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200-BP-5 AND 200-PO-1 GROUNDWATER OPERABLE UNITS FEASIBILITY STUDY FOR INTERIM ACTION, DOE/RL-2018-30, DRAFT A

This letter transmits 200-BP-5 and 200-PO-1 Groundwater Operable Units Feasibility Study for Interim Action, DOE/RL-2018-30, Draft A to the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) for review and comment.

The submittal of this document partially completes Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Milestone M-015-21A, Submit 200-BP-5 and 200-PO-1 Operable Unit Feasibility Study Report and Proposed Plan(s) for an Interim Action to Ecology. My staff has worked with Nina Menard of Ecology and Craig Cameron of EPA on this document. Per the Tri-Party Agreement Action Plan Figure 9-1, Ecology and EPA have 45 days to perform their reviews.

If you have any questions, please contact me, or your staff may contact, Mike Cline, of my staff, on (509) 376-6070.

Sincerely,

William F. Hamel, Assistant Manager
for the River and Plateau

AMRP:JPH

Attachment

cc: See page 2

DEC 18 2018

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DOE/RL-2018-30
Draft A

200-BP-5 AND 200-PO-1 GROUNDWATER OPERABLE UNITS FEASIBILITY STUDY FOR INTERIM ACTION

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
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DOE/RL-2018-30
Draft A

200-BP-5 AND 200-PO-1 GROUNDWATER OPERABLE UNITS FEASIBILITY STUDY FOR INTERIM ACTION

Date Published
November 2018

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office
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APPROVED
By Mary P. Curry at 3:50 pm, Nov 29, 2018

Release Approval Date

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Contents

1 Introduction 1-1

1.1 Purpose and Scope 1-3
1.2 Integration with Other Remedial Activities 1-6
1.2.1 Integration with Other Pump and Treat Operations 1-6
1.2.2 Integration with Waste Management Area C Closure 1-7
1.2.3 Integration with Future Remedial Activities 1-8

2 Background 2-1

2.1 Site Description 2-1
2.2 Site History 2-1
2.3 Geologic Setting 2-3
2.3.1 200-BP-5 Operable Unit 2-3
2.3.2 200-PO-1 Operable Unit 2-9
2.4 Hydrogeology 2-9
2.4.1 200-BP-5 Operable Unit 2-9
2.4.2 200-PO-1 Operable Unit 2-10
2.4.3 Groundwater Elevation and Flow 2-12
2.5 Land Use 2-12
2.5.1 Current and Reasonably Anticipated Future Land Use 2-12
2.5.2 Anticipated Future Land Use 2-15
2.6 Nature and Extent of Contamination 2-15
2.6.1 Uranium and Technetium-99 2-15
2.6.2 Co-Contaminants 2-19
2.7 Baseline Risk Assessment 2-19
2.7.1 Groundwater Contaminants of Potential Concern 2-20

3 Contaminants of Concern, Applicable or Relevant and Appropriate Requirements, Remedial Action Objectives, and Preliminary Remediation Goals 3-1

3.1 Contaminants of Concern 3-1
3.2 Applicable or Relevant and Appropriate Requirements 3-1
3.2.1 Applicable or Relevant and Appropriate Requirements Evaluation Process 3-1
3.2.2 Waivers from Applicable or Relevant and Appropriate Requirements 3-3
3.2.3 Potential Applicable or Relevant and Appropriate Requirements Identified 3-3
3.2.4 Waste Management Standards 3-19
3.2.5 Standards Controlling Emissions to the Environment 3-20
3.2.6 Radiological Air Emissions 3-21
3.2.7 Criteria/Toxic Air Emissions 3-22
3.2.8 Groundwater Beneficial Use 3-22

