311	135410	726.8	Fully penetr.
IW-11	569257	137263	726.8	Fully penetr.
IW-12	569338	136894	726.8	Fully penetr.
IW-13	569370	136560	726.8	Fully penetr.
IW-14	569390	136200	726.8	Fully penetr.
IW-15	569420	135816	726.8	Fully penetr.

Total	Injection	Extraction
m^3/d	9,522	-9,522
gpm	1,747	-1,747

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-35	566738	135853	-224.0	As built
299-W15-43	566489	136210	-142.0	As built
299-W15-45	566432	135961	-140.0	As built
299-W15-46	566752	135587	-294.0	As built
W18-36	565907	135419	285.7	As built
W18-37	565903	135323	257.7	As built
W18-38	565891	135233	256.6	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568357	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	681.4	Fully penetr.
IW-2	566864	137477	681.4	Fully penetr.
IW-3	566082	137339	681.4	Fully penetr.
IW-4	566067	136987	681.4	Fully penetr.
IW-5	566033	136450	681.4	Fully penetr.
IW-6	566034	135966	681.4	Fully penetr.
IW-7	566311	135410	681.4	Fully penetr.
IW-8	566471	134987	681.4	Fully penetr.
IW-9	568862	137789	681.4	Fully penetr.
IW-10	569110	137600	681.4	Fully penetr.
IW-11	569257	137263	681.4	Fully penetr.
IW-12	569338	136894	681.4	Fully penetr.
IW-13	569370	136560	681.4	Fully penetr.
IW-14	569390	136200	681.4	Fully penetr.
IW-15	569420	135816	681.4	Fully penetr.
IW-16	569386	135483	681.4	Fully penetr.

Total	Injection	Extraction
m^3/d	11,702	-11,702
gpm	2,147	-2,147

EW = extraction well
gpm = gallons per minute
IW = injection well

Table B-8. Well Locations and Rates: Sensitivity Case 6

First Stress Period (Year 2009 through 2011)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-1	566554	135943	-45.3	As built
299-W15-11	566412	136001	-98.5	As built
299-W15-34	566612	135960	-92.6	As built
299-W15-35	566738	135853	-224.0	As built
299-W15-36	566773	135429	0.0	As built
299-W15-40	566651	136205	-30.4	As built
299-W15-43	566489	136210	-142.5	As built
299-W15-44	566684	136066	-28.8	As built
299-W15-45	566432	135961	-140.8	As built
299-W15-46	566752	135587	-294.1	As built
299-W15-47	566775	135642	-117.1	As built
299-W15-6	566800	135654	-28.5	As built
299-W15-7	566676	135920	-41.5	As built
299-W15-765	566696	136373	-76.8	As built
299-W15-29	565920	135506	244.3	As built
299-W18-36	565907	135419	285.5	As built
299-W18-37	565903	135323	257.0	As built
299-W18-38	565891	135233	256.3	As built
299-W18-39	565884	135141	318.0	As built

Total	Injection	Extraction
m^3/d	1,361	-1,361
gpm	250	-250

Second Stress Period (Year 2012 through 2014)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-35	566738	135853	-224.0	As built
299-W15-43	566489	136210	-142.0	As built
299-W15-45	566432	135961	-140.0	As built
299-W15-46	566752	135587	-294.0	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	841.0	Fully penetr.
IW-2	566864	137477	841.0	Fully penetr.
IW-3	566082	137339	841.0	Fully penetr.
IW-4	566067	136987	841.0	Fully penetr.
IW-5	566033	136450	841.0	Fully penetr.
IW-6	566034	135966	841.0	Fully penetr.
IW-7	566311	135410	841.0	Fully penetr.
IW-11	569257	137263	726.8	Fully penetr.
IW-12	569338	136894	726.8	Fully penetr.
IW-13	569370	136560	726.8	Fully penetr.
IW-14	569390	136200	726.8	Fully penetr.
IW-15	569420	135816	726.8	Fully penetr.

Total	Injection	Extraction
m^3/d	9,521	-9,522
gpm	1,747	-1,747

Third Stress Period (Year 2015 through 2036)				
Name	X	Y	Rate (m^3/d)	Screen
299-W15-35	566738	135853	-224.0	As built
299-W15-43	566489	136210	-142.0	As built
299-W15-45	566432	135961	-140.0	As built
299-W15-46	566752	135587	-294.0	As built
EW-1	566657	136109	-545.1	As built
EW-2	566909	136285	-545.1	As built
EW-3	567359	136204	-545.1	As built
EW-4	567781	136383	-545.1	As built
EW-5	568313	136610	-545.1	As built
EW-6	566966	136757	-545.1	Fully penetr.
EW-7	567307	136520	-545.1	As built
EW-8	567776	136778	-545.1	As built
EW-9	566926	135325	-545.1	Fully penetr.
EW-10	566952	135806	-545.1	Fully penetr.
EW-11	567332	135545	-545.1	Fully penetr.
EW-12	567362	135925	-545.1	Fully penetr.
EW-13	567406	136996	-545.1	Fully penetr.
EW-14	567752	137164	-545.1	Fully penetr.
EW-15	567721	135887	-545.1	As built
EW-16	566693	136352	-545.1	Fully penetr.
EW-17	568357	137358	-545.1	Fully penetr.
EW-18	568325	137000	-545.1	As built
EW-19	568329	136363	-545.1	As built
EW-20	568330	136116	-545.1	Fully penetr.
IW-1	567178	137639	781.4	Fully penetr.
IW-2	566864	137477	781.4	Fully penetr.
IW-3	566082	137339	781.4	Fully penetr.
IW-4	566067	136987	781.4	Fully penetr.
IW-5	566033	136450	781.4	Fully penetr.
IW-6	566034	135966	781.4	Fully penetr.
IW-7	566311	135410	781.4	Fully penetr.
IW-8	566471	134987	781.4	Fully penetr.
IW-9	568862	137789	681.4	Fully penetr.
IW-10	569110	137600	681.4	Fully penetr.
IW-11	569257	137263	681.4	Fully penetr.
IW-12	569338	136894	681.4	Fully penetr.
IW-13	569370	136560	681.4	Fully penetr.
IW-14	569390	136200	681.4	Fully penetr.
IW-15	569420	135816	681.4	Fully penetr.
IW-16	569386	135483	681.4	Fully penetr.

Total	Injection	Extraction
m^3/d	11,702	-11,702
gpm	2,147	-2,147

EW = extraction well
gpm = gallons per minute
IW = injection well

Appendix C

Simulated Influent Concentrations by Well

Figures

Figure C-1. Base Case 1: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-1
Figure C-2. Base Case 2: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-2
Figure C-3. Sensitivity Case 1: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-3
Figure C-4. Sensitivity Case 2: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-4
Figure C-5. Sensitivity Case 3: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-5
Figure C-6. Sensitivity Case 4: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-6
Figure C-7. Sensitivity Case 5: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-7
Figure C-8. Sensitivity Case 6: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life) C-8
Figure C-9. Base Case 1: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-9
Figure C-10. Base Case 2: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-10
Figure C-11. Sensitivity Case 1: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-11
Figure C-12. Sensitivity Case 2: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-12
Figure C-13. Sensitivity Case 3: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-13
Figure C-14. Sensitivity Case 4: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-14
Figure C-15. Sensitivity Case 5: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-15
Figure C-16. Sensitivity Case 6: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life) C-16

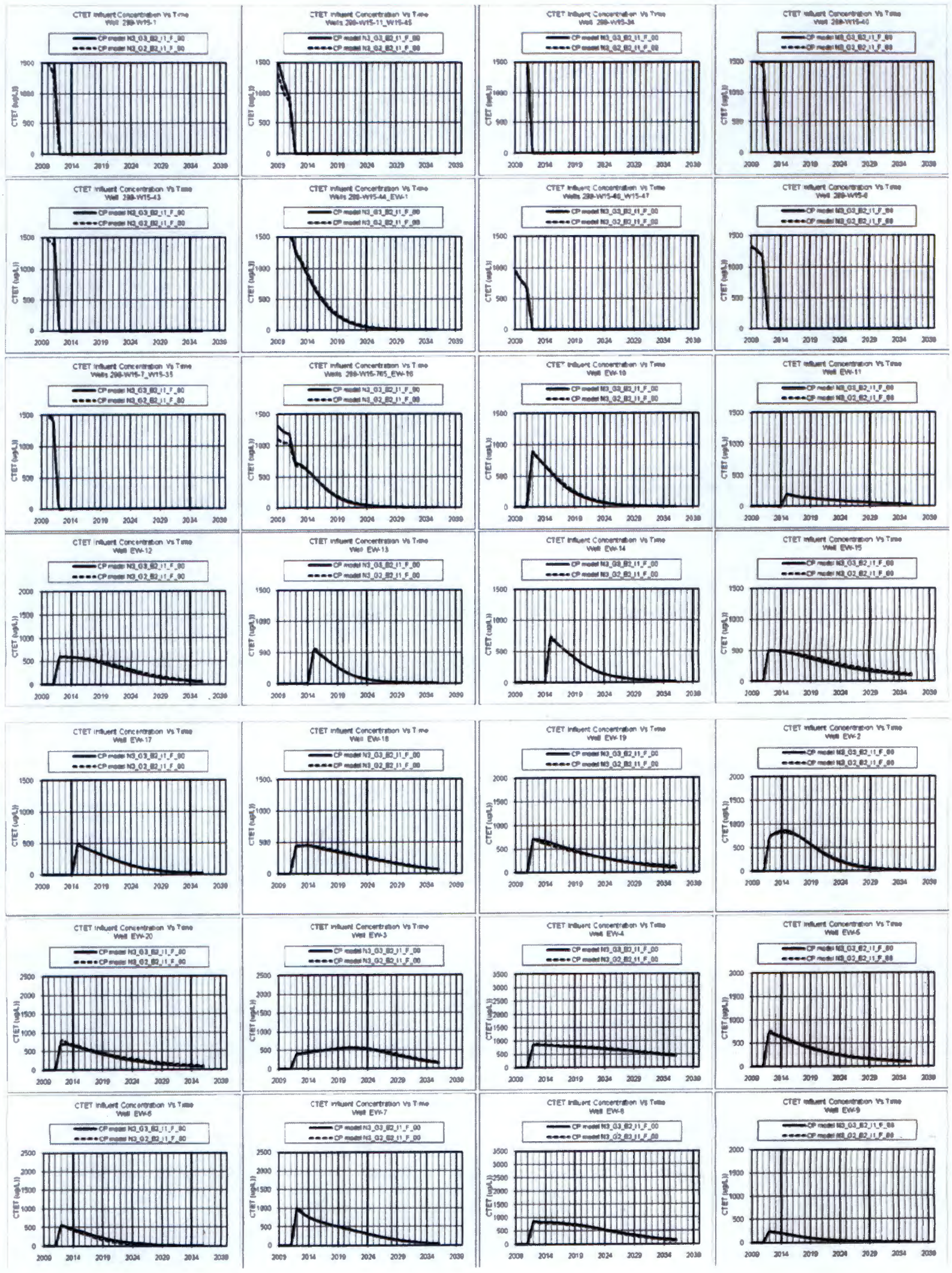

Figure C-1. Base Case 1: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

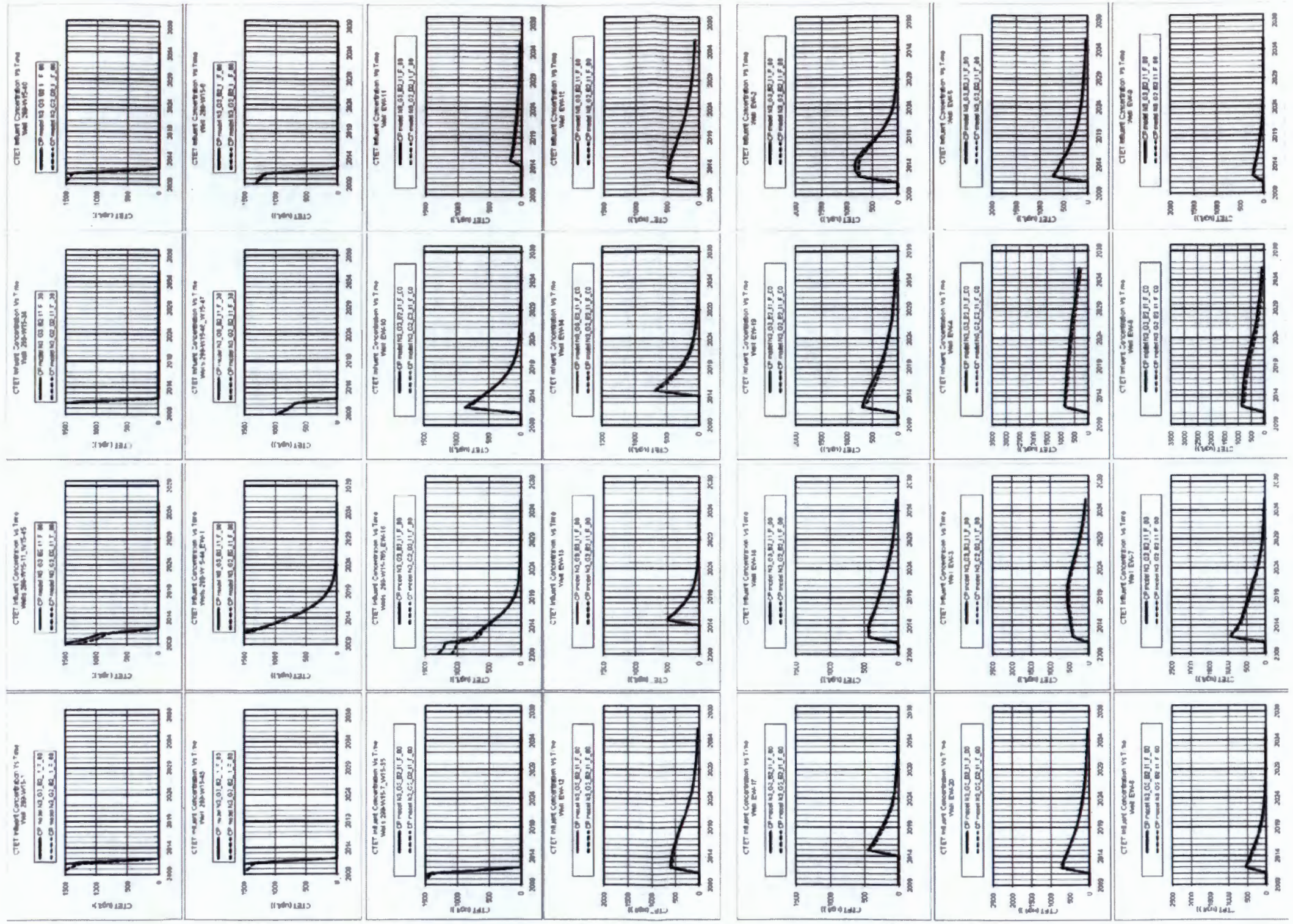

Figure C-2. Base Case 2: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

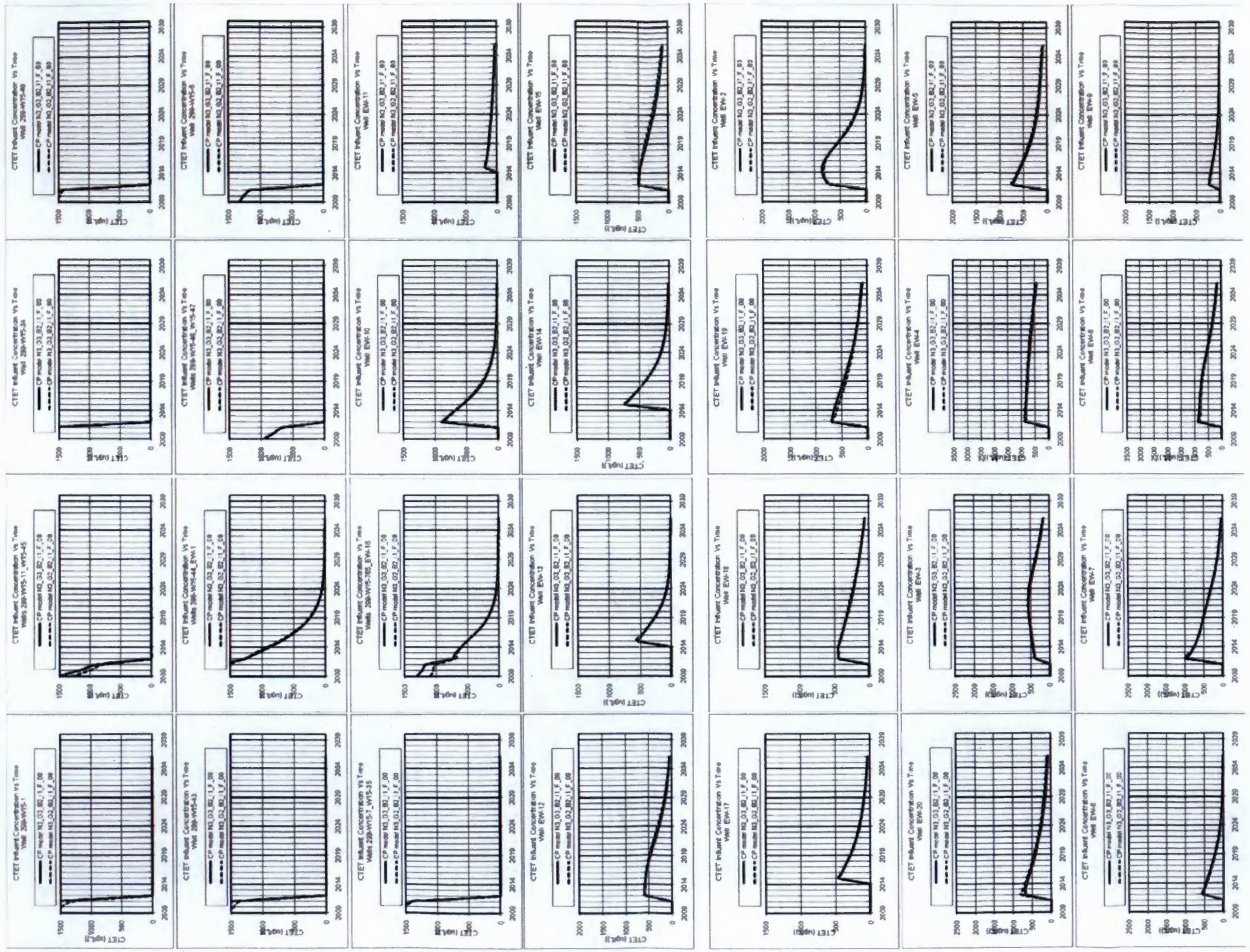

Figure C-3. Sensitivity Case 1: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

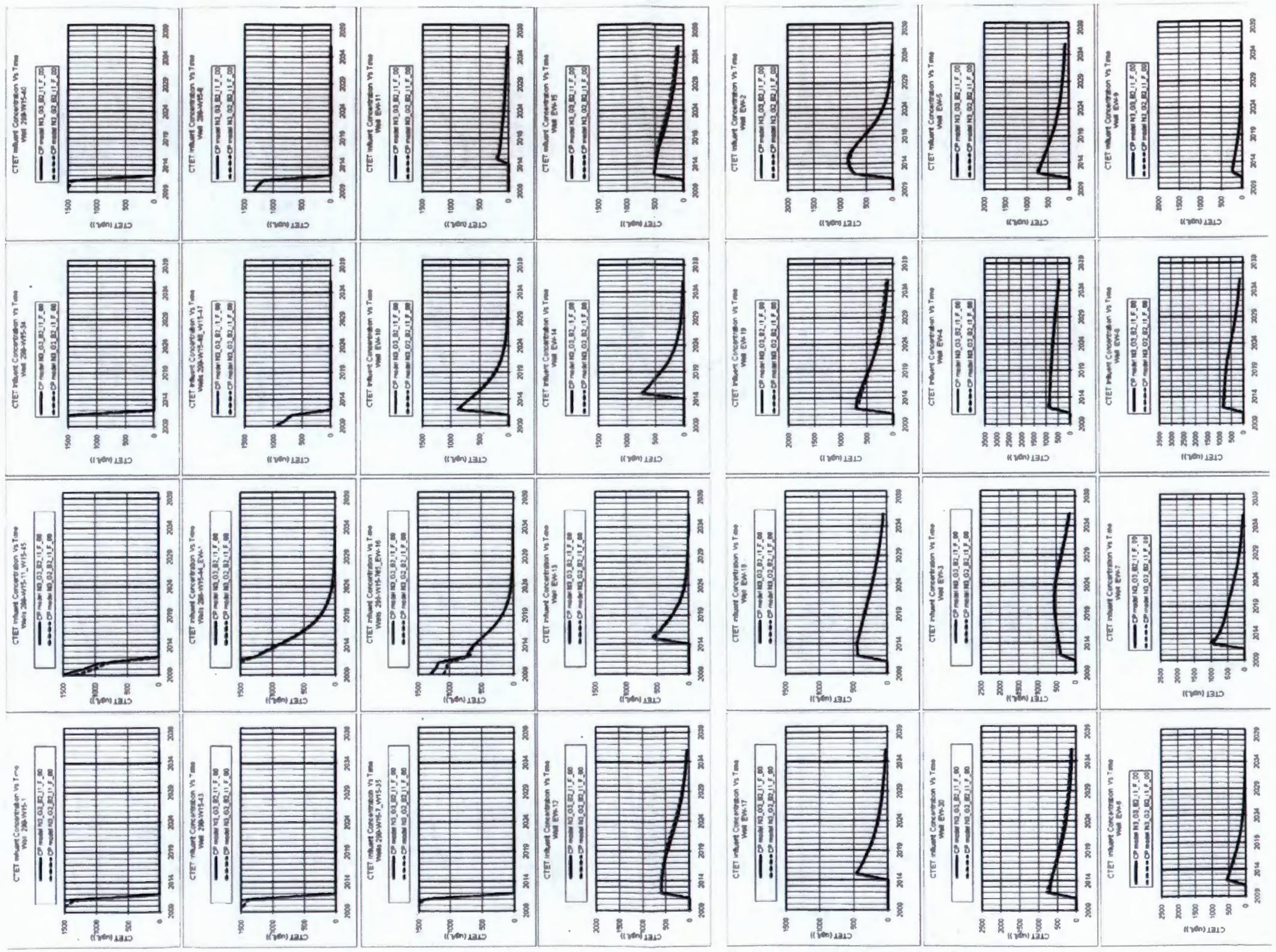

Figure C-4. Sensitivity Case 2: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