3.2.9 Surface Water Beneficial Use 3-22
3.3 Remedial Action Objectives and Interim Action Objectives 3-22
3.4 Preliminary Remediation Goals 3-23
4 Technology Identification and Screening 4-1
4.1 General Response Actions 4-1
4.1.1 Target Remediation Areas 4-1
4.2 Identification and Screening of Technology Types and Process Options 4-2
4.2.1 Identification and Screening of Technologies 4-2
4.2.2 Evaluation of Technologies and Selection of Representative Technologies 4-13
5 Development and Screening of Alternatives 5-1
5.1 Development of Remedial Alternatives 5-1
5.1.1 Development and Evaluation of Groundwater Extraction and Injection Pumping Scenarios 5-2
5.2 Description of Remedial Alternatives 5-23
5.2.1 Alternative 1 – No Action 5-23
5.2.2 Alternative 2 – Pump and Treat at B Complex, and C Farm and A-AX Farms 5-23
5.2.3 Alternative 3 – Pump and Treat at B Complex, C Farm and A-AX Farms, and Gable Gap 5-30
5.3 Screening of Remedial Alternatives 5-33
5.3.1 Effectiveness 5-33
5.3.2 Implementability 5-34
5.3.3 Cost 5-35
5.3.4 Remedial Alternative Screening Summary 5-36
6 Detailed and Comparative Analysis of Alternatives 6-1
6.1 Description of CERCLA Evaluation Criteria 6-1
6.2 Individual Analysis of Alternatives 6-1
6.2.1 Alternative 1 – No Action 6-6
6.2.2 Alternative 2 – Pump and Treat at B Complex, and C Farm and A-AX Farms 6-11
6.2.3 Alternative 3 – Pump and Treat at B Complex, C Farm and A-AX Farms, and Gable Gap 6-19
6.3 Comparative Evaluation of Alternatives 6-28
6.3.1 Overall Protection of Human Health and the Environment 6-28
6.3.2 Compliance with Applicable or Relevant and Appropriate Requirements 6-30
6.3.3 Long-Term Effectiveness and Permanence 6-30
6.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment 6-30
6.3.5 Short-Term Effectiveness 6-30
6.3.6 Implementability 6-30
6.3.7 Cost 6-35

7 References 7-1

Appendices

A ECF-HANFORD-18-0023, Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives ..... A-i

B ECE-200BP518-00003, Environmental Cost Estimate for the 200-BP-5/200-PO-1 Interim Action Feasibility Study ..... B-i

Figures

Figure 1-1. Location of the 200-BP-5 and 200-PO-1 OUs 1-2
Figure 1-2. Uranium and Technetium-99 Groundwater Plumes in the 200 East Area 1-4
Figure 2-1. Location of the Pasco Basin and the 200-BP-5 and 200-PO-1 OUs 2-2
Figure 2-2. General Geologic Structures of the Pasco Basin and the Hanford Site 2-4
Figure 2-3. Top-of-Basalt Structure Map, 200-BP-5 OU Near-Field Area 2-5
Figure 2-4. Generalized Pleistocene Paleo-Erosional Surface Topography Within the 200-BP-5 OU 2-6
Figure 2-5. Hydrostratigraphy of the 200-BP-5 and 200-PO-1 OUs 2-7
Figure 2-6. Hydrostratigraphy of the 200-BP-5 OU and 200-PO-1 OUs Far-Field Areas Near the Columbia River 2-8
Figure 2-7. Perched Water Zone at the B Complex 2-11
Figure 2-8. Average Water Table and Flow Direction for the 200 East Area, 2016 2-13
Figure 2-9. Groundwater Table at the Hanford Site, 2016 2-14
Figure 2-10. Location of Waste Sites and Monitoring Wells in the 200 East Area 2-17
Figure 2-11. Groundwater Plumes Around the Target Remediation Areas of the 200-BP-5 and 200-PO-1 OUs 2-18
Figure 5-1. Subregions Used to Evaluate Groundwater Modeling Simulation Results 5-4
Figure 5-2. Extraction/Injection Well Locations Used in Modeling 5-8
Figure 5-3. Uranium Plume at Year 0 of Alternative 1 (No Action) (Initial Conditions) 5-9
Figure 5-4. Techentium-99 Plume at Year 0 of Alternative 1 (No Action) (Initial Conditions) 5-9
Figure 5-5. Alternative 1 (No Action) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources 5-13
Figure 5-6. Alternative 1 (No Action) Technetium-99 Plume at Years 5, 15, 25, and 50 with No Continuing Sources 5-14
Figure 5-7. Alternative 2 (B Complex, C Tank Farm and A-AX Tank Farms, 300 gal/min) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources 5-17
Figure 5-8. Alternative 2 (B Complex, C Tank Farm and A-AX Tank Farms, 300 gal/min) Technetium-99 Plume at Years 5, 10, 15, and 25 with No Continuing Sources 5-18

Figure 5-9. Alternative 3 (B Complex, C Tank Farm and A-AX Tank Farms, Gable Gap, 400 gal/min) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources 5-19
Figure 5-10. Alternative 3 (B Complex, C Tank Farm and A-AX Tank Farms, Gable Gap, 400 gal/min) Technetium-99 Plume at Years 5, 10, 15, and 25 with No Continuing Sources 5-20
Figure 5-11. Uranium Plume at Year 50 for Alternative 2 (B Complex, C Tank Farm and A-AX Tank Farms, Gable Gap, 400 gal/min) with Continuing Sources 5-22
Figure 5-12. Technetium-99 Plume at Year 50 for Alternative 2 (B Complex, C Tank Farm and A-AX Tank Farms, Gable Gap, 400 gal/min) with Continuing Sources 5-22
Figure 5-13. Existing Conveyance Pipeline from the 200 East Area to the 200 West P&T 5-24
Figure 5-14. Block Flow Diagram of the Existing 200 West P&T 5-26
Figure 5-15. Block Flow Diagram of the 200 West P&T with Alternative 2 Flows 5-27
Figure 5-16. Block Flow Diagram of the 200 West P&T with Alternative 3 Flows 5-31
Figure 5-17. Predicted Cleanup Times for Target COCs Based on 95 UCL Concentrations (No Continuing Source) 5-35
Figure 6-1. CERCLA Remedial Action Alternative Evaluation Criteria 6-2
Figure 6-2. Alternative 1 – Predicted Uranium 95 UCL Concentrations and Plume Areas 6-9
Figure 6-3. Alternative 1 – Predicted Technetium-99 95 UCL Activities and Plume Areas 6-10
Figure 6-4. Alternative 2 – Predicted Uranium 95 UCL Concentrations and Plume Areas 6-17
Figure 6-5. Alternative 2 – Predicted Technetium-99 95 UCL Activities and Plume Areas 6-18
Figure 6-6. Alternative 3 – Predicted Uranium 95 UCL Concentrations and Plume Areas 6-26
Figure 6-7. Alternative 3 – Predicted Technetium-99 95 UCL Activities and Plume Areas 6-27
Figure 6-8. Alternatives Comparison – Predicted Uranium 95 UCL Concentrations and Plume Areas in B Complex 6-31
Figure 6-9. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in B Complex 6-32
Figure 6-10. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in C Tank Farm and A-AX Tank Farms 6-33
Figure 6-11. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in Gable Gap 6-34

Tables

Table 2-1. Summary of Uranium and Technecium-99 Results from the Tap Water (Residential) Exposure Scenario for the 200-BP-5 and 200-PO-1 OUs 2-20
Table 2-2. Summary of COPCs for the 200-BP-5 and 200-PO-1 OUs BRA by Exposure Area 2-21
Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs 3-4
Table 3-2. 200-BP-5 and 200-PO-1 OU PRGs for COCs 3-23
Table 4-1. Estimated Groundwater Plume Area, Thickness, and Pore Volume for Technetium-99 and Uranium in the 200-BP-5 and 200-PO-1 OUs 4-2
Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action 4-3
Table 4-3. Categories and Types of Current Hanford Access Restrictions/ICs 4-10
Table 5-1. Modeling Scenario Extraction/Injection Wells and Flow Rates 5-7
Table 5-2. Projected Cleanup Times Based on 95 UCL and C_{max} Assuming No Continuing Sources 5-11
Table 5-3. 200 West P&T Processes for 200-BP-5 and 200-PO-1 OU Target COCs and Co-Contaminants 5-28
Table 5-4. Alternative 2 Components and Assumptions 5-29
Table 5-5. Alternative 3 Components and Assumptions 5-32
Table 5-6. Comparison of Remedial Alternative Cost Estimates 5-35
Table 6-1. CERCLA Remedial Action Alternative Evaluation Criteria Description 6-3
Table 6-2. Detailed Evaluation for Alternative 1 – No Action 6-7
Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Tank Farm and A-AX Tank Farms 6-12
Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Tank Farm and A-AX Tank Farms, and Gable Gap 6-20
Table 6-5. Comparative Evaluation of Alternatives 6-29

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Terms

95 UCL	95th percentile upper confidence limit
AEA	*Atomic Energy Act of 1954*
ARAR	applicable or relevant and appropriate requirement
BRA	baseline risk assessment
CCU	Cold Creek unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
C_{max}	maximum concentration
CMS	corrective measures study
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
DWS	drinking water standard
EC	engineering control
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FBR	fluidized bed reactor
FS	feasibility study
GAC	granular activated carbon
GRA	general response action
HAB	Hanford Advisory Board
HCP EIS	*Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement*
HQ	hazard quotient
HSU	hydrostratigraphic unit
IC	institutional control
IROD	interim Record of Decision