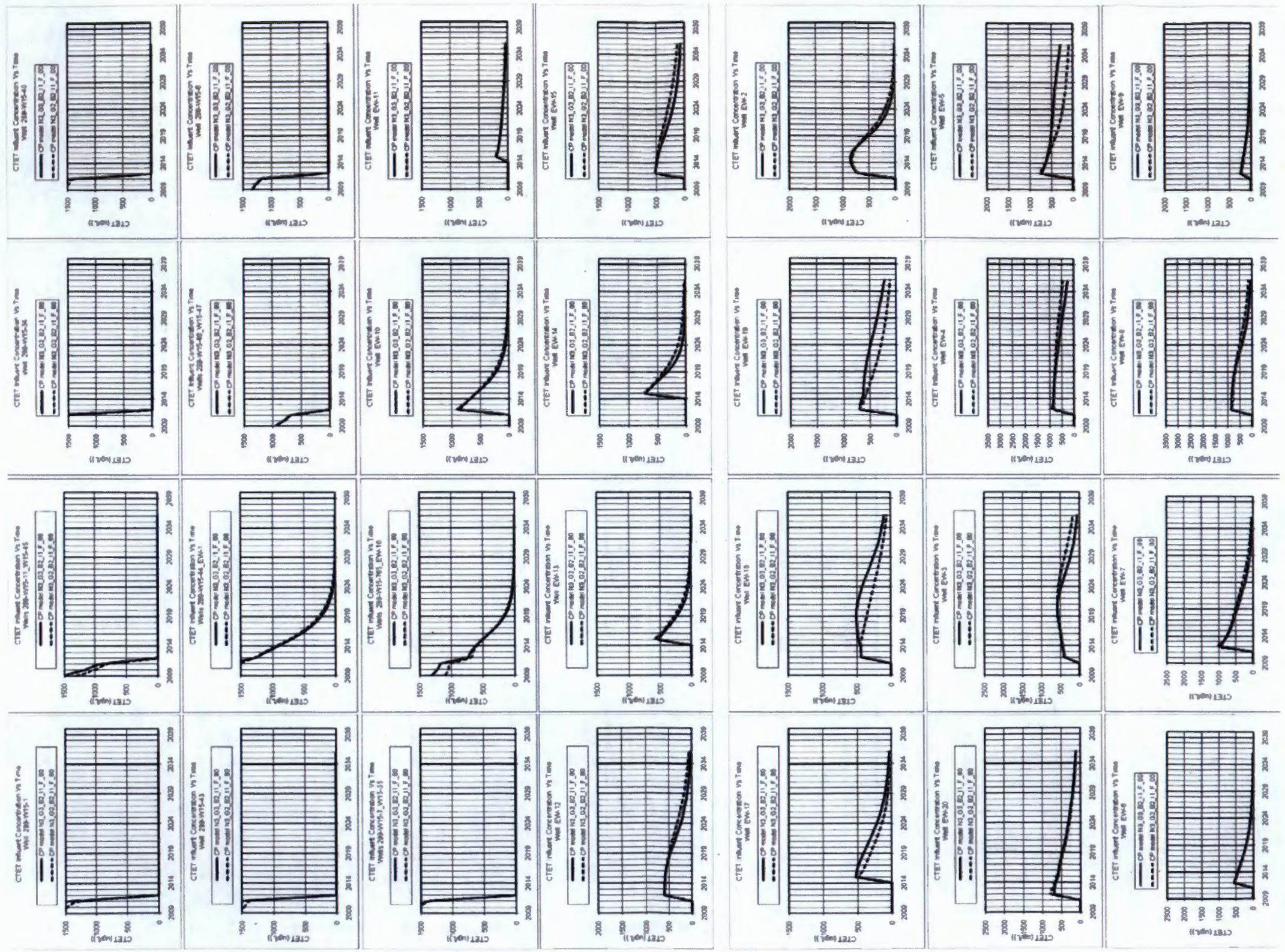

Figure C-5. Sensitivity Case 3: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

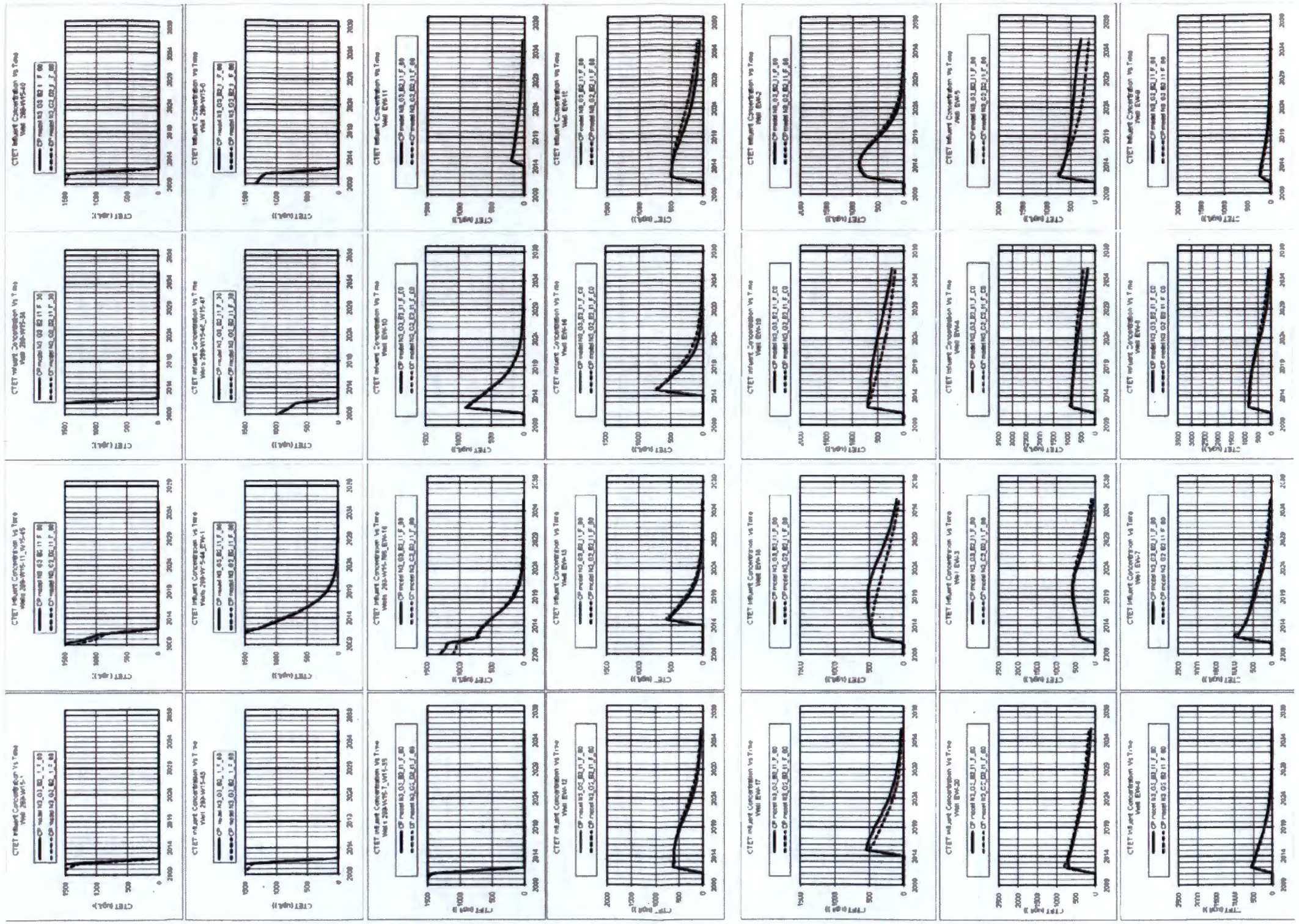

Figure C-6. Sensitivity Case 4: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

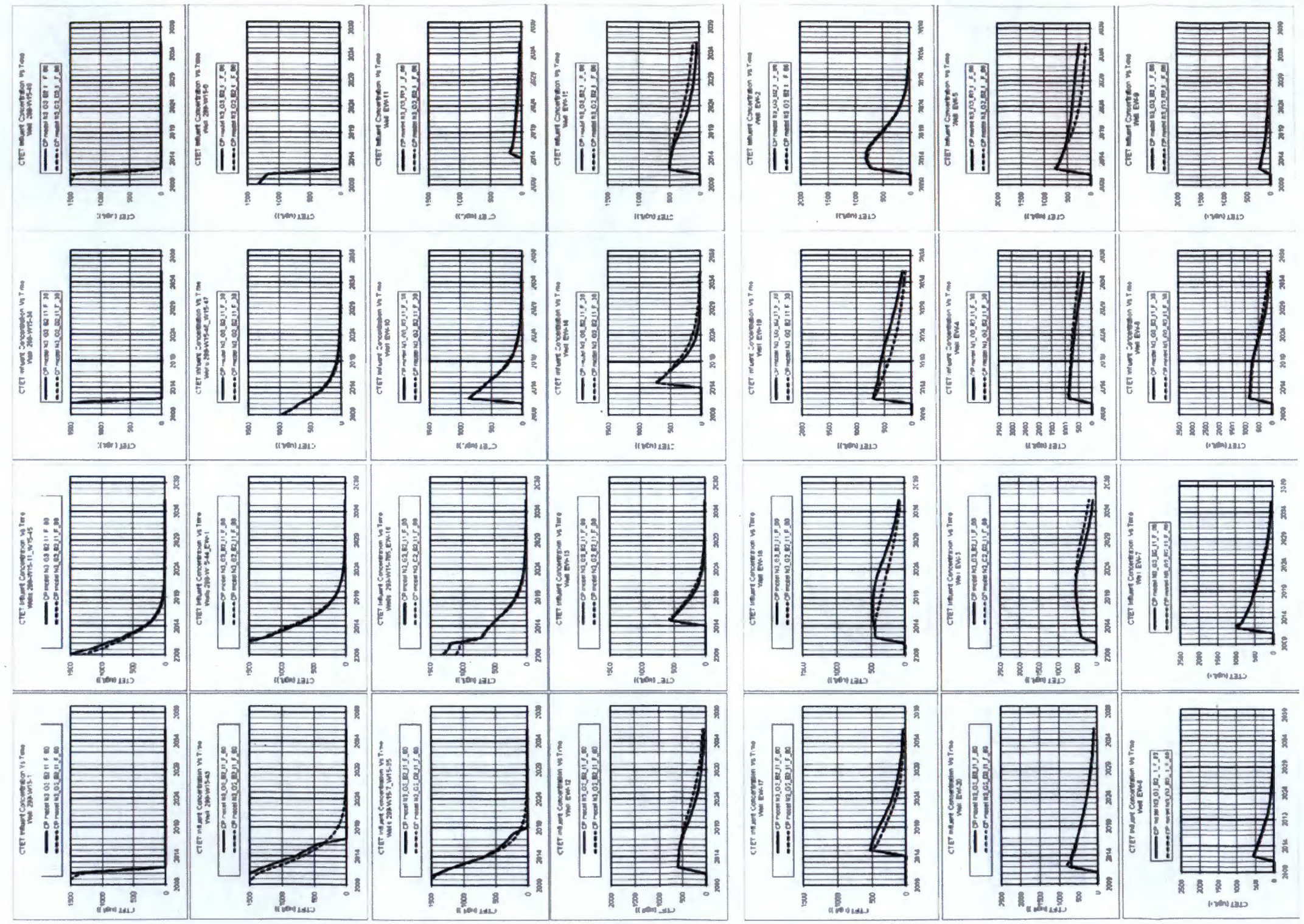

Figure C-7. Sensitivity Case 5: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

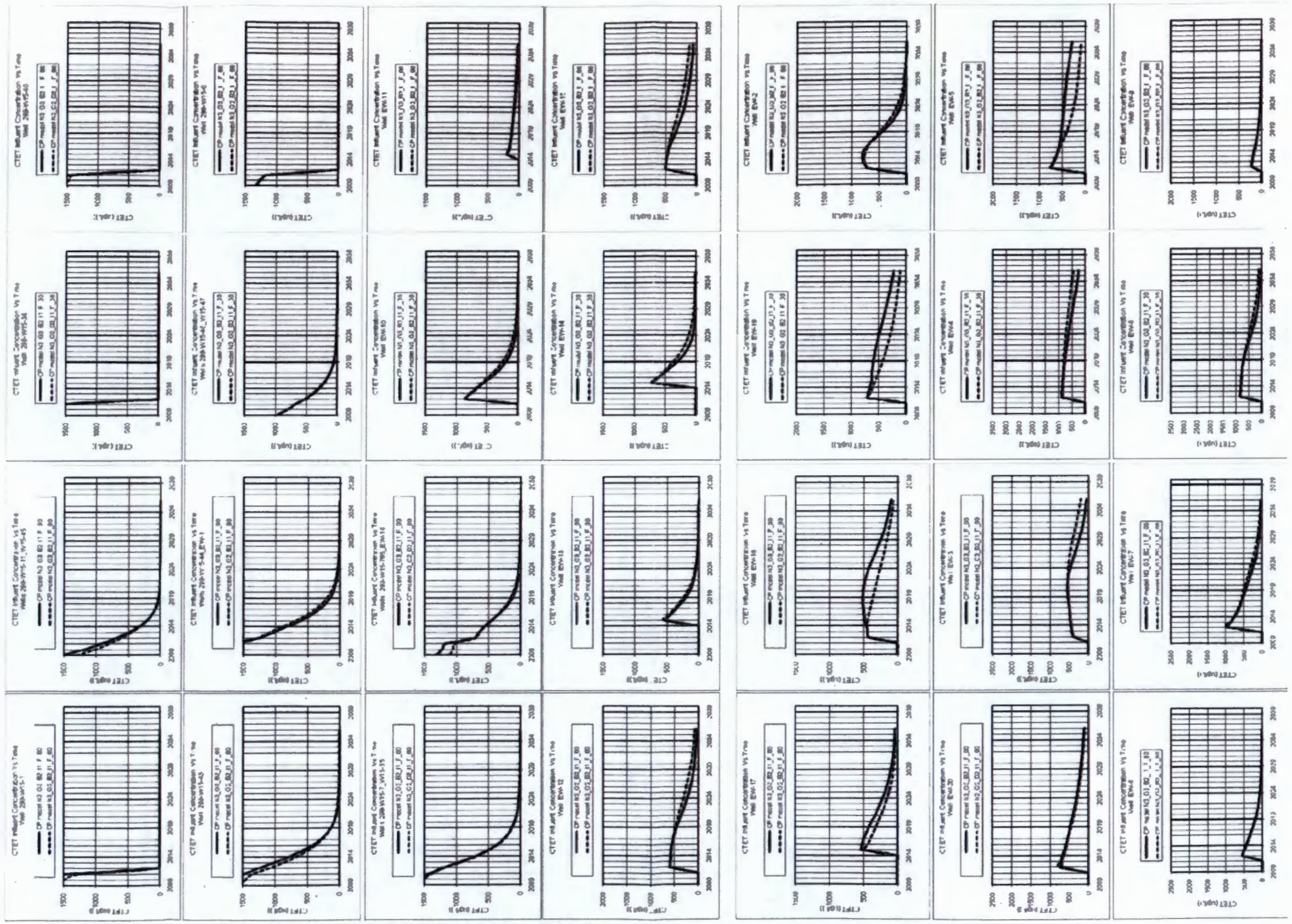

Figure C-8. Sensitivity Case 6: Flow-Weighted Influent Concentrations Versus Time (100-Year Half-Life)

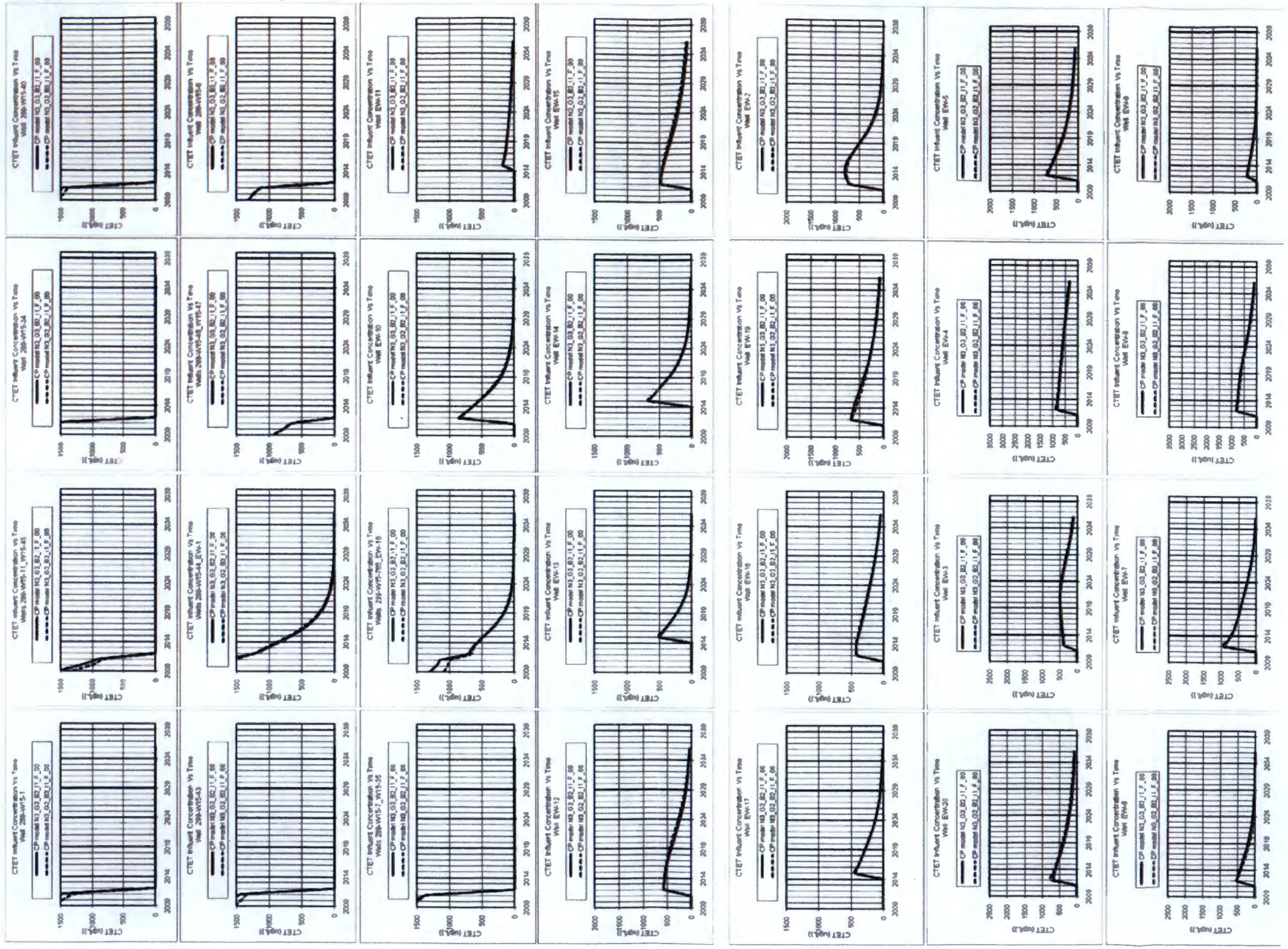

Figure C-9. Base Case 1: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

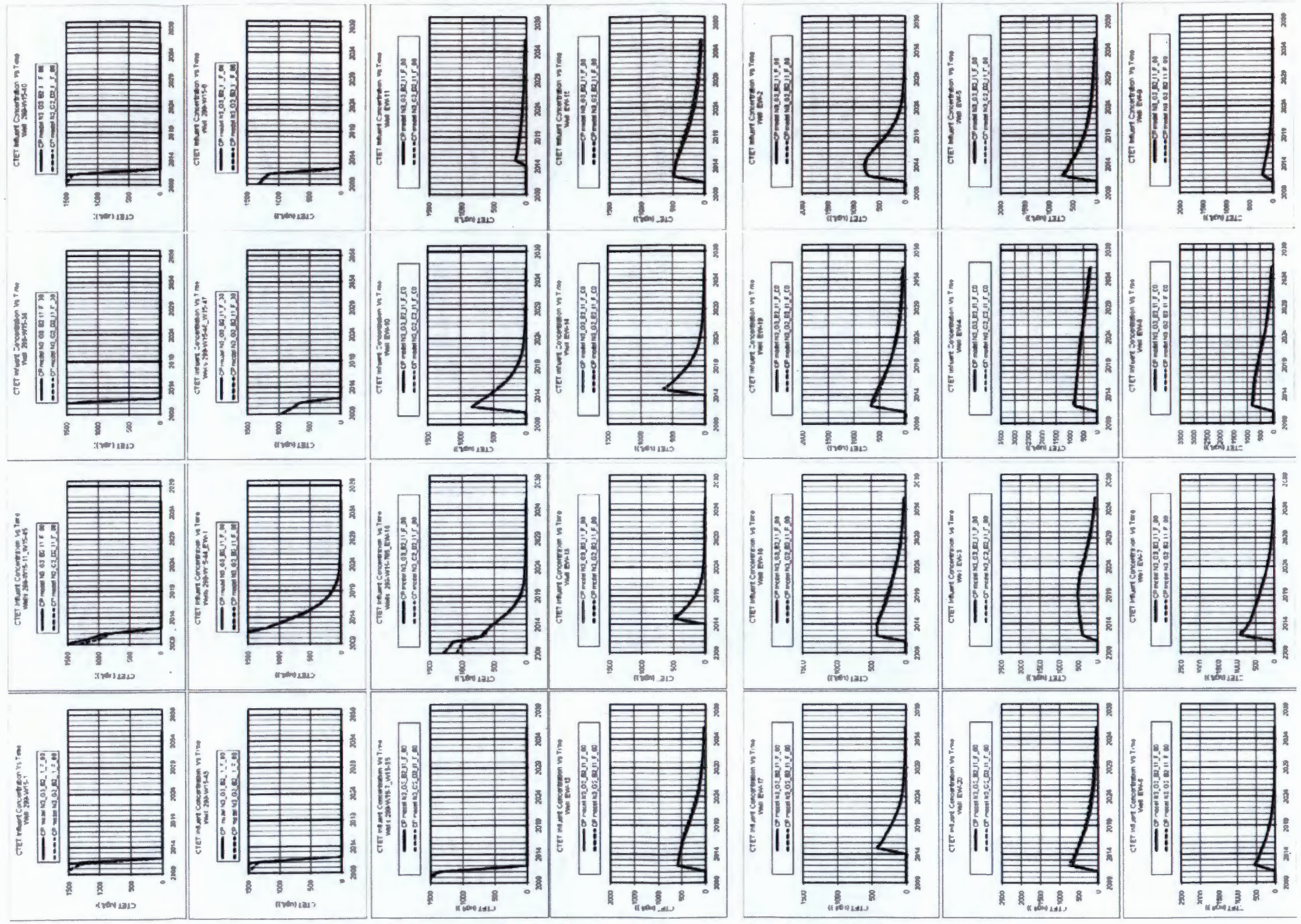

Figure C-10. Base Case 2: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

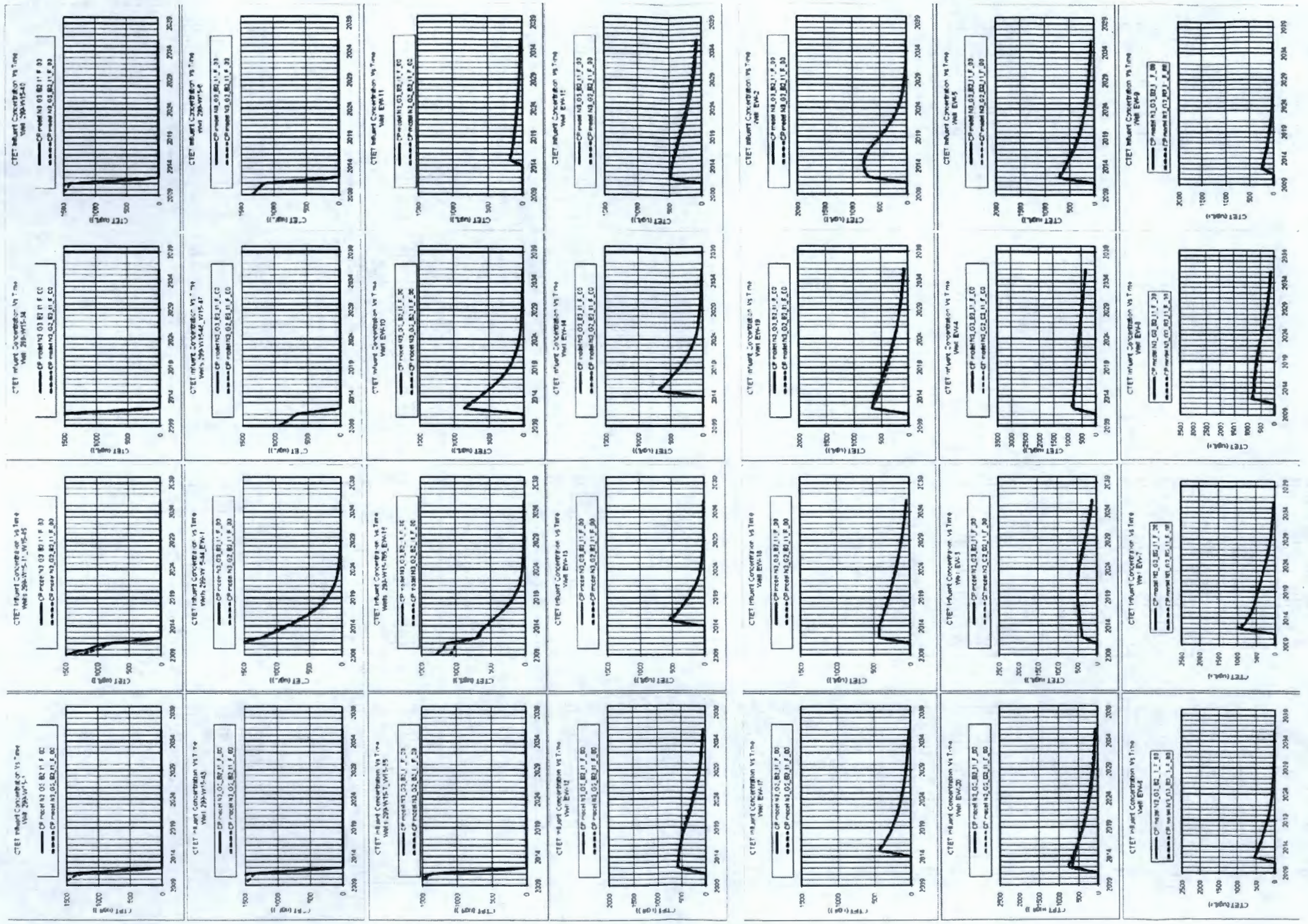

Figure C-11. Sensitivity Case 1: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