IX	ion exchange
K_d	distribution coefficient
LLWMA	low-level waste management area
MCL	maximum contaminant level
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NTCRA	non-time-critical removal action
O&M	operations and maintenance
OU	operable unit
P&T	pump and treat
P2RGWM	Plateau-to-River Groundwater Transport Model
PCB	polychlorinated biphenyl
PP	Proposed Plan
PRG	preliminary remediation goal
PUREX	Plutonium-Uranium Extraction (Plant)
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RD/RAWP	remedial design/remedial action work plan
RFI	RCRA facility investigation
RI	remedial investigation
Rlm	Ringold Formation member of Wooded Island – lower mud unit
RO	reverse osmosis
ROD	Record of Decision
Rwia	Ringold Formation member of Wooded Island – unit A
Rwie	Ringold Formation member of Wooded Island – unit E
SAP	sampling and analysis plan
STOMP	Subsurface Transport Over Multiple Phases
TBC	to be considered

TMV	toxicity, mobility, or volume
Tri-Parties	DOE, EPA, and Ecology
UPR	unplanned release
WMA	waste management area

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1 Introduction

The 200-BP-5 and 200-PO-1 Groundwater Operable Units (OUs) in the 200 East Area of the Hanford Site (Figure 1-1) are undergoing the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation (RI)/feasibility study (FS) process. Groundwater contamination in the 200-BP-5 and 200-PO-1 OUs primarily resulted from liquid waste discharges associated with historical operations at the B Plant (241-B), the Plutonium-Uranium Extraction (PUREX) Plant (241-A), and their associated facilities. DOE/RL-2009-127, *Remedial Investigation for the 200-BP-5 Groundwater Operable Unit*, documents the RI/FS for the 200-BP-5 OU. DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, and associated addendum (DOE/RL-2009-85 ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Addendum 1) document the RI/FS for the 200-PO-1 OU. Groundwater within the 200-BP-5 and 200-PO-1 OUs was evaluated in respective RIs (DOE/RL-2009-127; DOE/RL-2009-85). Under current site use conditions, no complete human exposure pathways to groundwater exist.

Source OUs (e.g., 200-DV-1, 200-EA-1, 200-IS-1, and 200-SW-2) and the canyon OUs (200-CB-1 and 200-CP-1) and waste management areas (WMAs) in the 200 East Area overlying the groundwater OUs are in various stages of the CERCLA RI/FS or *Resource Conservation and Recovery Act of 1976* (RCRA) facility investigation (RFI)/corrective measures study (CMS) process. Because the source investigations are not complete, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) (also known as the Tri-Parties) agree that necessary information is not yet available to prepare an FS supporting a Record of Decision (ROD) for a final action for the 200-BP-5 and 200-PO-1 Groundwater OUs. Therefore, the Tri-Parties are pursuing an interim ROD (IROD) for the 200-BP-5 and 200-PO-1 OUs to expedite remediation of groundwater contaminant plumes that are more efficiently remediated in the near-term and to support a RCRA corrective action decision for WMA C. The Tri-Parties agree that a final (non-interim) ROD for the 200 East Area groundwater OUs will be developed after contaminant sources are adequately characterized.

During the development and implementation phases of the interim action, groundwater monitoring will continue throughout the 200-BP-5 and 200-PO-1 OUs. The existing sampling and analysis plans (SAPs) for these two OUs will be updated (as appropriate) and will remain in effect while the interim action is implemented:

- DOE/RL-2014-33, *Groundwater Sampling and Analysis Plan for the 200-BP-5 Groundwater Operable Unit*
- DOE/RL-2003-04, *Sampling and Analysis Plan for the 200-PO-1 Groundwater Operable Unit*

This FS for interim action for the 200-BP-5 and 200-PO-1 Groundwater OUs has been prepared to support the selection of an interim action in the IROD. This FS screens remedial technologies and assembles the retained technologies into remedial action alternatives to address the target areas and target contaminants of concern (COCs) in accordance with Section 1.1 of 2018-002, *Hanford Federal Facility Agreement and Consent Order Interagency Management Integration Team (IAMIT) Decision/ Determination/Action Assignment 200-BP-5 and 200-PO-1 Interim Record of Decision*, approved by the Interagency Management Integration Team.

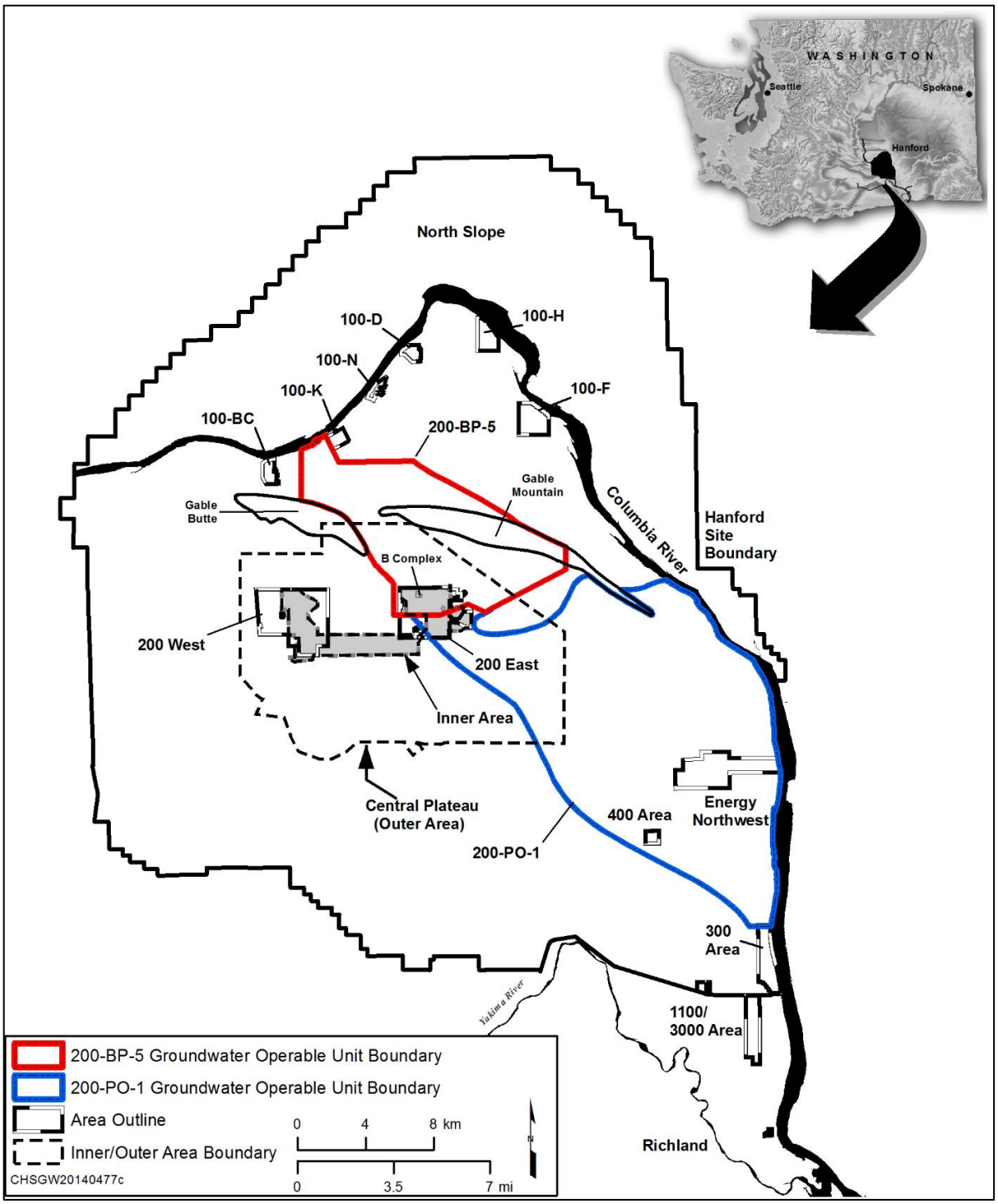

Figure 1-1. Location of the 200-BP-5 and 200-PO-1 OUs

1.1 Purpose and Scope

The purpose of the interim action for the 200-BP-5 and 200-PO-1 OUs IROD is to remediate groundwater contaminant plumes that merit near-term action based on the potential for contaminants to migrate away from source areas. These contaminants could pose a risk to human health and the environment if exposure were to occur.

The primary objective of the 200-BP-5 and 200-PO-1 interim action is to capture and remove the target COCs (identified as uranium and technetium-99) from groundwater under the B Complex[1] and the C Farm and A-AX Farms area sufficient to reach drinking water standards (DWSs)[2] within a reasonable timeframe.