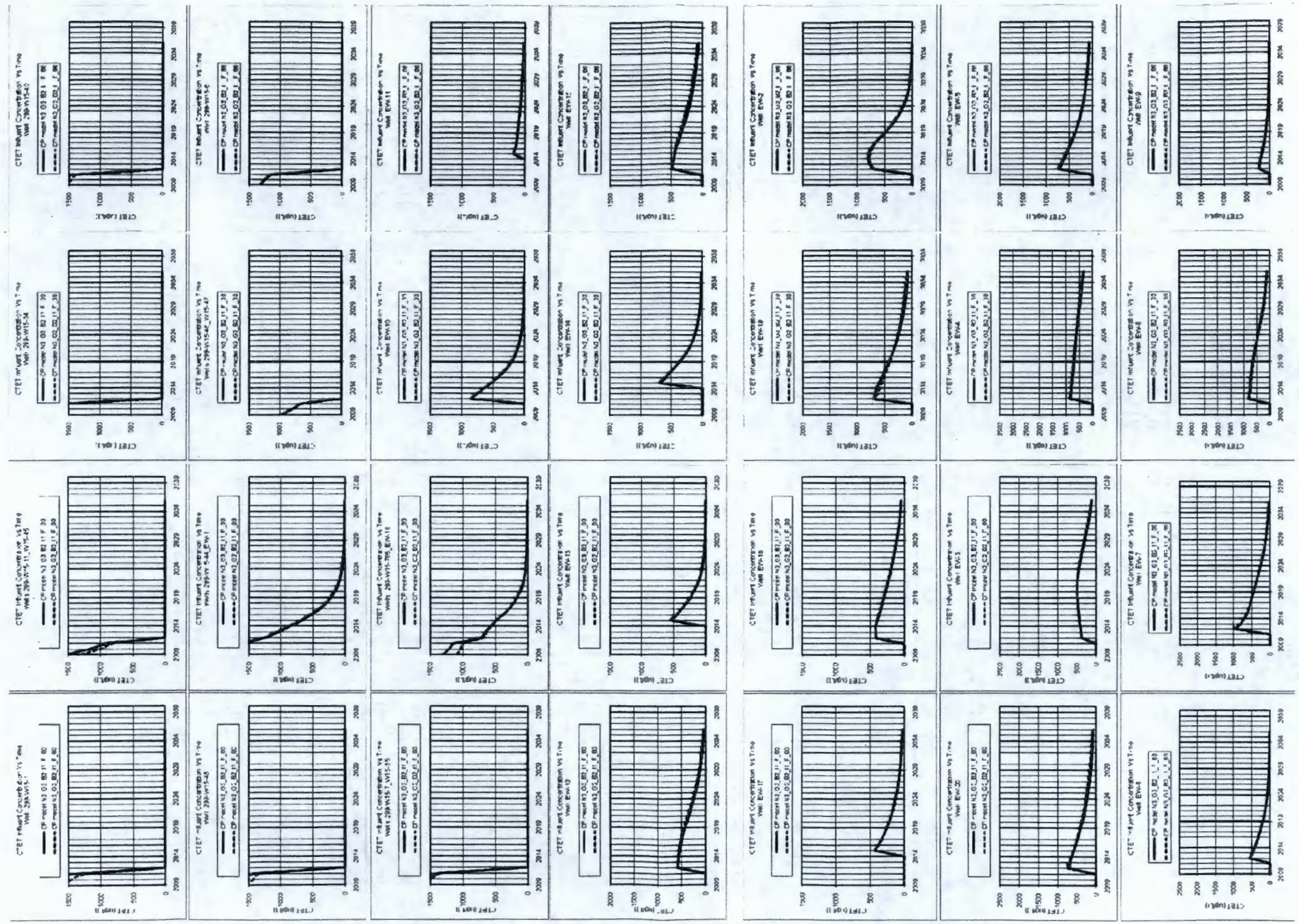

Figure C-12. Sensitivity Case 2: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

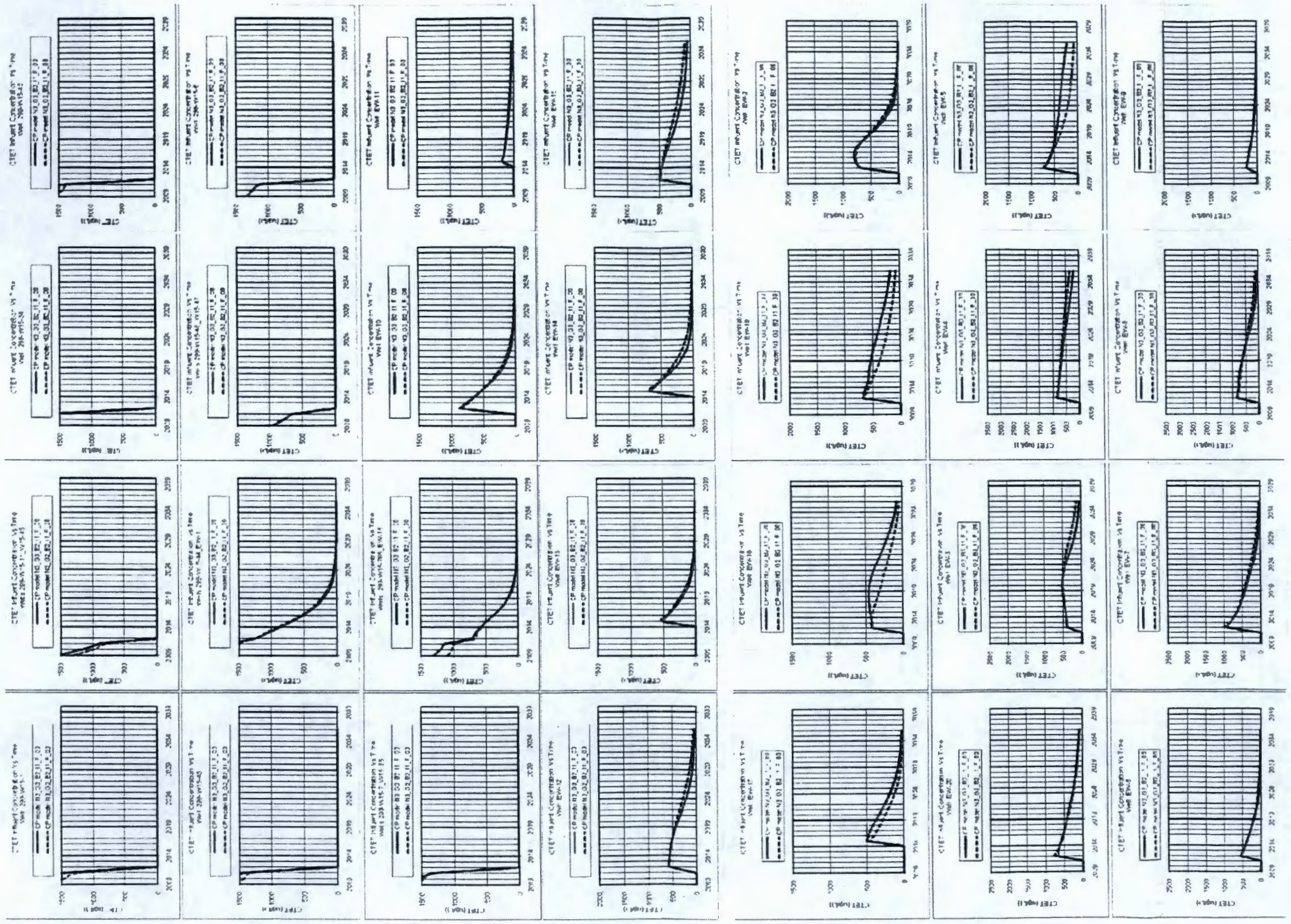

Figure C-13. Sensitivity Case 3: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

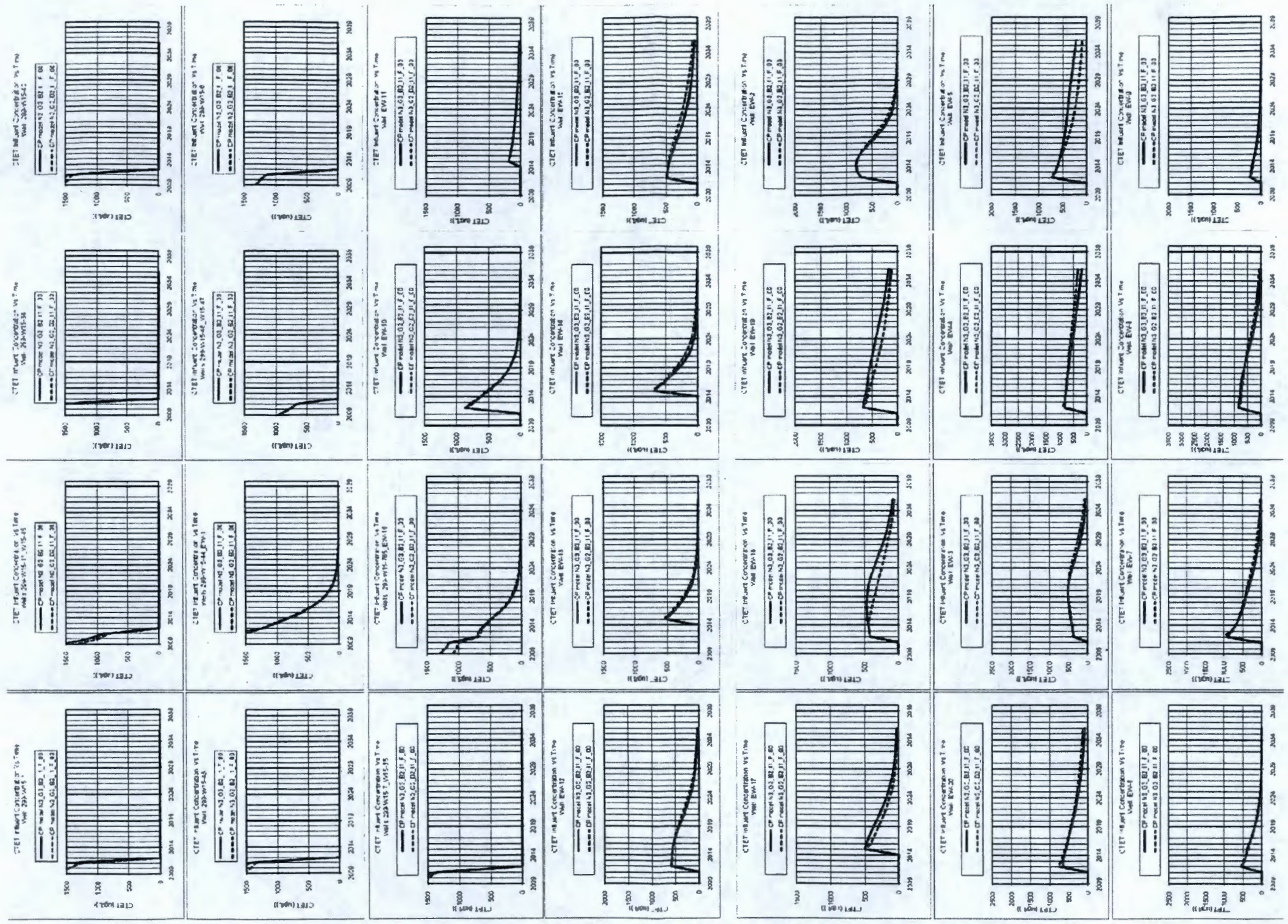

Figure C-14. Sensitivity Case 4: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

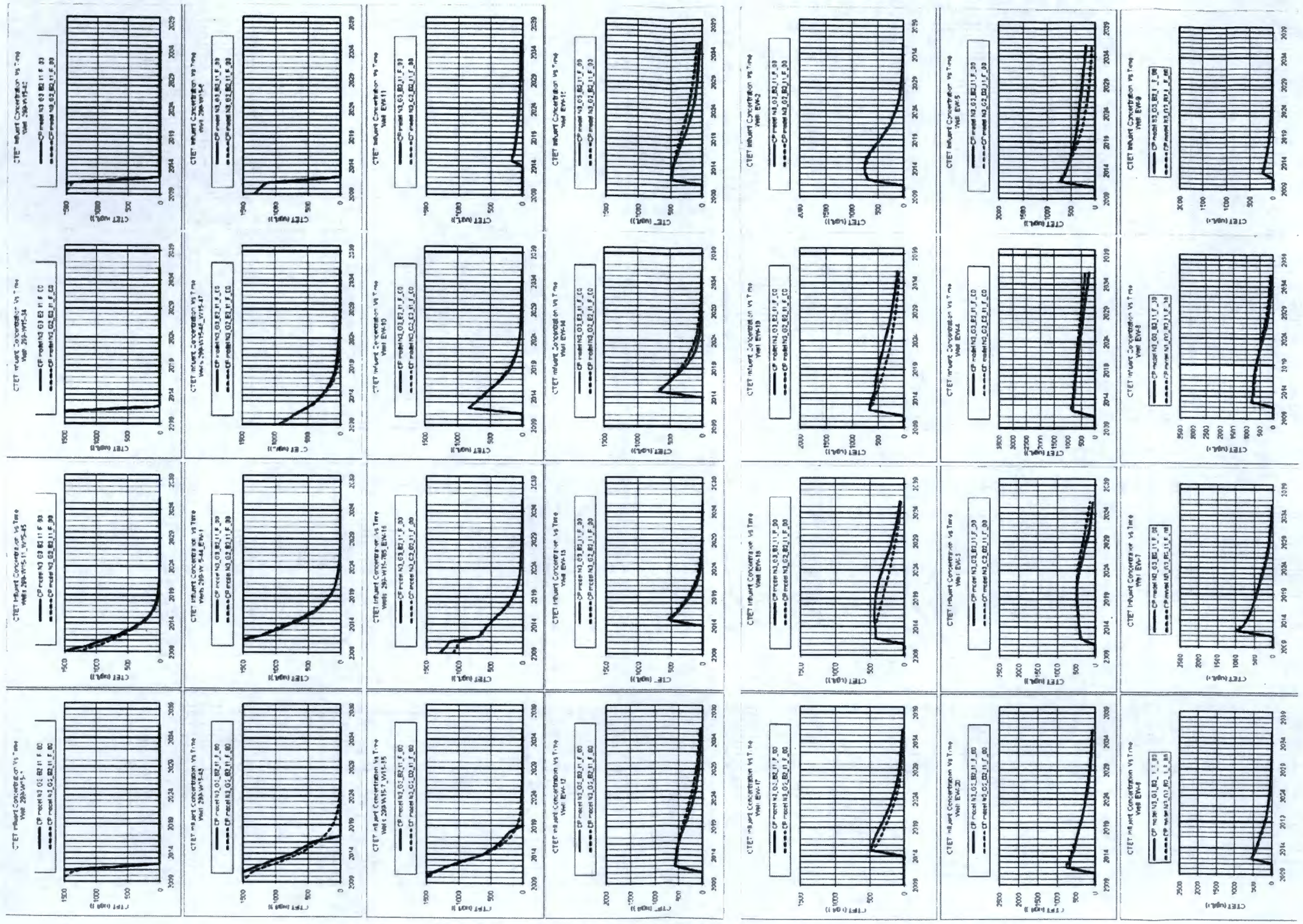

Figure C-15. Sensitivity Case 5: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

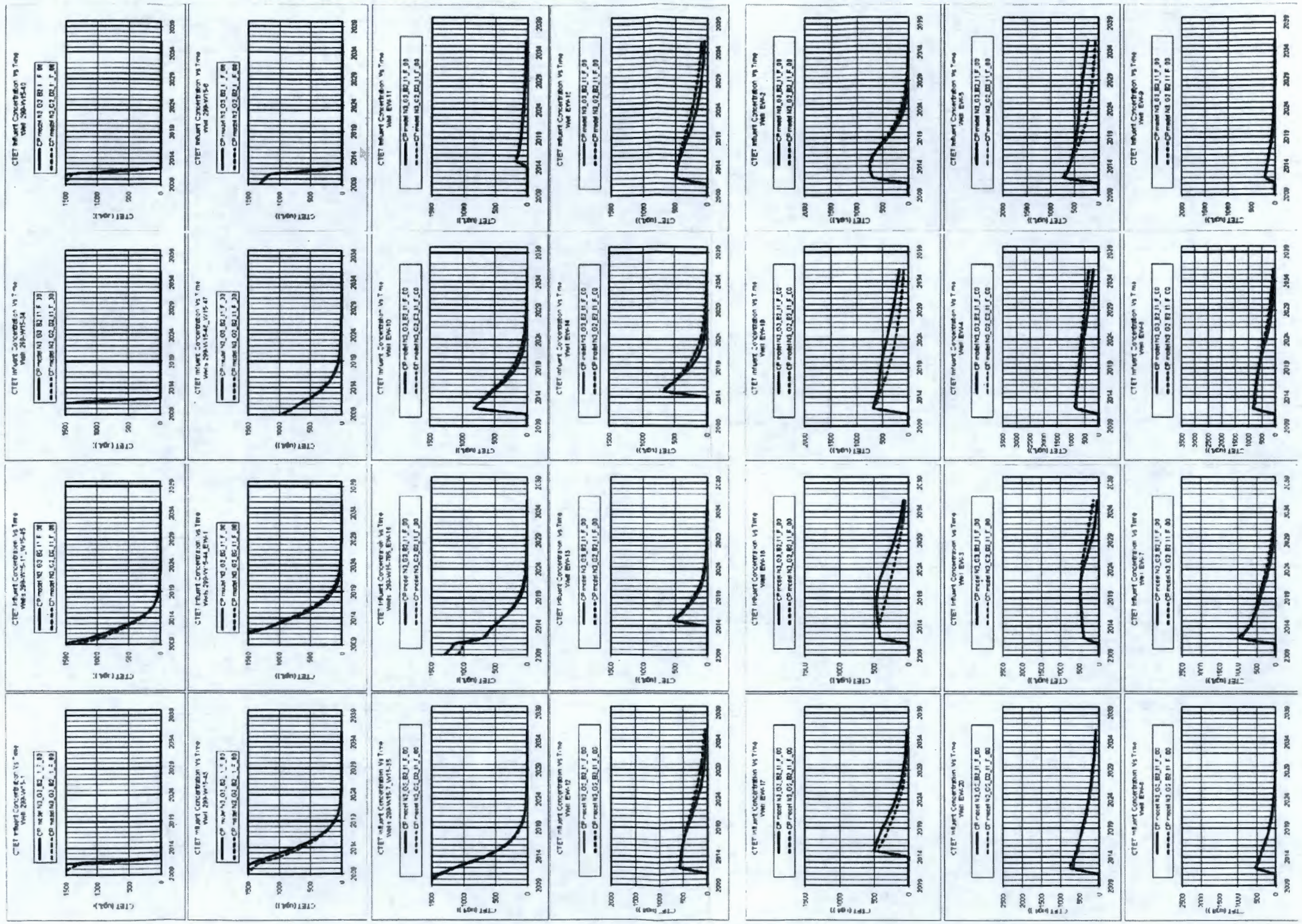

Figure C-16. Sensitivity Case 6: Flow-Weighted Influent Concentrations Versus Time (41-Year Half-Life)

Appendix D

Simulated Mass Recovery by Well

Figures

Figure D-1. Base Case 1: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-1
Figure D-2. Base Case 2: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-2
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Figure D-4. Sensitivity Case 2: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-4
Figure D-5. Sensitivity Case 3: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-5
Figure D-6. Sensitivity Case 4: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-6
Figure D-7. Sensitivity Case 5: Cumulative Mass Recovery Versus Time (100-Year Half-Life) D-7
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Figure D-9. Base Case 1: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-9
Figure D-10. Base Case 2: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-10
Figure D-11. Sensitivity Case 1: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-11
Figure D-12. Sensitivity Case 2: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-12
Figure D-13. Sensitivity Case 3: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-13
Figure D-14. Sensitivity Case 4: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-14
Figure D-15. Sensitivity Case 5: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-15
Figure D-16. Sensitivity Case 6: Cumulative Mass Recovery Versus Time (41-Year Half-Life) D-16