A secondary objective for the interim action is to consider capture and removal of the target COC (technetium-99) from groundwater in the Gable Mountain and Gable Butte (Gable Gap) area as an efficiency consideration during operation of the 200 West pump and treat (P&T) facility.

Information from remedy performance monitoring and routine groundwater sampling[3] gathered during the interim action will support future decisions for the 200-BP-5 and 200-PO-1 OUs.

The purpose of this FS for interim action is to develop and evaluate interim action alternatives for cleanup of targeted groundwater contaminant plumes[4] in the 200-BP-5 and 200-PO-1 OUs, and to support preparation of a Proposed Plan (PP) and the IROD. The basic elements of this FS have been followed in accordance with EPA CERCLA guidance (EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*). However, this FS for interim action focuses on three select areas and two target COCs that merit near-term remediation (Figure 1-2):

- B Complex plumes: uranium and technetium-99
- C Farm and A-AX Farms plumes: technetium-99
- Gable Gap plume: technetium-99

Groundwater contaminants that exceed the DWSs within these target remediation areas include nitrate, iodine-129, tritium, and cyanide, which are considered co-contaminants in this FS.

---

[1] The B Complex consists of several crib and trench disposal sites and three single-shell tank farms (B-BX-BY Farms.)

[2] The EPA DWSs, or maximum contaminant levels (MCLs), for uranium and technetium-99 are 30 μg/L and 900 pCi/L, respectively. EPA has established an MCL of 4 mrem/yr for beta particle and photon radioactivity from manmade radionuclides (e.g., technetium-99) in drinking water. The average concentration of technetium-99, which is assumed to yield 4 mrem/yr, is 900 pCi/L. If other radionuclides that emit beta particles and photon radioactivity are present in addition to technetium-99, the sum of the annual dose from all of the radionuclides shall not exceed 4 mrem/yr. For simplicity, this FS will use the 900 pCi/L as the MCL value for technetium-99.

[3] While routine groundwater monitoring is not part of the IROD, this monitoring will continue pursuant to the existing 200-BP-5 OU and 200-PO-1 OU SAPs and any future SAP addendums.

[4] The term “plume,” as used in this FS, refers to the area/volume of the groundwater aquifer in which contaminant concentrations exceed preliminary remediation goals (PRGs), as documented in Section 3.4.

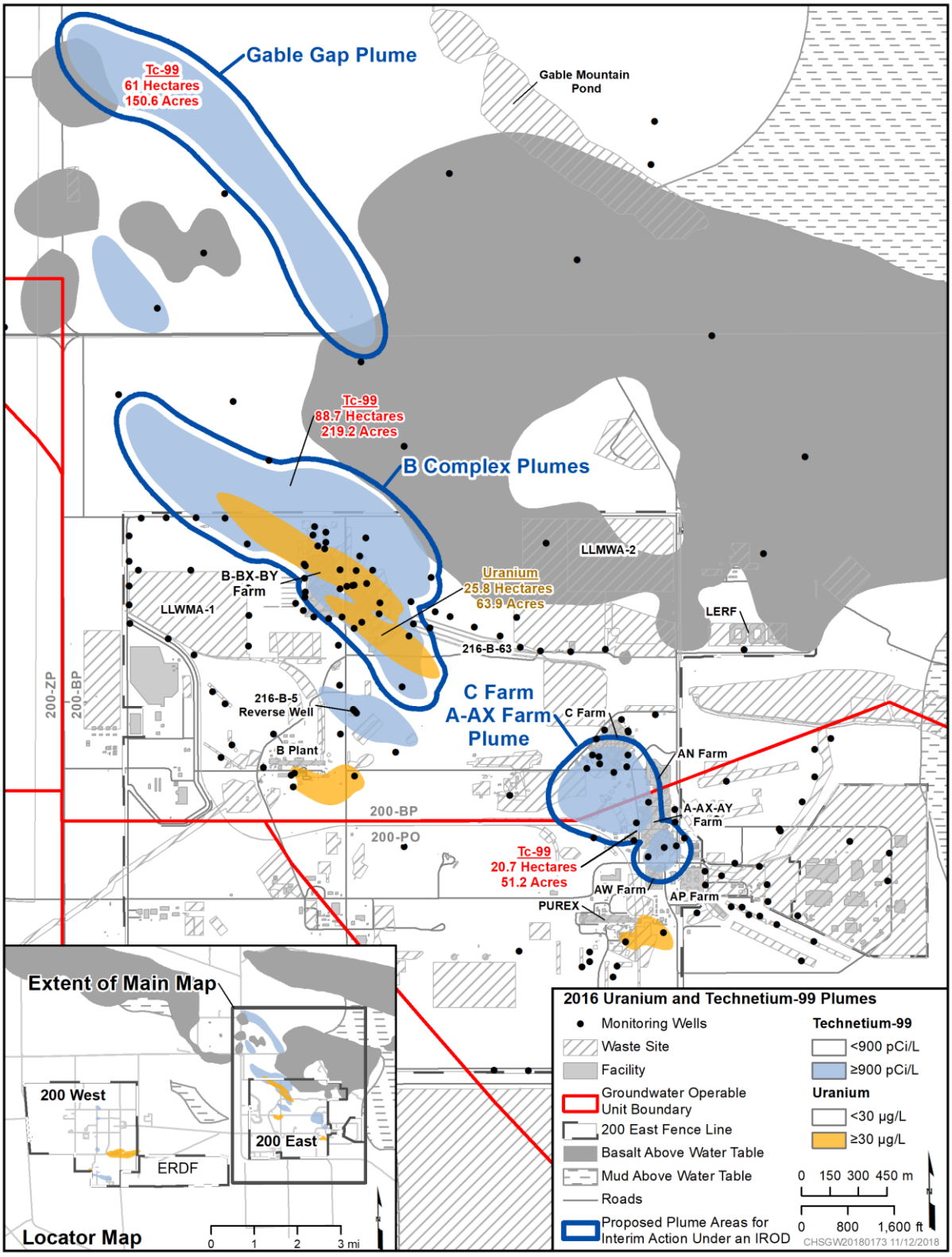

Figure 1-2. Uranium and Technetium-99 Groundwater Plumes in the 200 East Area

The uranium and technetium-99 contamination in groundwater at the B Complex and combined C Farm and A-AX Farms area originated from past liquid discharges from overlying waste sites and/or tank leaks and unplanned releases (UPRs) associated with these farms. The uranium and technetium-99 plumes beneath the B Complex area and the technetium-99 plume beneath the C Farm and A-AX Farms area are of primary interest for the following reasons:

- The plumes are large (the B Complex uranium plume is 26 ha [64 ac], the B Complex technetium-99 plume is 89 ha [219 ac], and the C Farm and A-AX Farms technetium-99 plume is 21 ha [51 ac]). The plumes exhibit high concentrations (maximum concentration [C_{max}] is in excess of 10 times the DWS). Consequently, these plumes represent a majority of the mobile mass of uranium and technetium-99 in the 200-BP-5 and 200-PO-1 OUs.
- The contaminants are mobile, and the plumes are expanding downgradient from the source areas.
- The plumes have a continuing source of contamination that is currently arriving from the vadose zone.
- The aquifer in the plume areas is highly transmissive. Therefore, the plumes are conducive to remediation by P&T, as previously demonstrated in the B Complex area.

The interim action will continue until one or more of the following occurs:

- Uranium and technetium-99 concentrations are below their respective DWSs (i.e., measured uranium concentrations are <30 µg/L and measured technetium-99 concentrations are <900 pCi/L, and the calculated cumulative drinking water dose is <4 mrem/yr).
- The Tri-Parties agree to terminate the interim action.
- The interim action is superseded by a final ROD for the 200-BP-5 and 200-PO-1 OUs.

The Gable Gap technetium-99 plume, located to the north of the 200 East Area, originated from past discharges from the B Complex that migrated northward when the general groundwater flow was to the north-northwest. This plume is in an area that is characterized by few wells and where groundwater flow is currently stagnant or nearly stagnant. Because the plume is relatively stable, immediate action is not considered to be a priority; however, remediation of the Gable Gap technetium-99 plume is a secondary objective for the following reasons:

- The technetium-99 plume is large (61 ha [151 ac]).
- It will take a long period of time for concentrations to reach the DWS through radiological decay. With a long half-life, the technetium-99 plume is expected to persist for hundreds of years without active remediation.
- Initiating a near-term action for this plume would lead to an improved understanding of the extent of this plume and aquifer characteristics.
- Conducting P&T of this plume in the near-term would constitute an efficient use of the existing 200 West P&T, provided that sufficient treatment capacity exists.