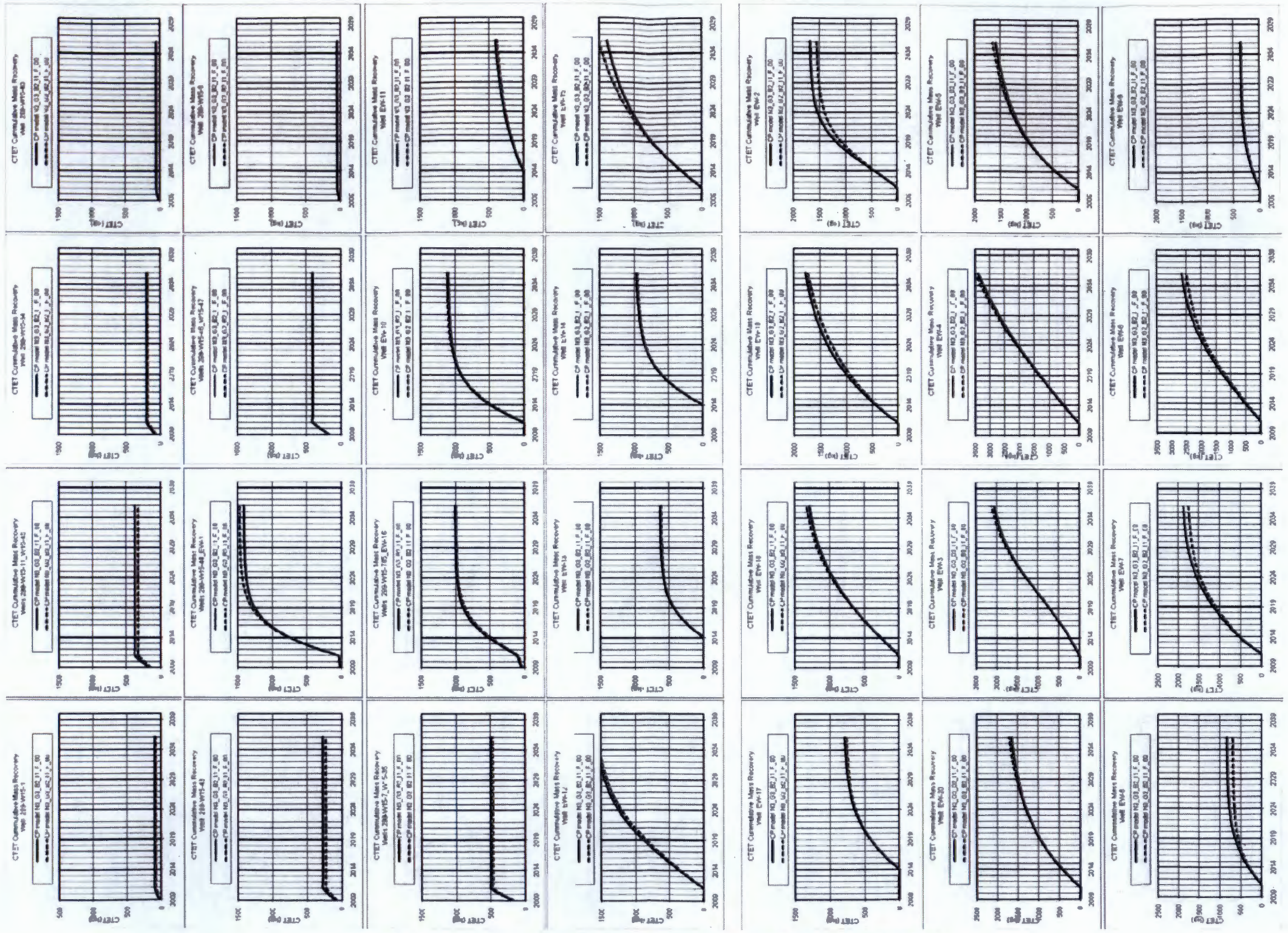

Figure D-1. Base Case 1: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

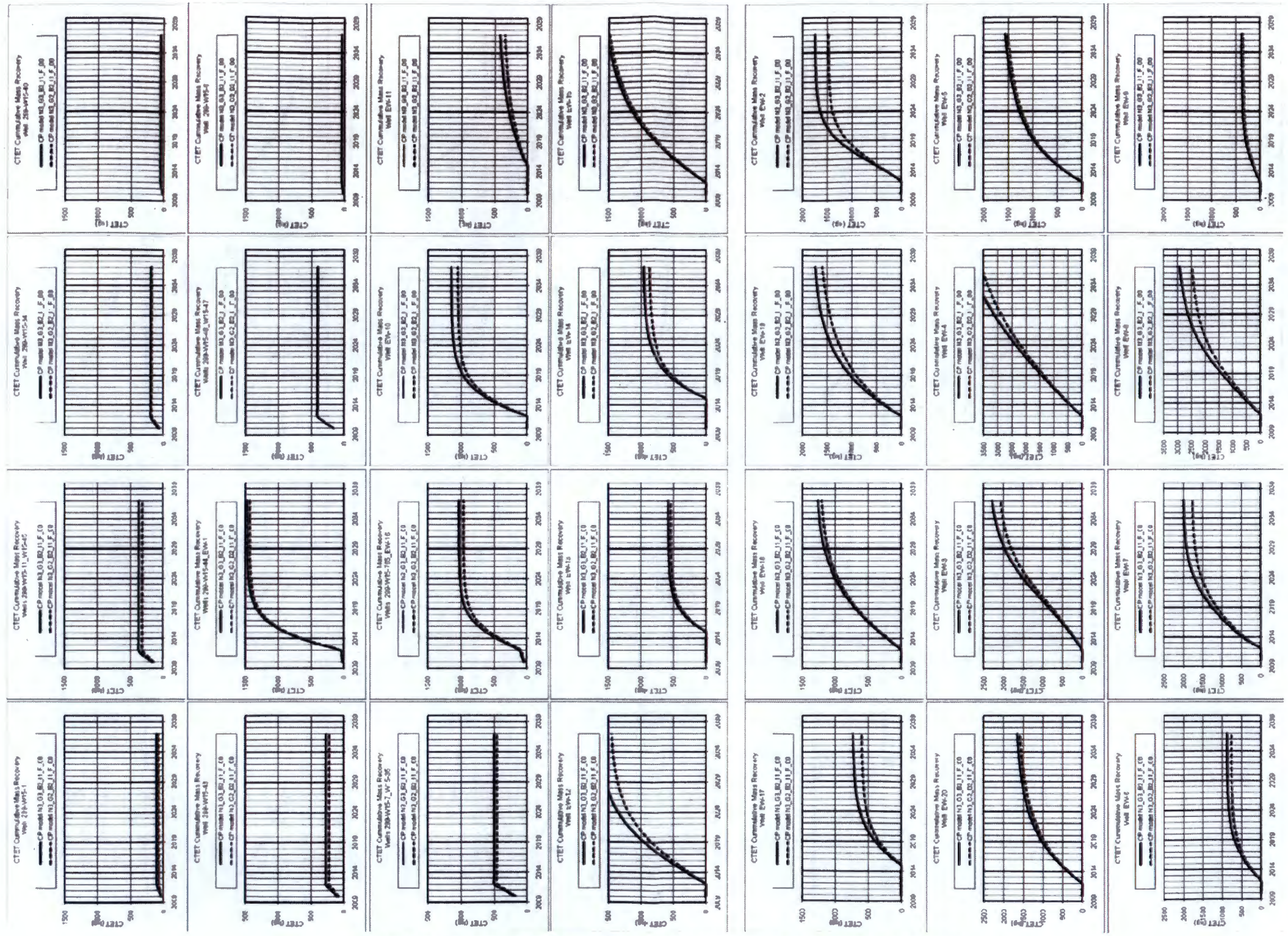

Figure D-2. Base Case 2: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

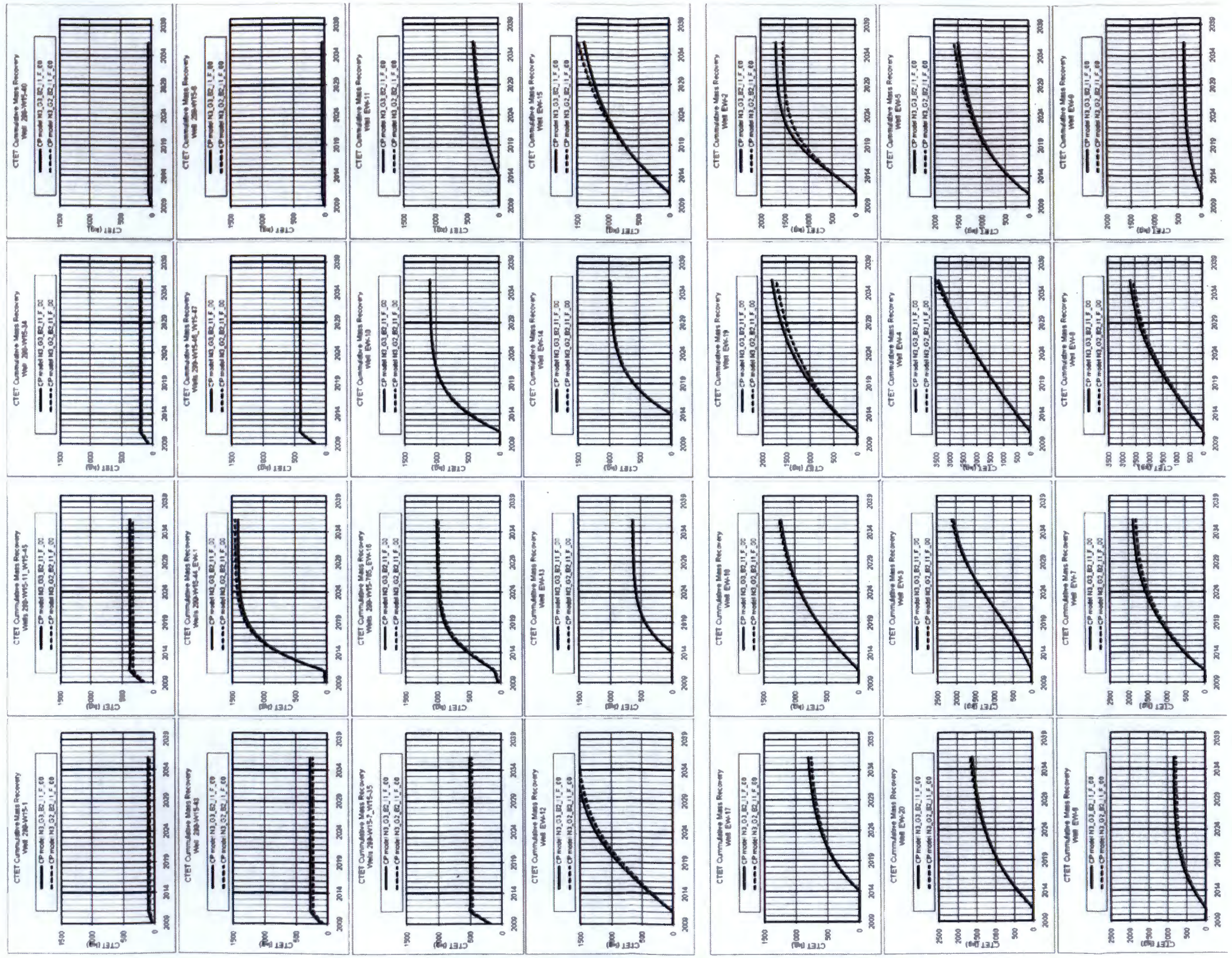

Figure D-3. Sensitivity Case 1: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

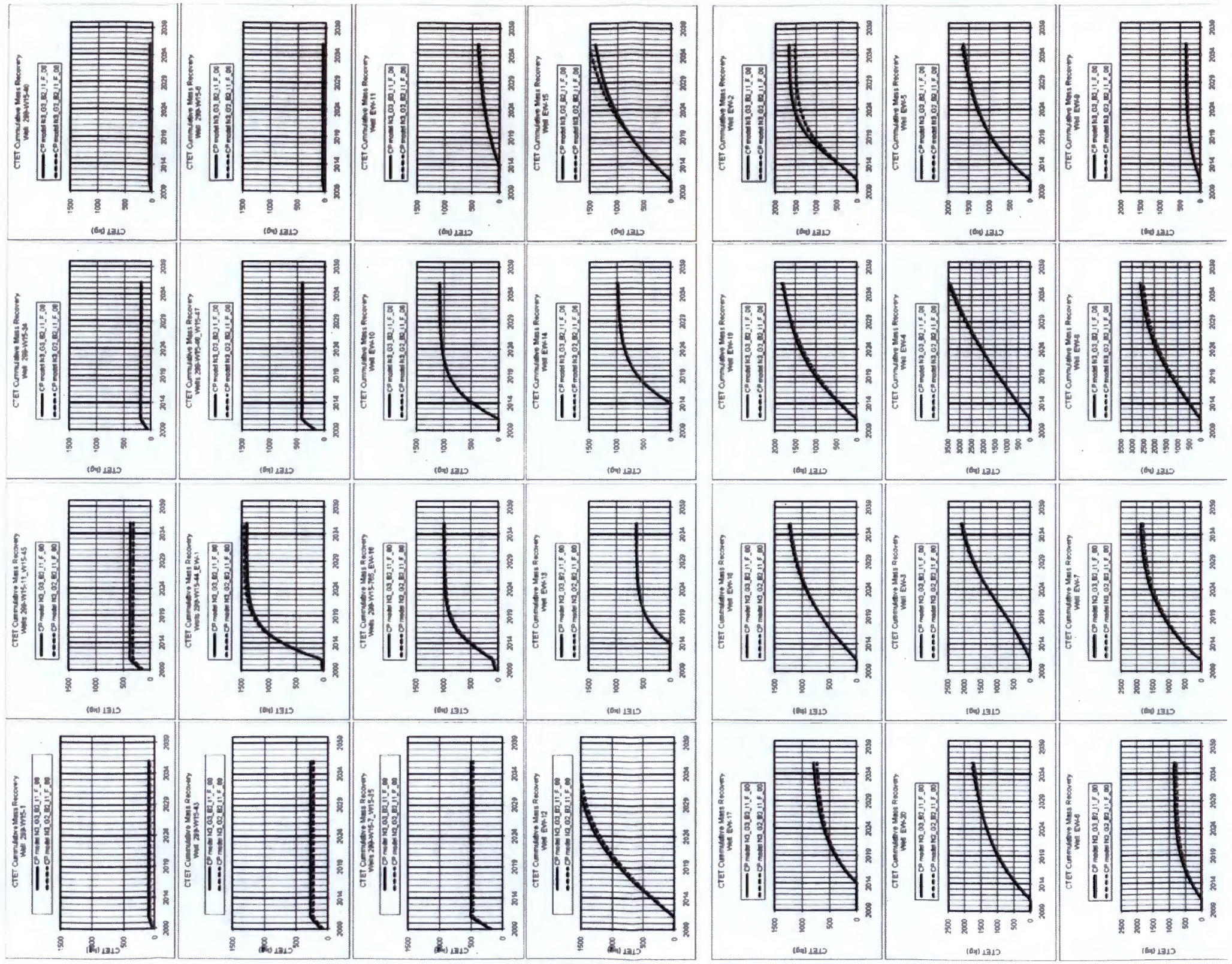

Figure D-4. Sensitivity Case 2: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

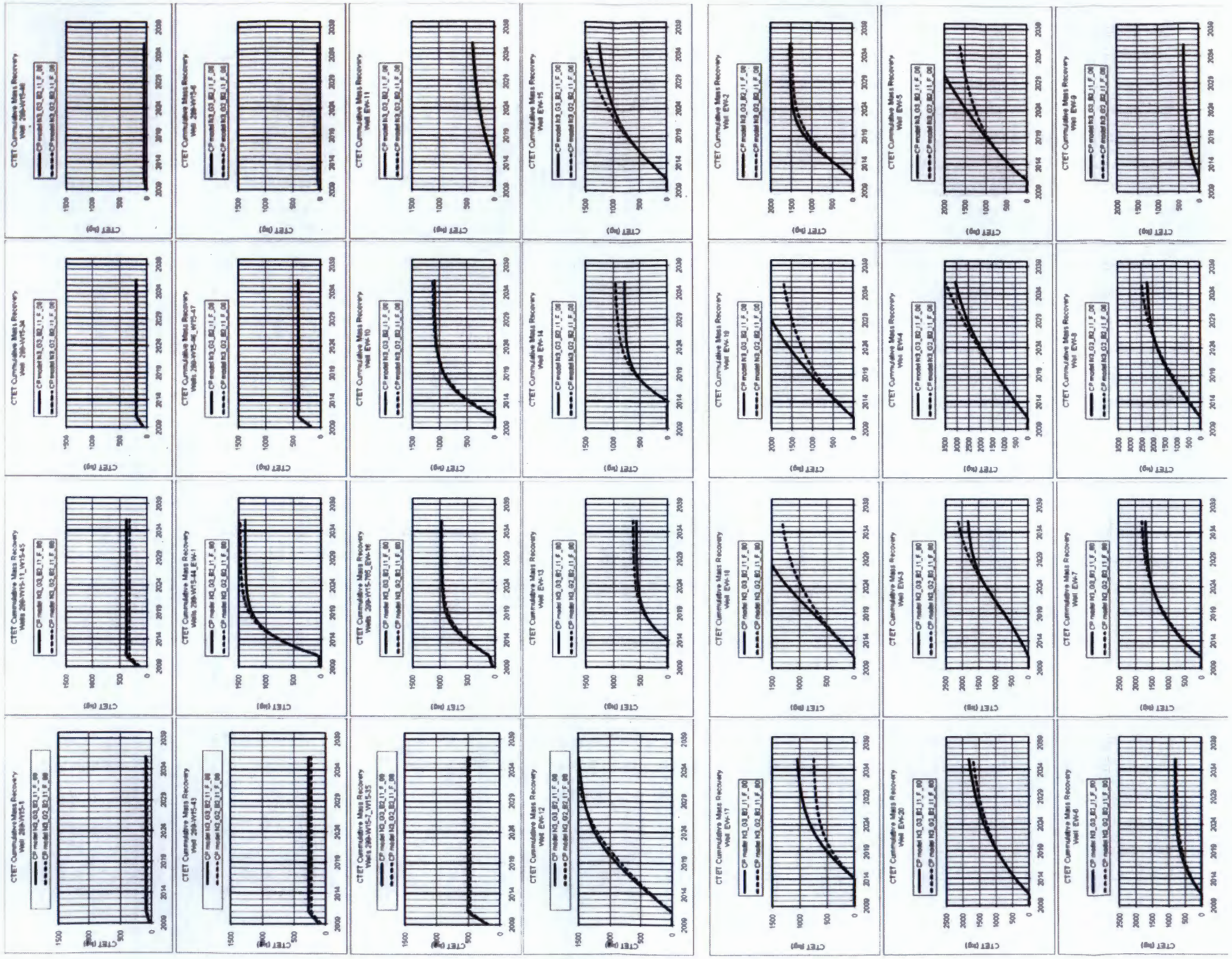

Figure D-5. Sensitivity Case 3: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

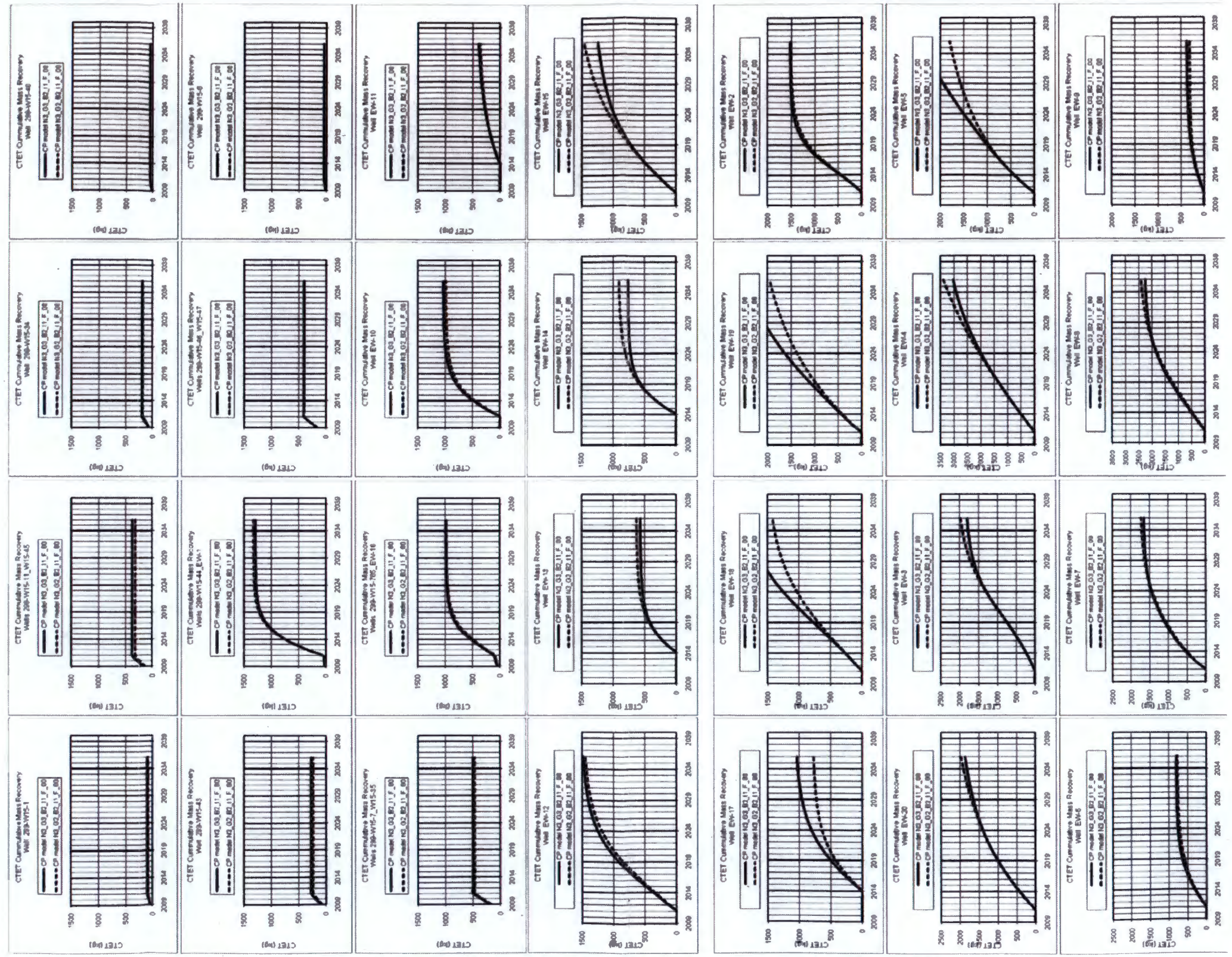

Figure D-6. Sensitivity Case 4: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

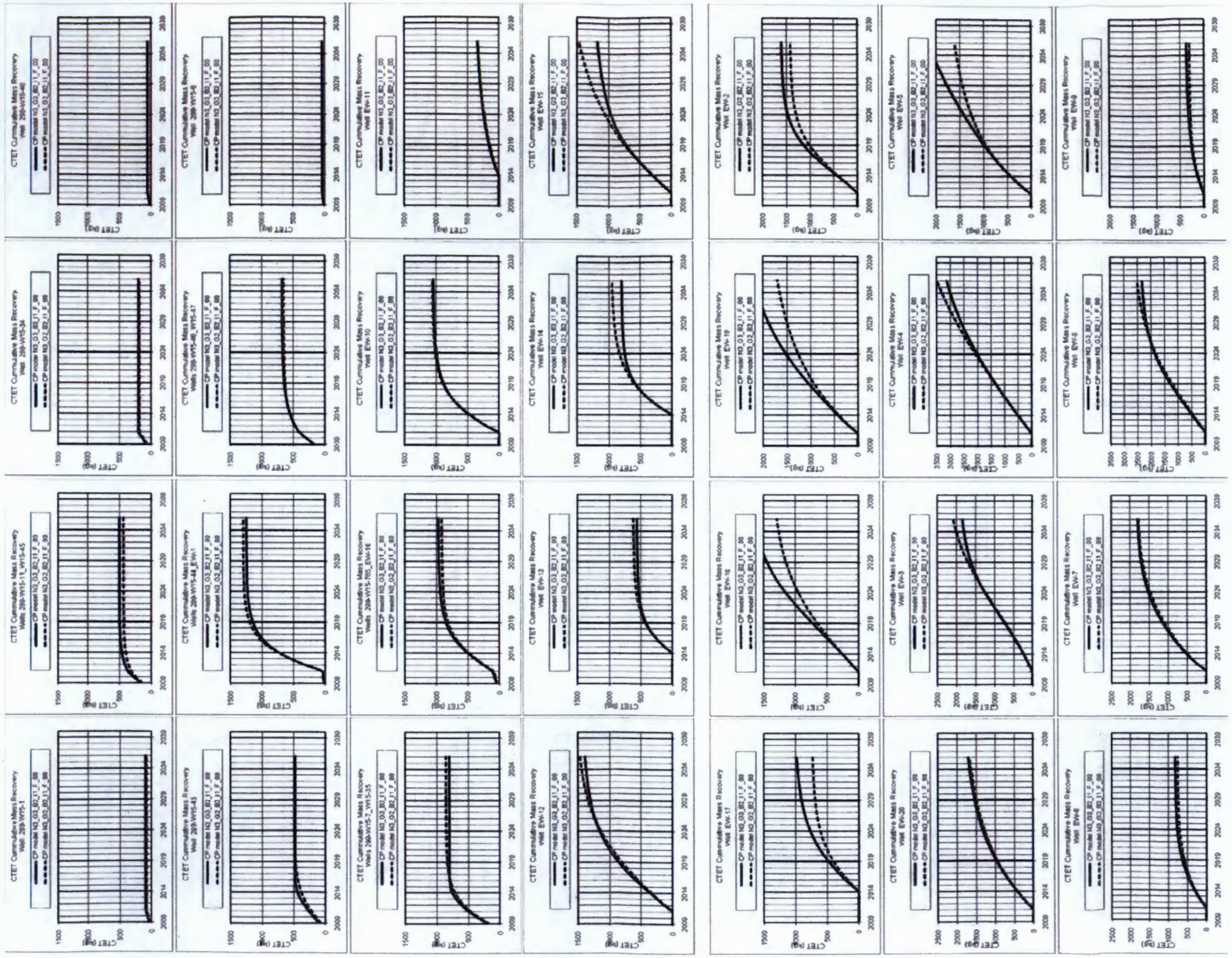

Figure D-7. Sensitivity Case 5: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

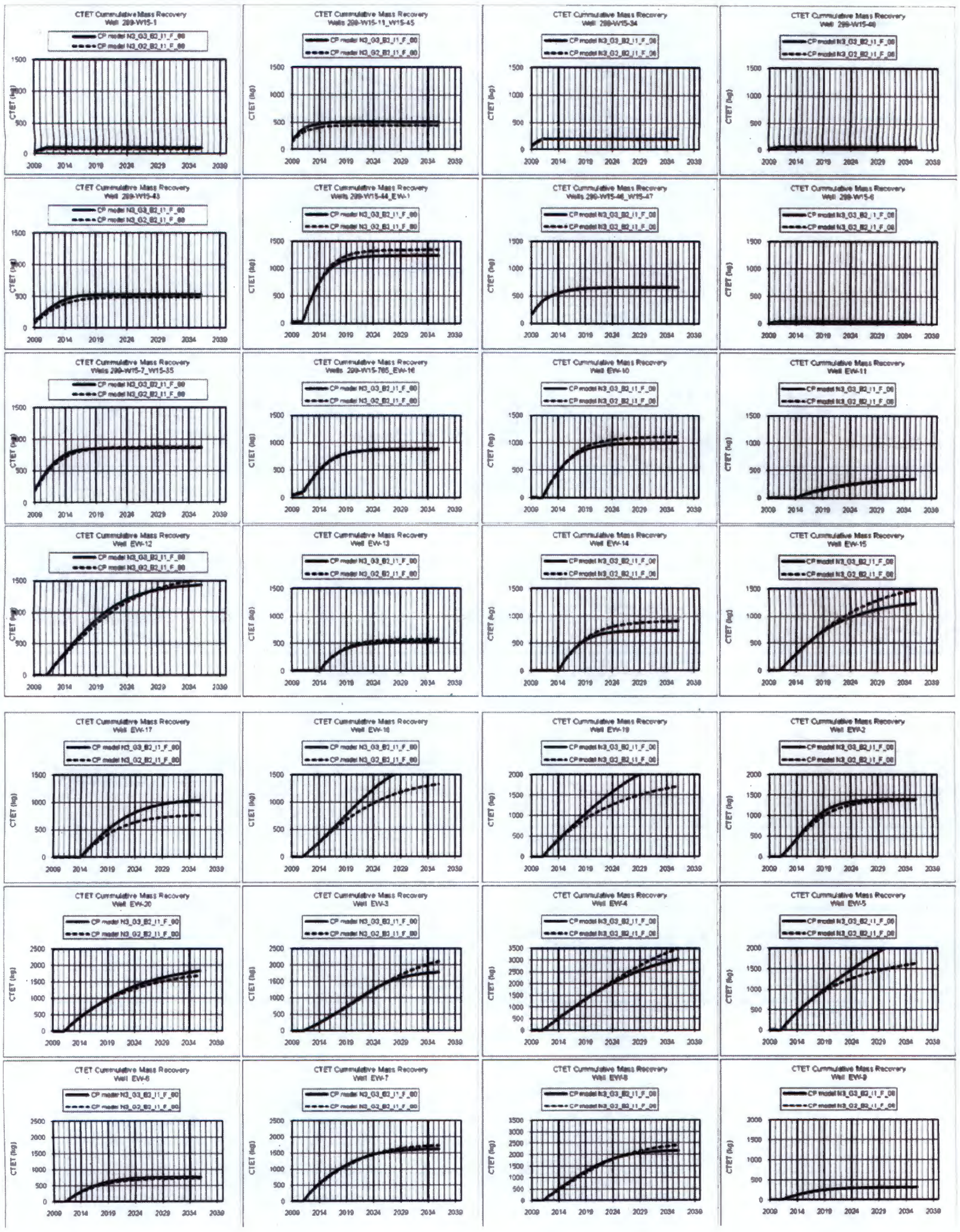

Figure D-8. Sensitivity Case 6: Cumulative Mass Recovery Versus Time (100-Year Half-Life)

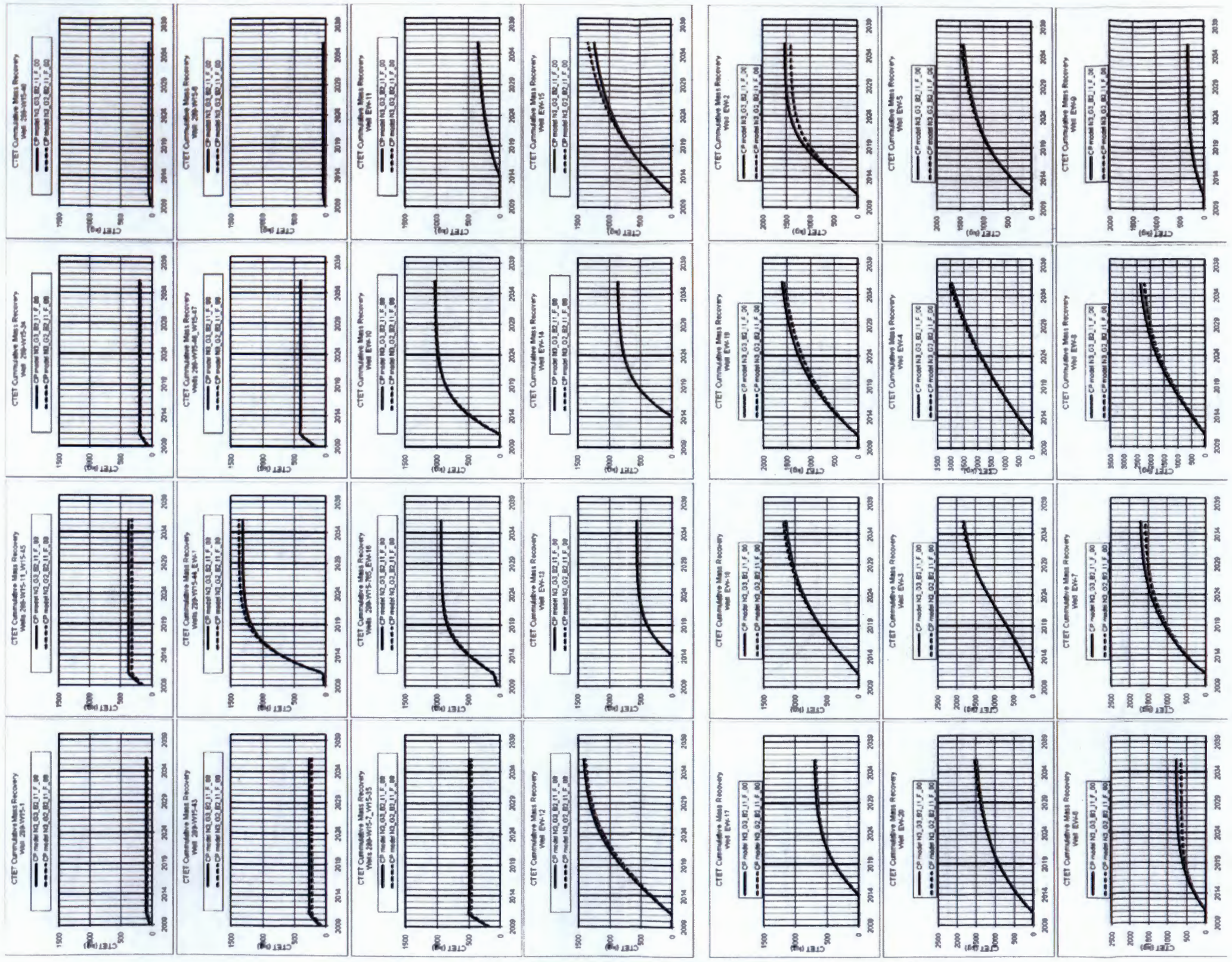

Figure D-9. Base Case 1: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

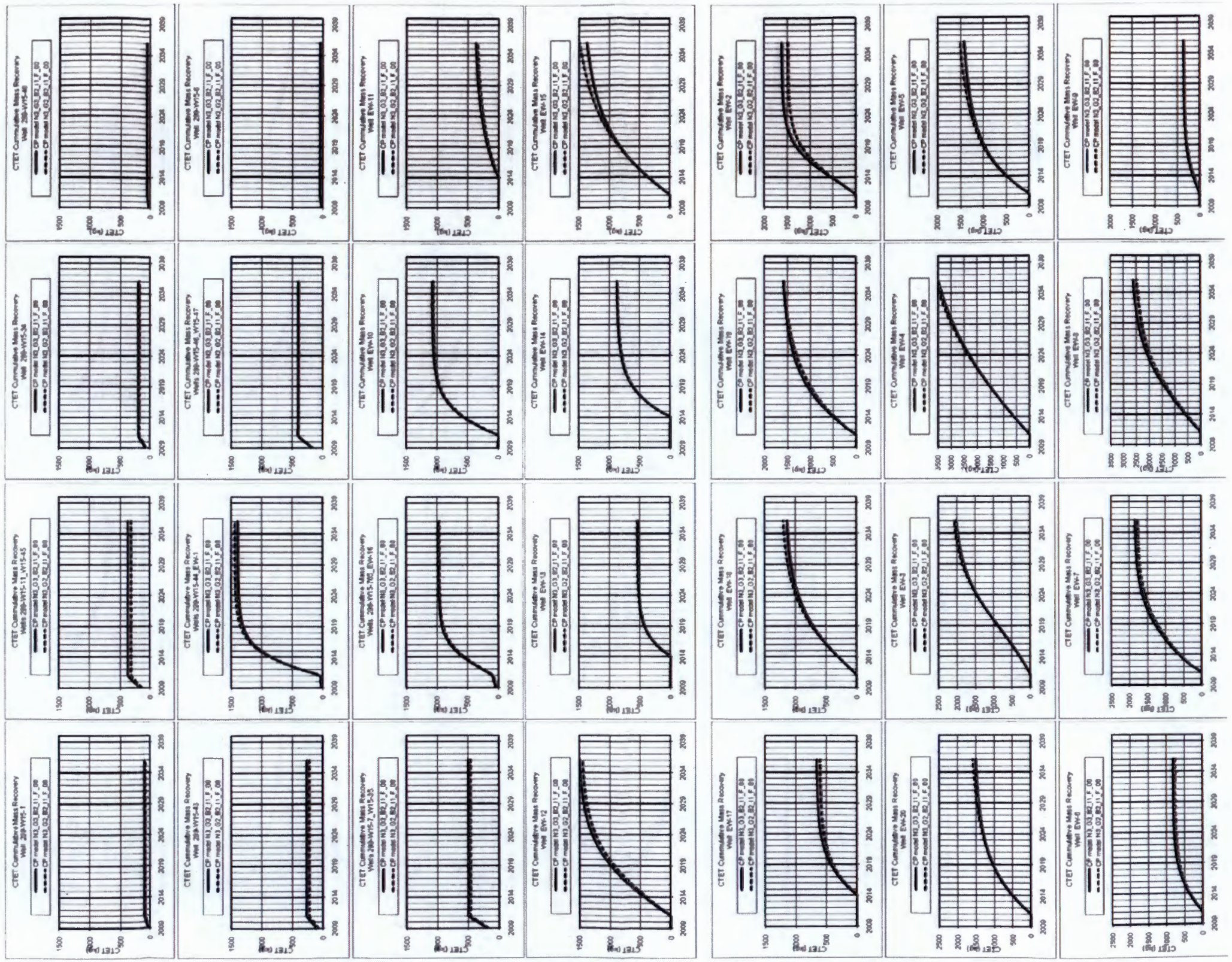

Figure D-10. Base Case 2: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

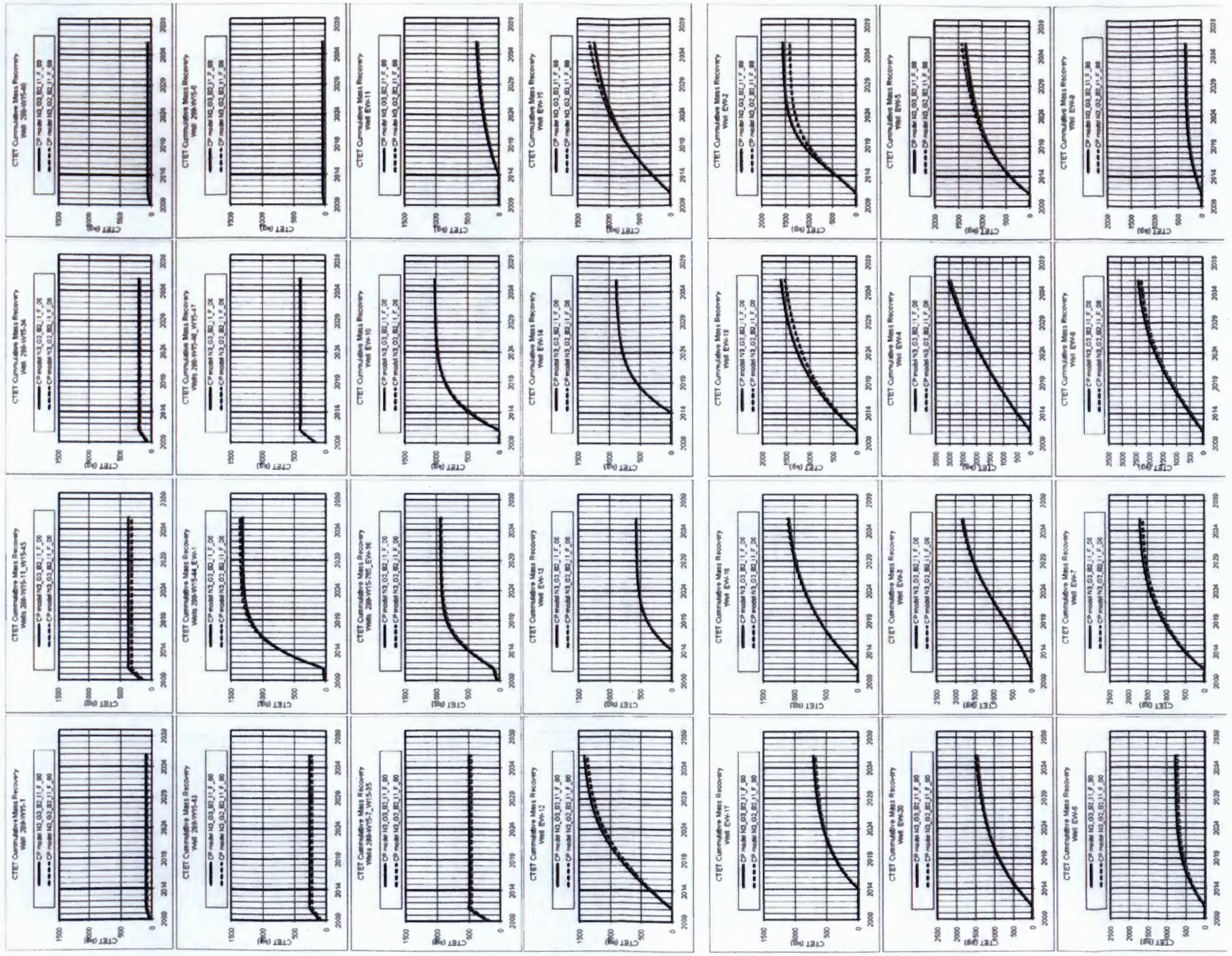

Figure D-11. Sensitivity Case 1: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

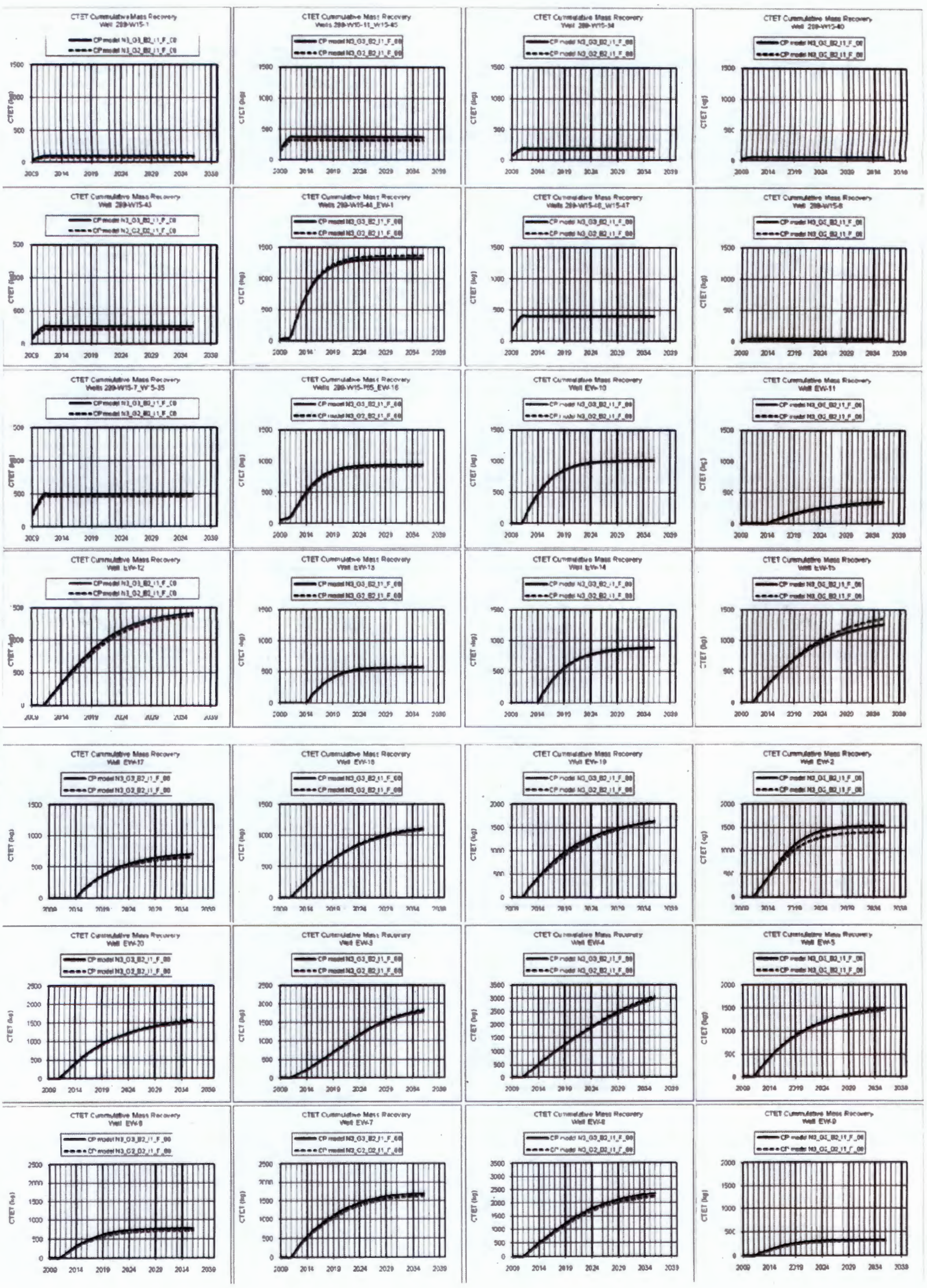

Figure D-12. Sensitivity Case 2: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

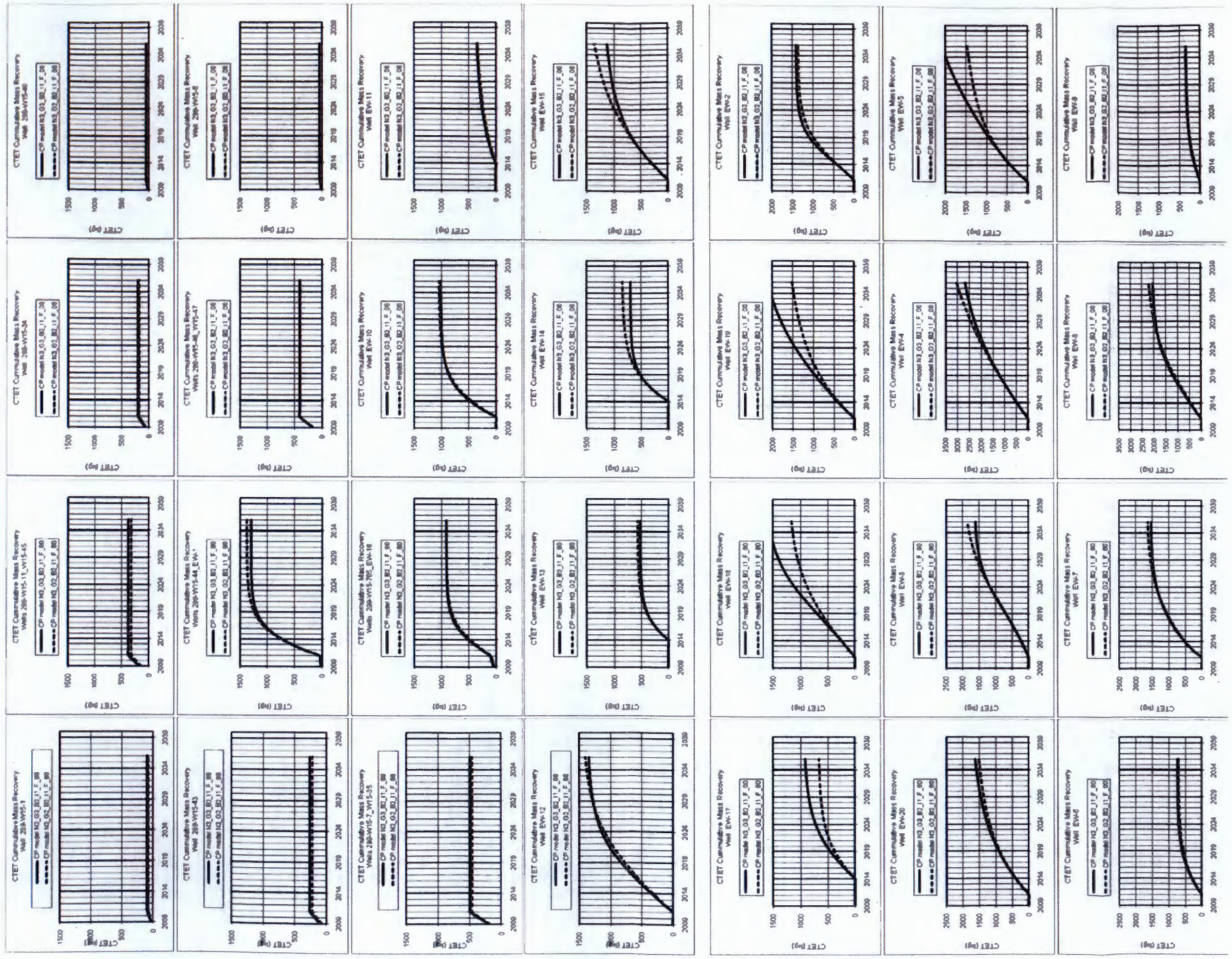

Figure D-13. Sensitivity Case 3: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

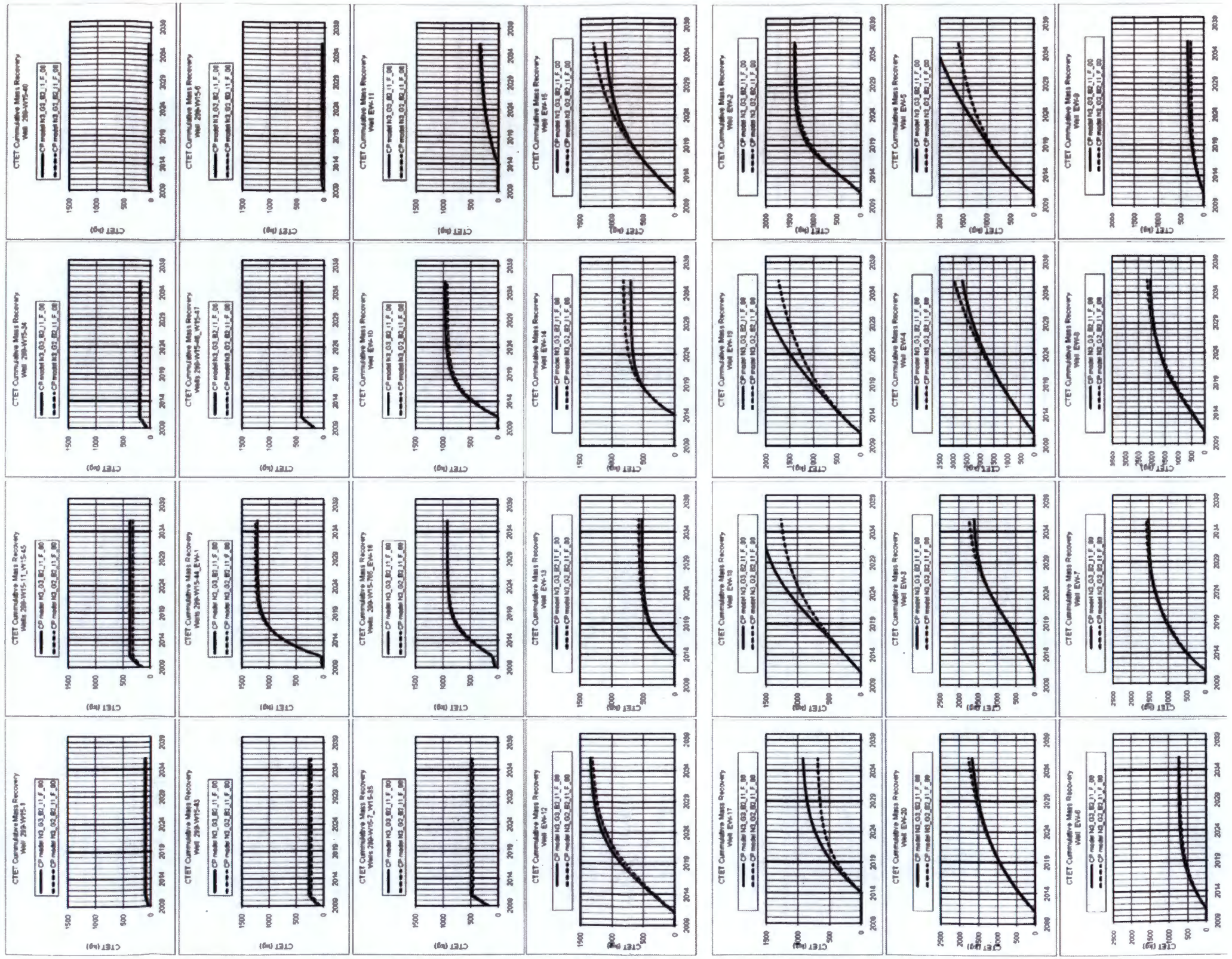

Figure D-14. Sensitivity Case 4: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

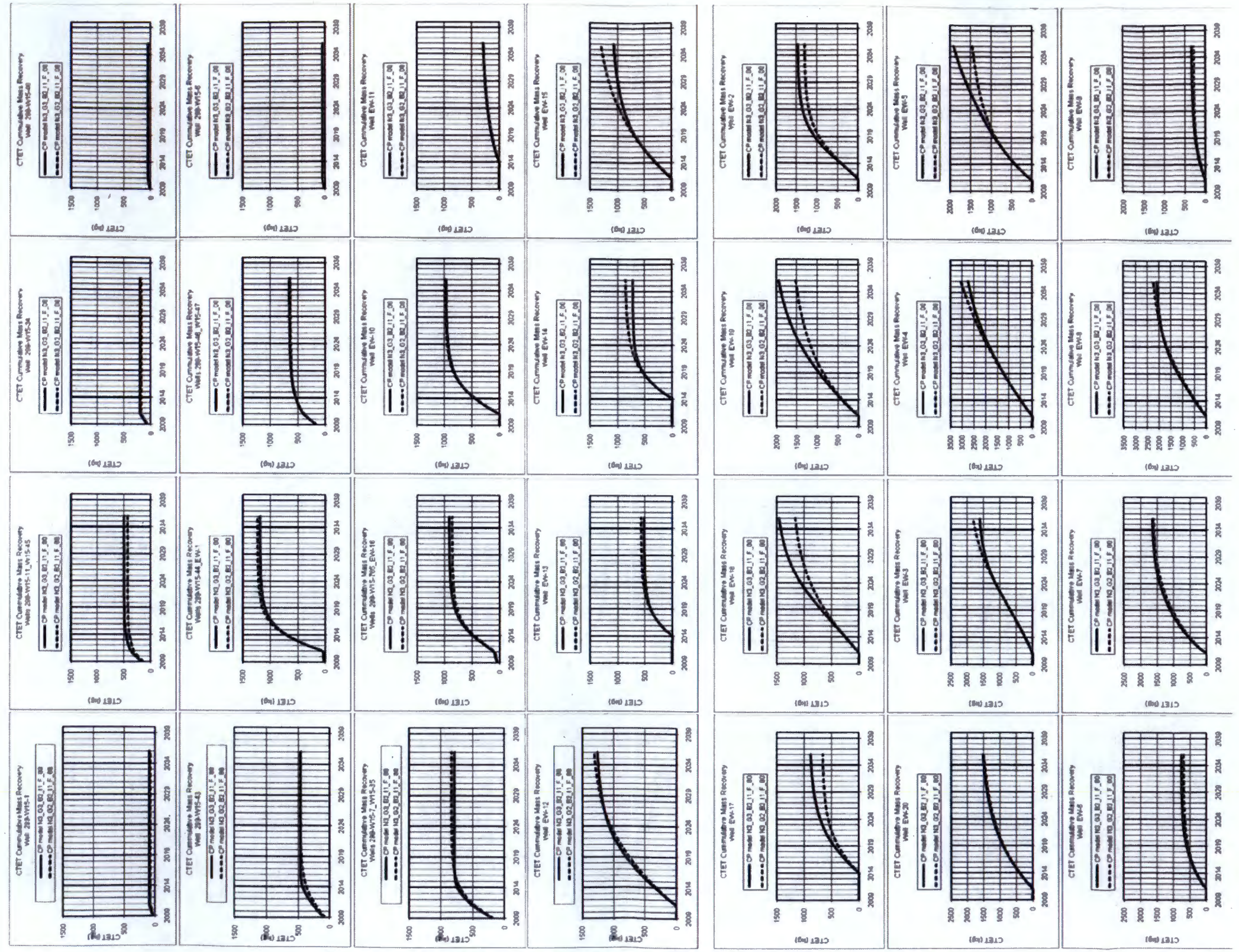

Figure D-15. Sensitivity Case 5: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

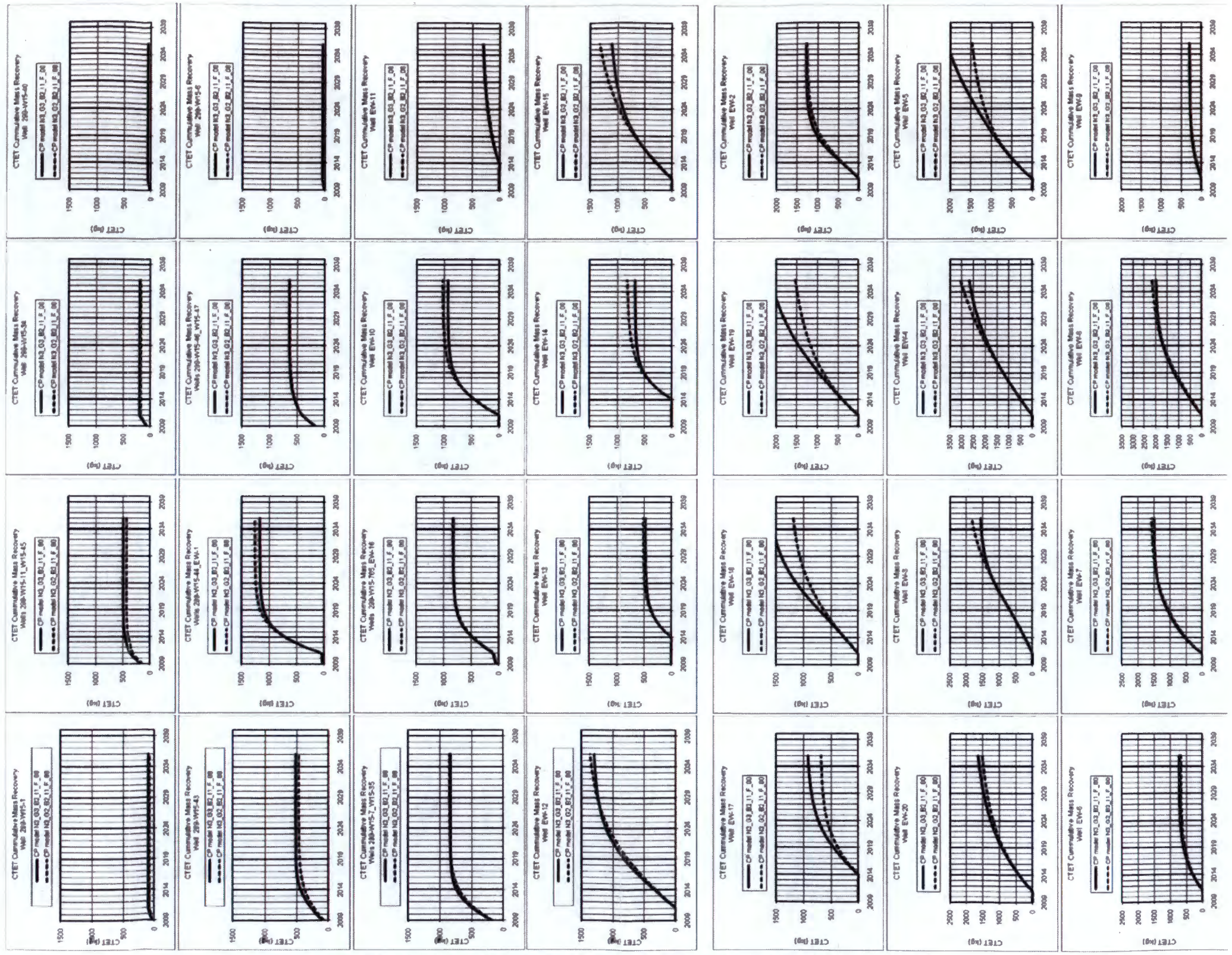

Figure D-16. Sensitivity Case 6: Cumulative Mass Recovery Versus Time (41-Year Half-Life)

Appendix E

Simulated Combined System-Wide Mass Recovery

Figures

Figure E-1. Simulated Mass Recovery, Base Case 1, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-1
Figure E-2. Simulated Mass Recovery, Base Case 2, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-2
Figure E-3. Simulated Mass Recovery, Sensitivity Case 1, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-3
Figure E-4. Simulated Mass Recovery, Sensitivity Case 2, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-4
Figure E-5. Simulated Mass Recovery, Sensitivity Case 3, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-5
Figure E-6. Simulated Mass Recovery, Sensitivity Case 4, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-6
Figure E-7. Simulated Mass Recovery, Sensitivity Case 5, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-7
Figure E-8. Simulated Mass Recovery, Sensitivity Case 6, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-8
Figure E-9. Simulated Mass Recovery, Base Case 1, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-9
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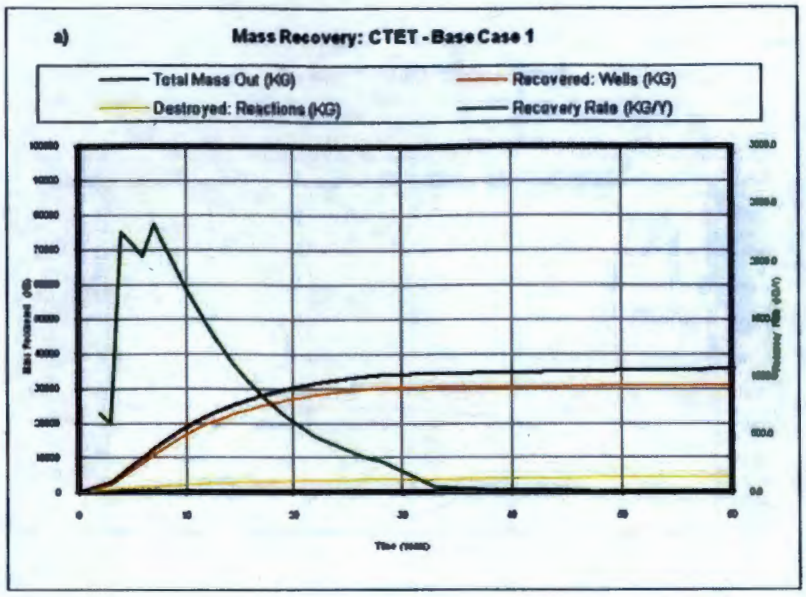
Figure E-11. Simulated Mass Recovery, Sensitivity Case 1, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-11
Figure E-12. Simulated Mass Recovery, Sensitivity Case 2, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-12
Figure E-13. Simulated Mass Recovery, Sensitivity Case 3, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-13
Figure E-14. Simulated Mass Recovery, Sensitivity Case 4, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-14
Figure E-15. Simulated Mass Recovery, Sensitivity Case 5, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-15
Figure E-16. Simulated Mass Recovery, Sensitivity Case 6, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage E-16



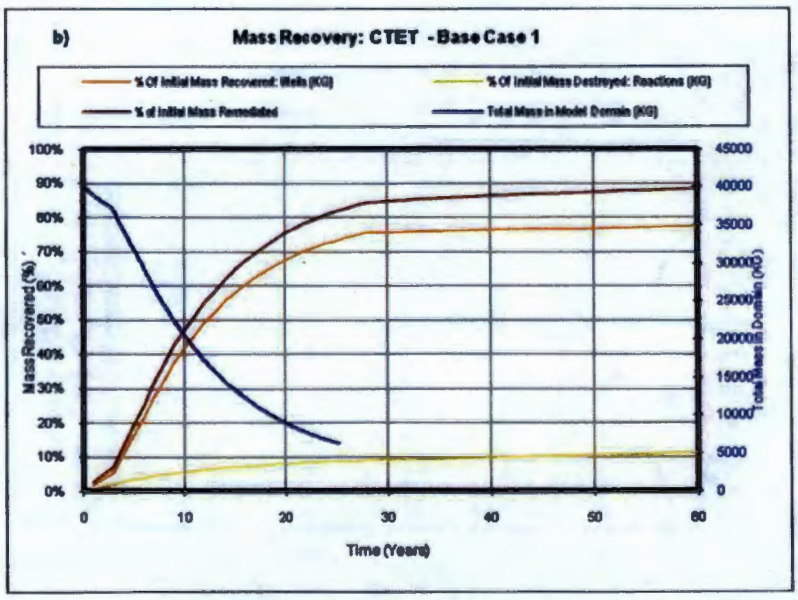
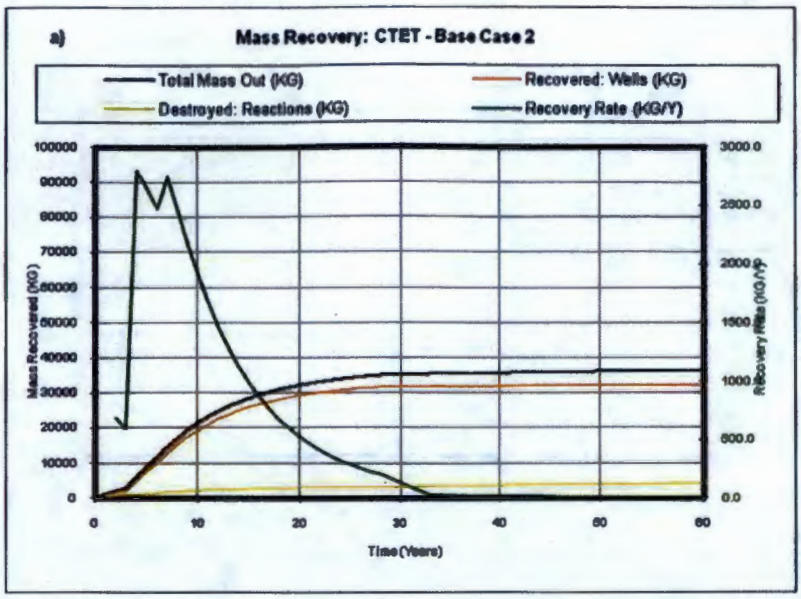


Figure E-1. Simulated Mass Recovery, Base Case 1, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



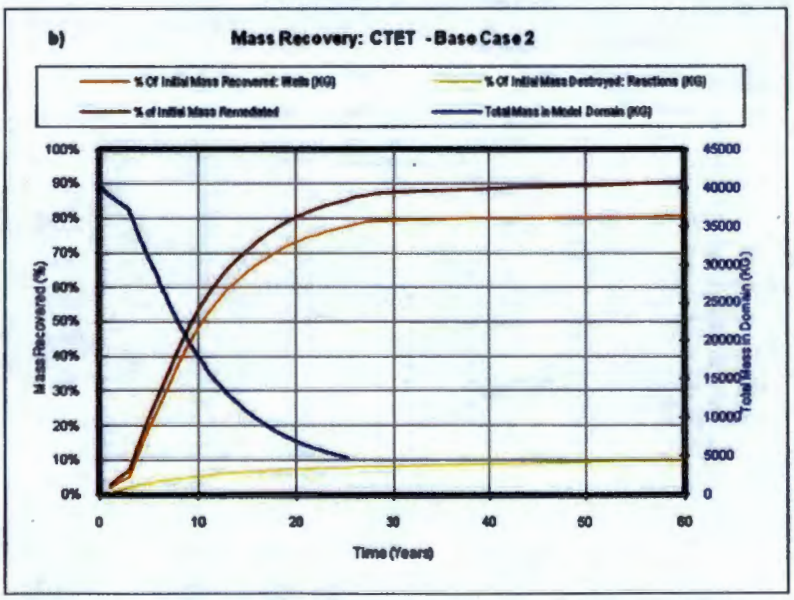


Figure E-2. Simulated Mass Recovery, Base Case 2, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage

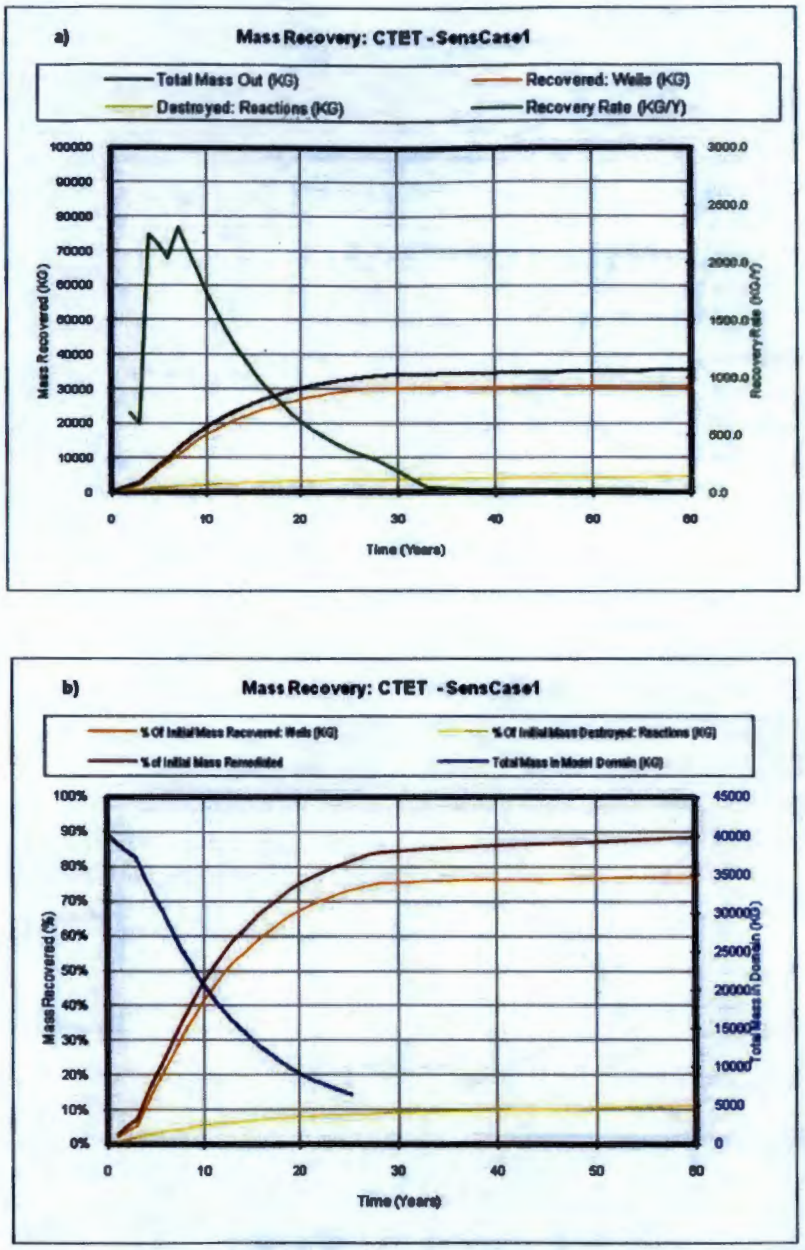
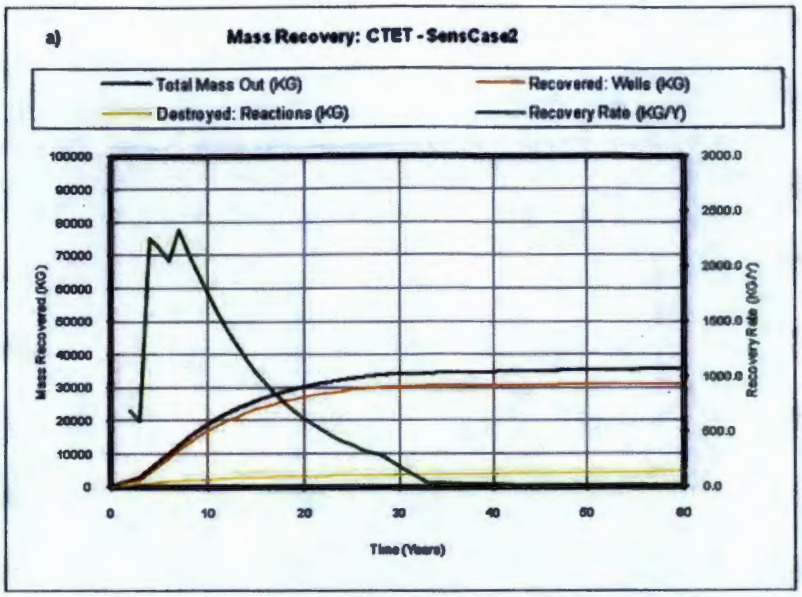


Figure E-3. Simulated Mass Recovery, Sensitivity Case 1, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



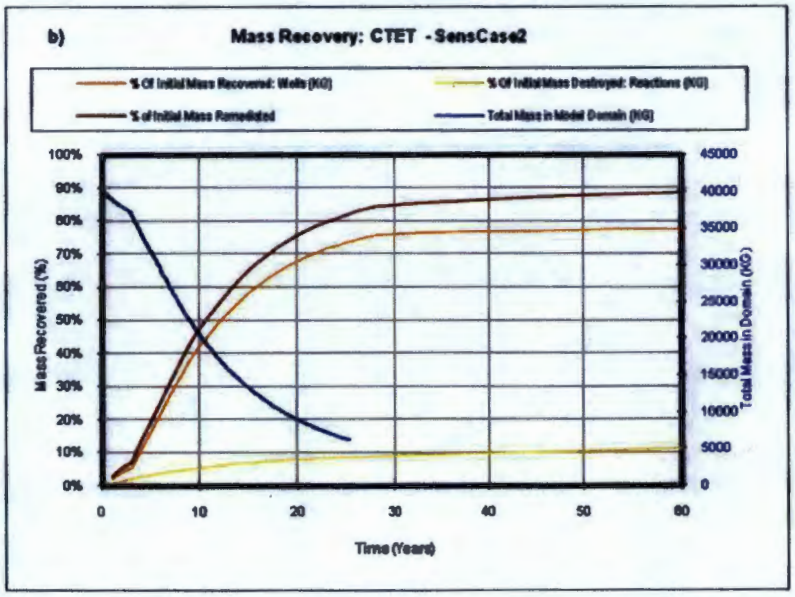
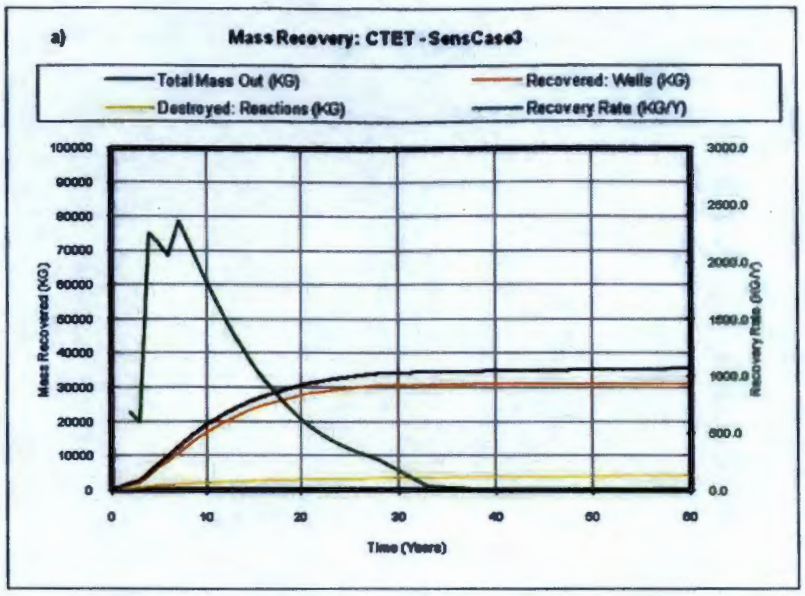


Figure E-4. Simulated Mass Recovery, Sensitivity Case 2, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



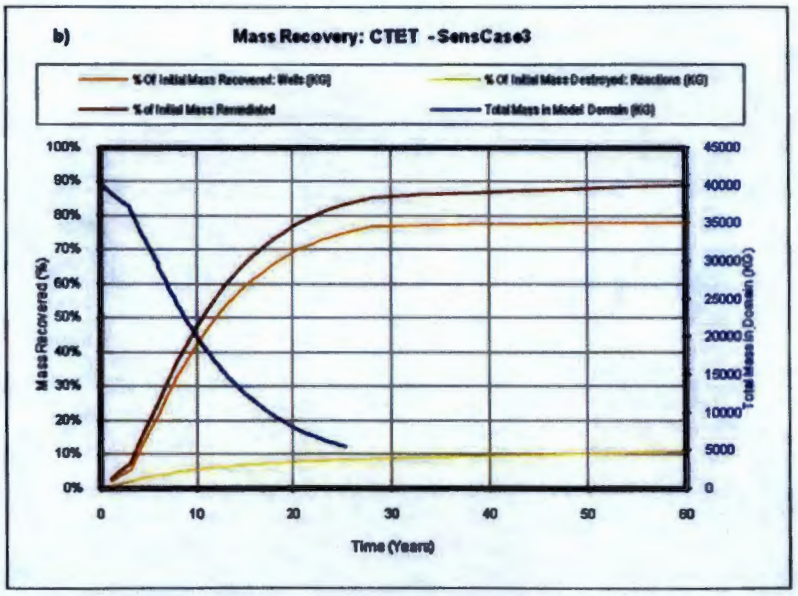
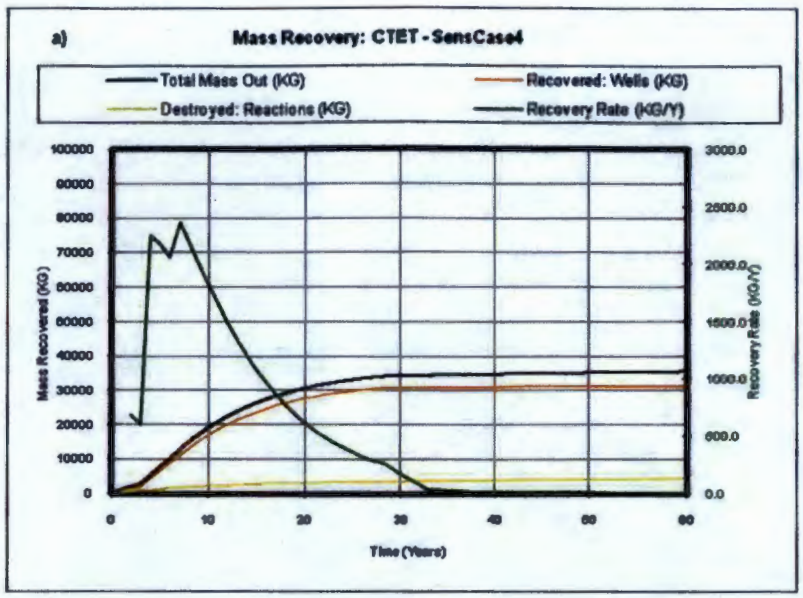


Figure E-5. Simulated Mass Recovery, Sensitivity Case 3, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



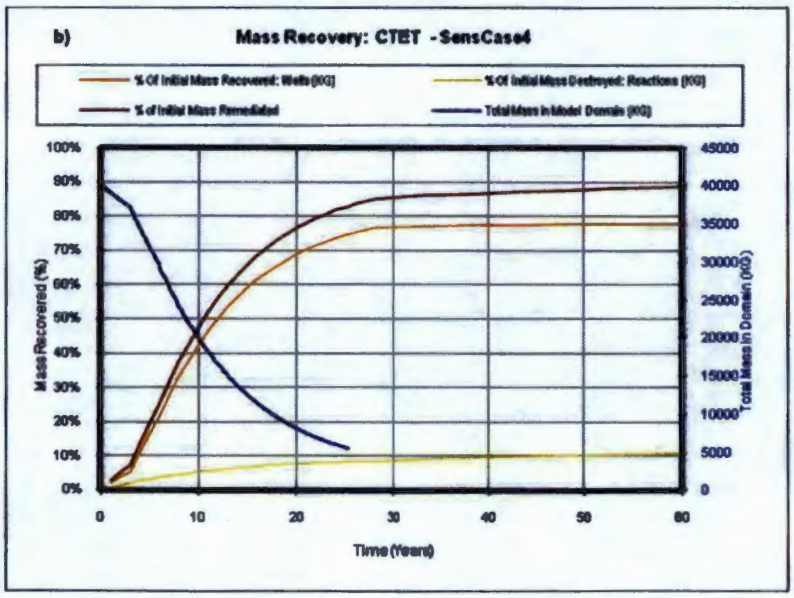
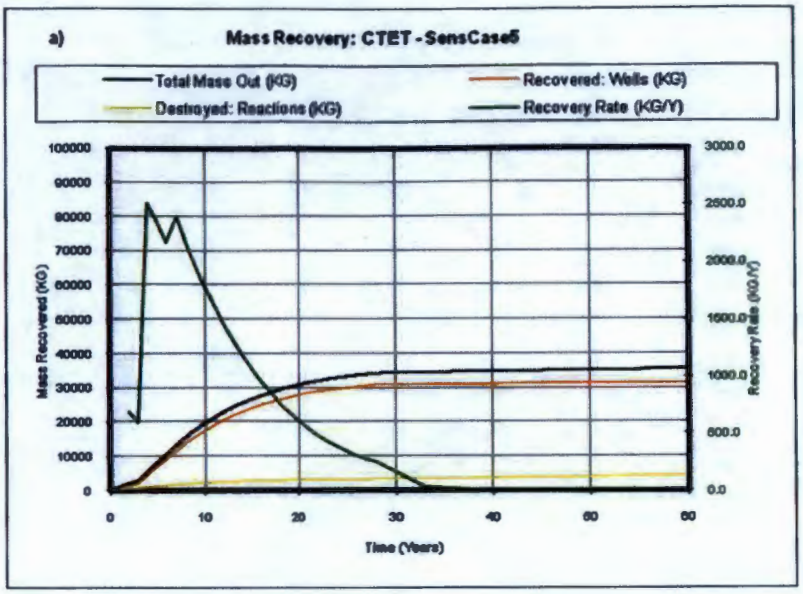


Figure E-6. Simulated Mass Recovery, Sensitivity Case 4, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



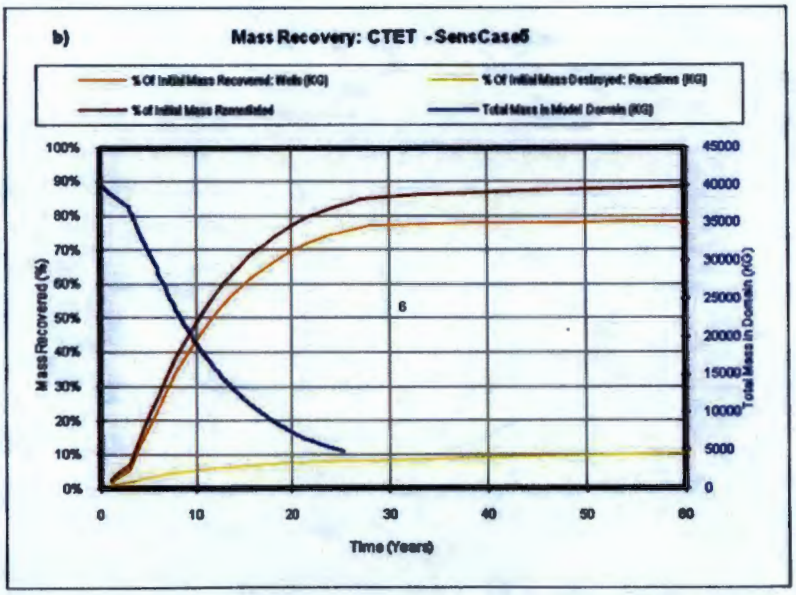
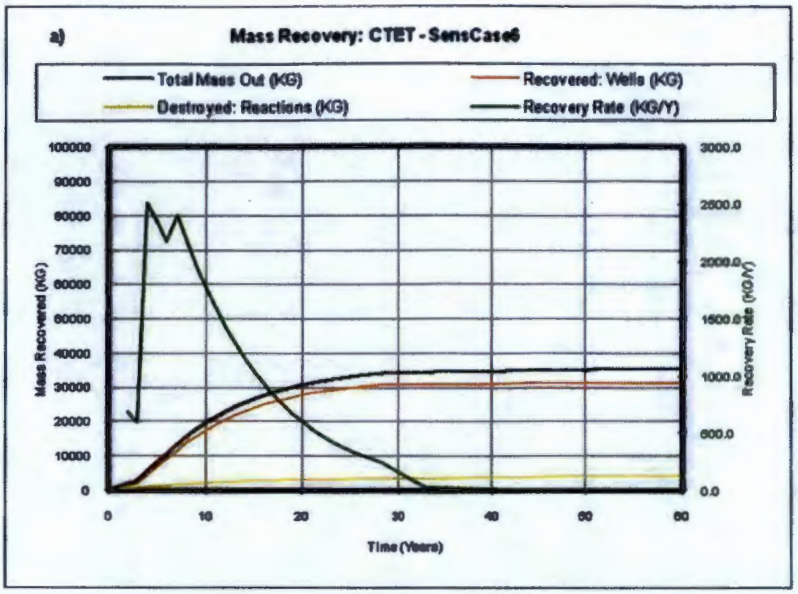


Figure E-7. Simulated Mass Recovery, Sensitivity Case 5, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



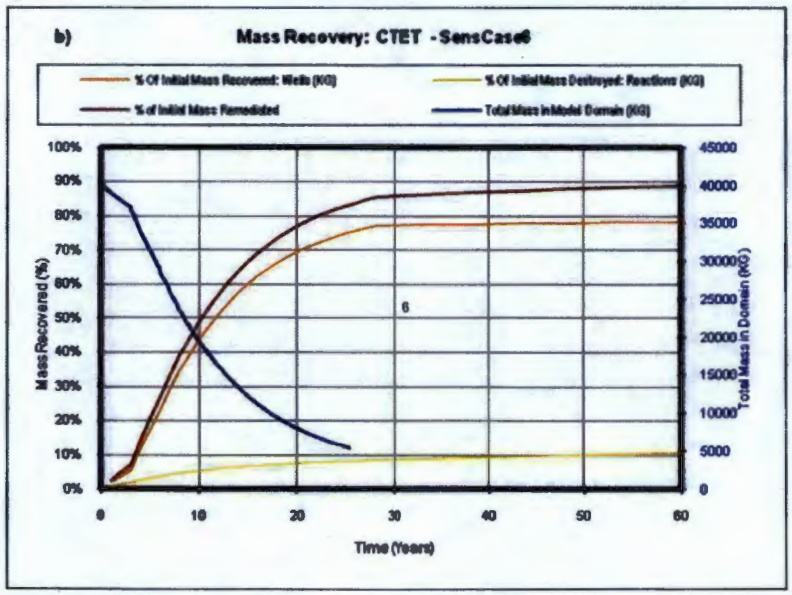
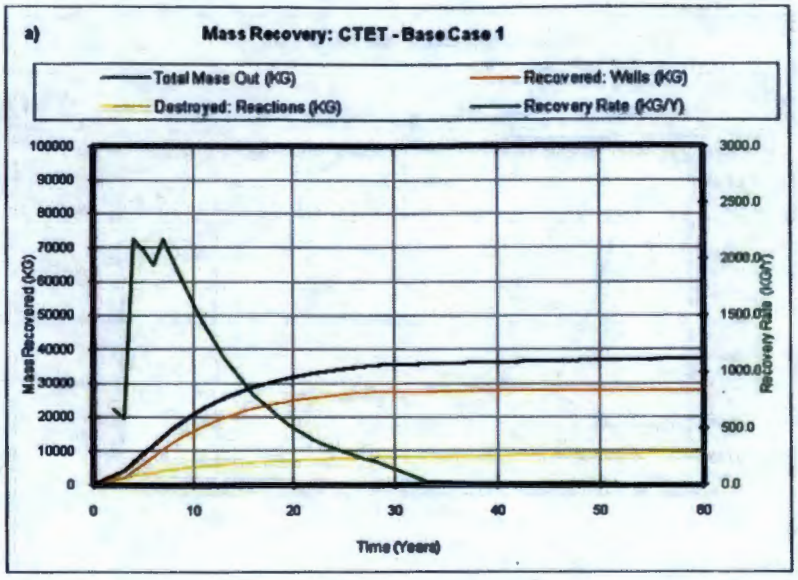


Figure E-8. Simulated Mass Recovery, Sensitivity Case 6, 100-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



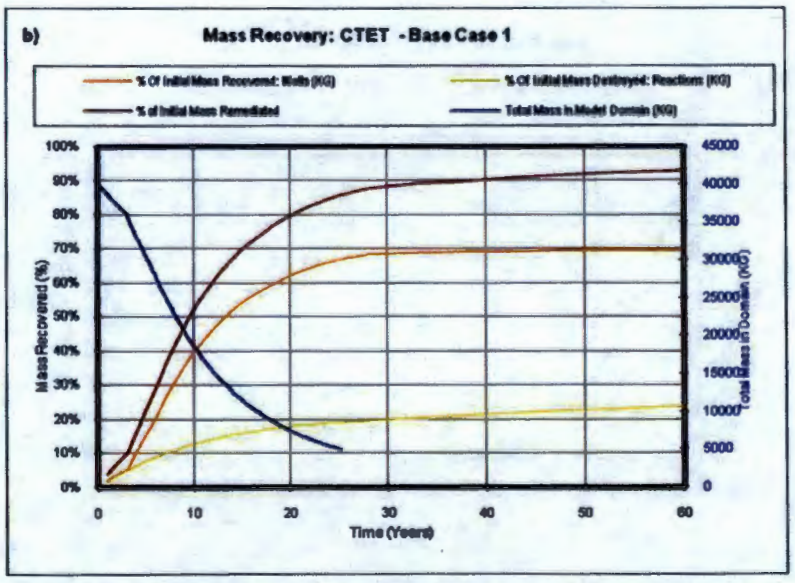
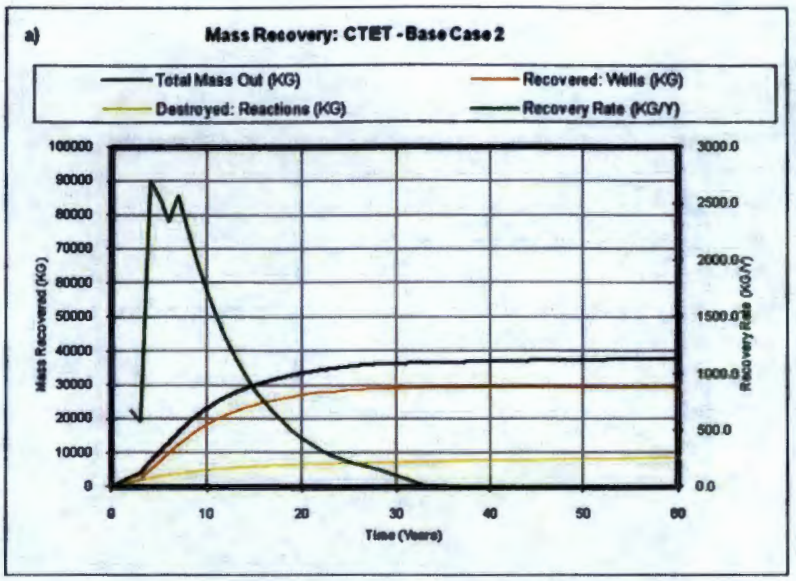


Figure E-9. Simulated Mass Recovery, Base Case 1, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



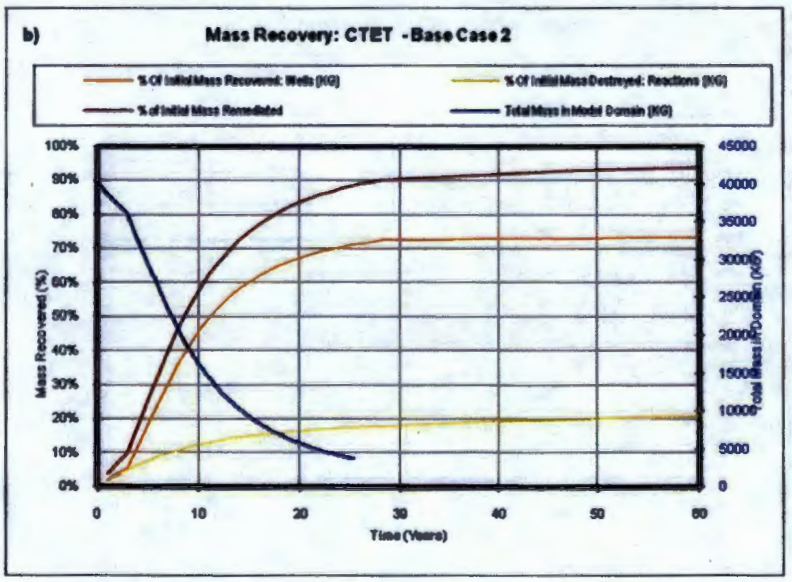
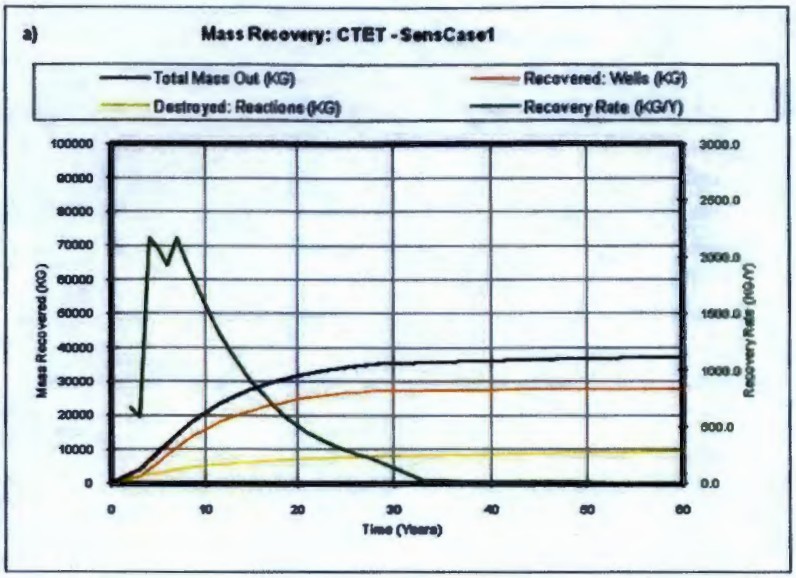


Figure E-10. Simulated Mass Recovery, Base Case 2, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



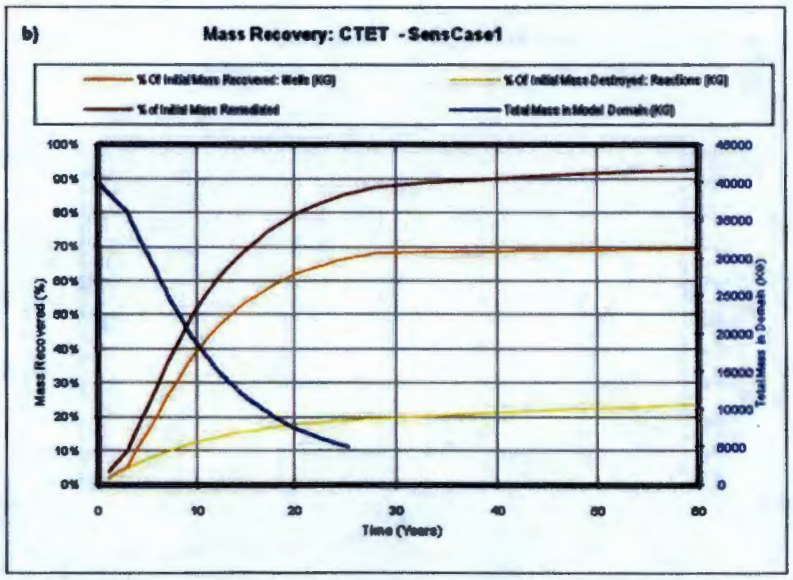


Figure E-11. Simulated Mass Recovery, Sensitivity Case 1, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage

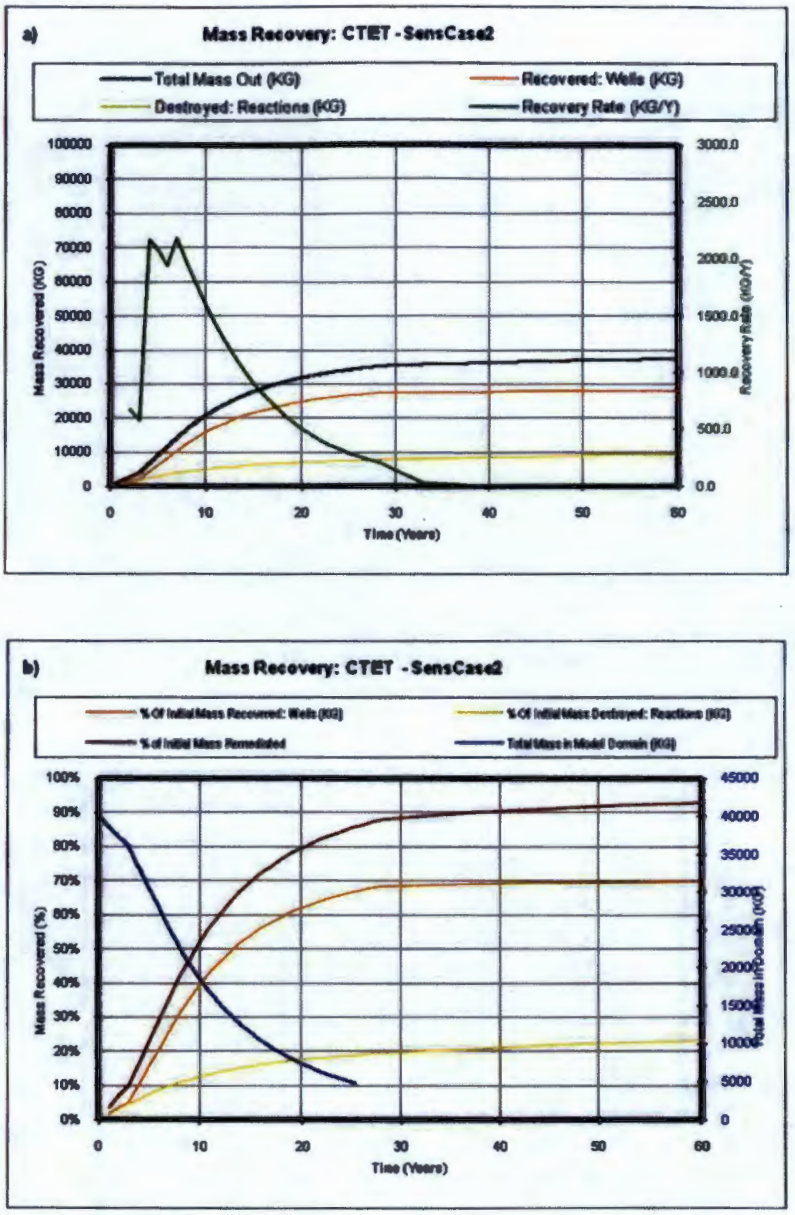


Figure E-12. Simulated Mass Recovery, Sensitivity Case 2, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage

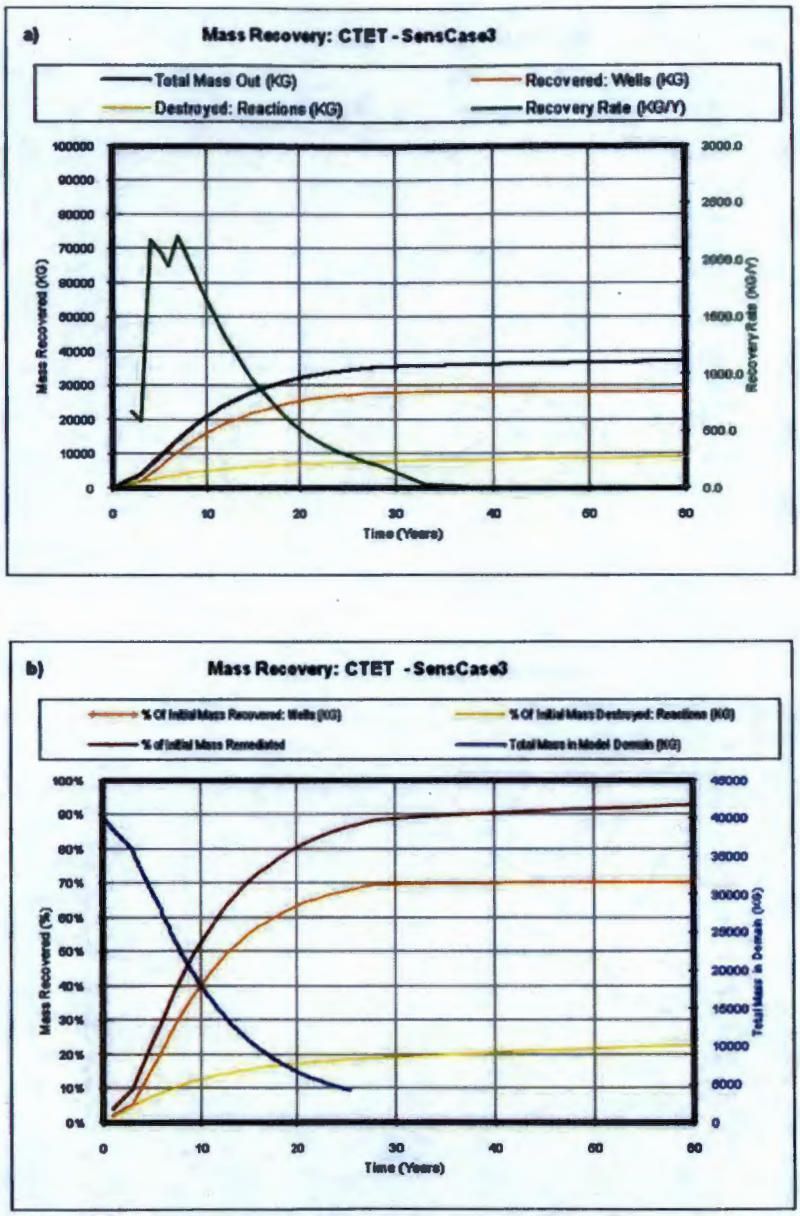


Figure E-13. Simulated Mass Recovery, Sensitivity Case 3, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage

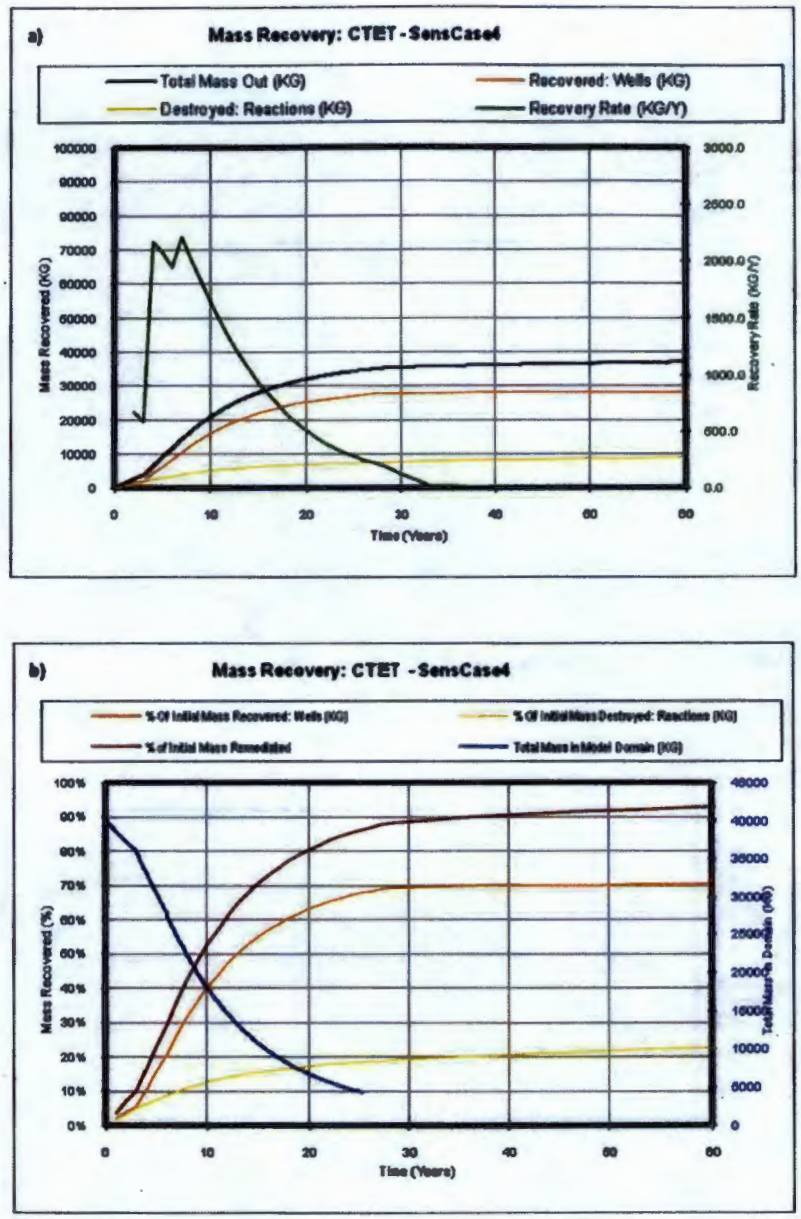
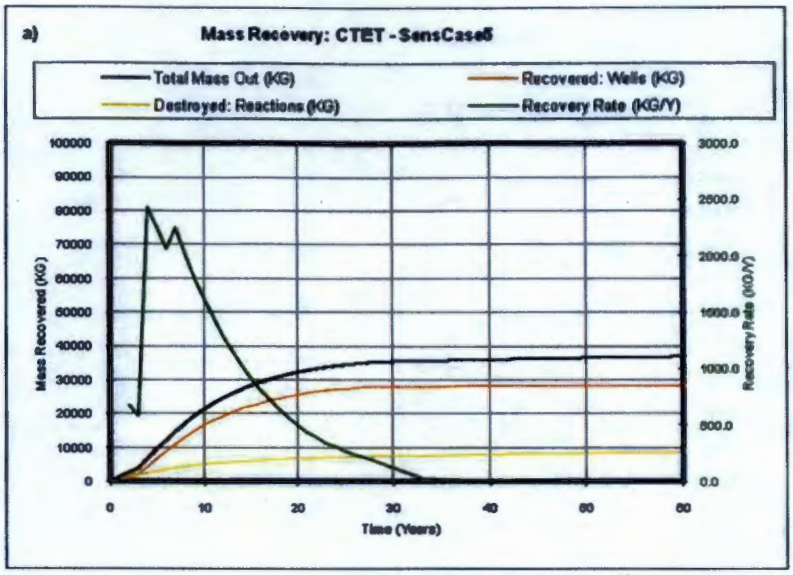


Figure E-14. Simulated Mass Recovery, Sensitivity Case 4, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



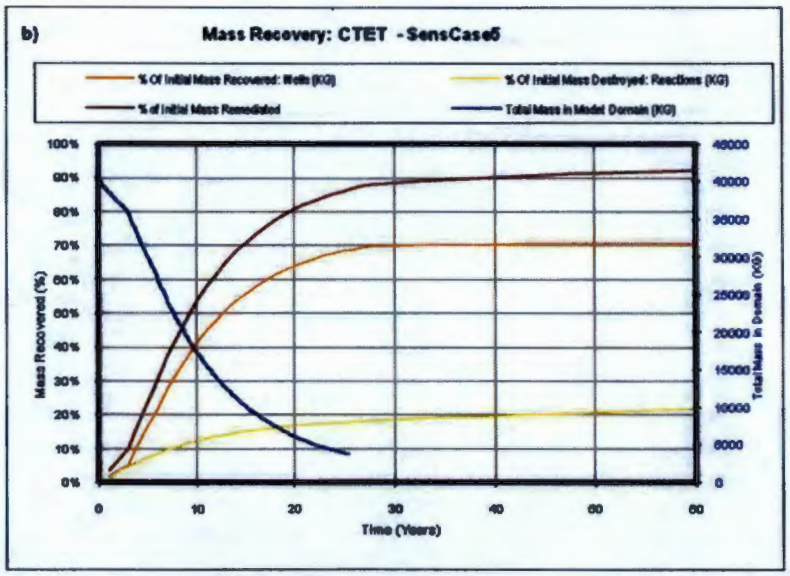
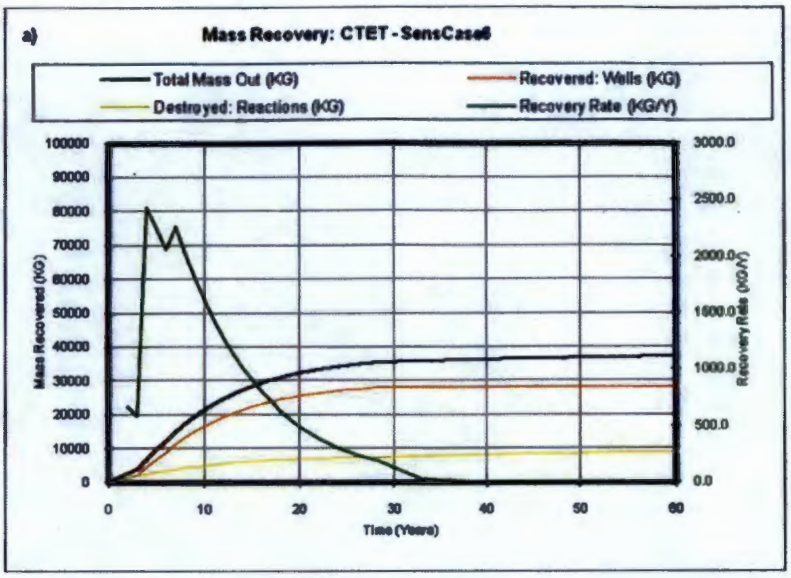


Figure E-15. Simulated Mass Recovery, Sensitivity Case 5, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage



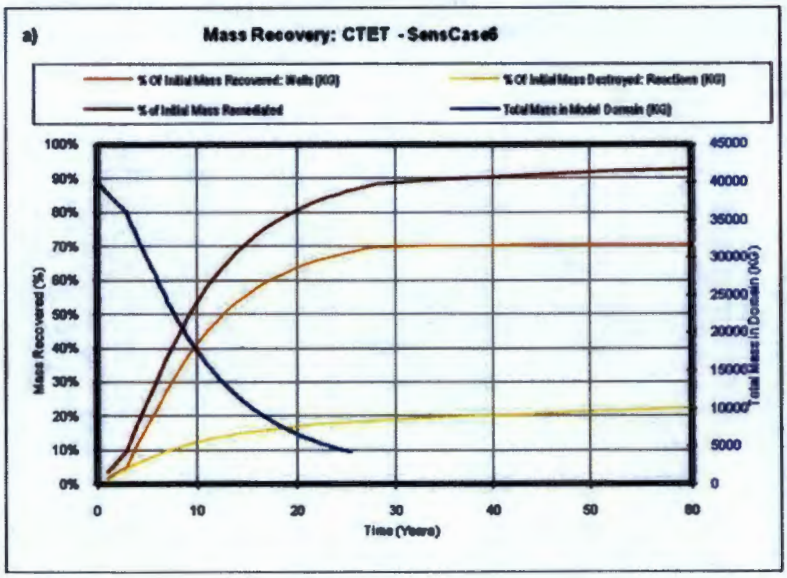


Figure E-16. Simulated Mass Recovery, Sensitivity Case 6, 41-Year Half-Life: (a) Cumulative Mass, (b) Cumulative Percentage

Appendix F

CHPRC Software Installation and Checkout Form

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM

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

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

GENERAL INFORMATION:

1. Software Name: MODFLOW 2000, MODFLOW 2000 MST, & MT3DMS (Build 0003) Software Version No.: 0003

EXECUTABLE INFORMATION:

2. Executable Name (include path):

```
All files installed in directory c:/bin - MD5 signatures uniquely identify exec files:
mf2k-0003dp.exe (double precision MODFLOW 2000) - AE3452C29826D16AF7812E68E41453F6
mf2k-0003sp.exe (single precision MODFLOW 2000) - 512B752916371FE1325703298AA4E8E8
mf2k-mst-0003dp.exe (double prec MODFLOW with MST) - 21D01926D4313410BD7F4E63C863AA27
mf2k-mst-0003sp.exe (single prec MODFLOW with MST) - 22E7B852571A93A2EFAC90A6690E41B5
mt3dms-mst-0003dp.exe (double prec MT3DMS with MST)- CB3343D6D7554D9C0E662A597E47D687
mt3dms-mst-0003sp.exe (single prec MT3DMS with MST)- 2D34D56262561B23259DF9C03B66C791
```

3. Executable Size (bytes): MD5 signatures for executable files are listed above.

COMPILATION INFORMATION:

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

   Compiled by SSPA

5. Operating System (include version number):

   Compiled by SSPA

INSTALLATION AND CHECKOUT INFORMATION:

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

   S.S. Papadopulos and Assoc, INC, FE404

7. Operating System (include version number):

   Windows 7

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

TEST CASE INFORMATION:

9. Directory/Path:

   Test invoked by batch file \test\run-install-tests.bat

10. Procedure(s):

    CHPRC-00259 Rev 1, MODFLOW and Related Codes Software Test Plan

11. Libraries:

    Statically linked

12. Input Files:

    Found in test subdirectories

13. Output Files:

    Found in test subdirectories

14. Test Cases:

    MF-ITC-1 (both standard and MST versions of MODFLOW)- run for single & double precision
    MT-ITC-1 - run for single and double precision

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: MODFLOW 2000, MODFLOW 2000 MST, & MT3DMS (Build 0003) Software Version No.: 0003

15. Test Case Results:

Pass

16. Test Performed By: Marinko Karanovic

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

18. Disposition (Include HISI update): APPROVED ADDED TO HISI LISTING FOR MODFLOW & MT3DMS S/W

Prepared By:

19.	WE Nichols	9/13/2010
Software Owner (Signature)	Print	Date

20. Test Personnel:

	Marinko Karanovic	09/01/2010
Sign	Print	Date
Sign	Print	Date
Sign	Print	Date

Approved By:

21.	N/R (CHPRC-00258 Rev 2)	
Software SME (Signature)	Print	Date

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