Four other uranium or technetium-99 plumes exist in the 200-BP-5 and 200-PO-1 OUs. These plumes are relatively small in size and have substantially less mass than the plumes targeted for interim action in this FS. Figure 1-2 depicts these plumes, which are summarized as follows:

- **B Plant uranium plume:** This plume is located south and east of B Plant, and it is believed to have originated from discharges to the 216-B-12 Crib, located upgradient to the west of B Plant. The plume is found in the upper unconfined aquifer, and has separated and moved downgradient from the source crib. The plume is approximately 6 ha (15 ac) in area, and is defined by two wells with concentrations ranging from approximately 40 to 55 µg/L (the DWS for uranium is the maximum contaminant level [MCL] value of 30 µg/L).

- **216-B-5 Reverse Well technetium-99 plume:** This plume is defined by a single well screened at 6.1 to 9.1 m (20 to 30 ft) below the water table. Technetium-99 concentrations in the area of the 216-B-5 Reverse Well were first observed to exceed the DWS in a single well in 2013. Concentrations in this well reached 13,300 pCi/L in 2015 and 2016. A number of other wells monitoring the area remain below the DWS (the MCL for technetium-99 is 900 pCi/L). The source of the plume is uncertain, and the estimated area is approximately 9 ha (22 ac).

- **PUREX uranium plume:** This plume is located south and east of the PUREX Plant, and is believed to have originated from discharges to overlying waste sites. The plume is found in the upper unconfined aquifer and has historically been defined by one to three wells with concentrations in excess of the DWS. The concentrations observed in these wells have ranged from below the DWS to a maximum of 106 µg/L. Uranium above the DWS is currently detected in only one well. Based on 2016 groundwater contaminant measurements, the plume has decreased in size since it was first defined in 2008, with a plume area of approximately 3 ha (7.4 ac).

Although these smaller plumes are not within the scope of the interim action, the plumes will continue to be monitored under the routine monitoring OU SAPs previously identified in this chapter.

1.2 Integration with Other Remedial Activities

The following sections discuss how the interim remedial action at 200-BP-5 and 200-PO-1 OUs (as evaluated in this FS) would integrate with the P&T operation currently proceeding at the B Complex, the upcoming closure of WMA C, and future remedial activities in these two groundwater OUs.

1.2.1 Integration with Other Pump and Treat Operations

This interim action includes the P&T operation currently being conducted for B Complex groundwater under a non-time-critical removal action (NTCRA). Perched water extracted from the 200-DV-1 OU beneath the B Complex will continue to be collected and conveyed via a common pump station and cross-site pipeline along with the B Complex groundwater extracted under this interim action.

Groundwater extracted via P&T in the 200-BP-5 and 200-PO-1 OUs under this interim action would be treated at the existing 200 West P&T (groundwater treatment system), which currently treats water from the 200-UP-1, 200-ZP-1, 200-BP-5, and 200-DV-1 OUs, as well as the Environmental Restoration Disposal Facility (ERDF) and modutanks. Proposed modifications to the 200 West P&T discussed in this FS will provide additional treatment capacity, which is necessary to accommodate the additional flow from the 200-BP-5 and 200-PO-1 OUs associated with the IROD.

1.2.2 Integration with Waste Management Area C Closure

Work is proceeding toward closure for WMA C. Key documents in that decision process are components of Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*, Appendix I, "Performance Assessment":

- RPP-ENV-58782, *Performance Assessment of Waste Management Area C, Hanford Site, Washington*
- RPP-ENV-58806, *RCRA Closure Analysis of Tank Residuals Impacts at Waste Management Area C, Hanford Site, Washington*
- RPP-RPT-58329, *Baseline Risk Assessment for Waste Management Area C*
- RPP-RPT-59197, *Analysis of Past Tank Waste Leaks and Losses in the Vicinity of Waste Management Area C at the Hanford Site, Southeast Washington*

RPP-ENV-58806 and RPP-RPT-59197 support landfill closure of tanks and ancillary equipment for residual waste to be left in place after tank retrieval. RPP-ENV-58782 and RPP-RPT-58329 support RCRA corrective action of soil contamination. The past leaks assessment provides a projection of contaminant release from the WMA C vadose zone to groundwater, and the baseline risk assessment (BRA) identifies contaminants that have impacted groundwater or have the potential to contaminate groundwater in the future. Comparison of the estimated releases for technetium-99 (the primary contaminant impacting groundwater) for WMA C from RPP-RPT-59197 (based on inventory estimates and vadose zone transport simulations of technetium-99 releases) versus that for the 200-BP-5 OU RI report (DOE/RL-2009-127) (based on inventory estimates from RPP-ENV-33418, *Hanford C-Farm Leak Assessments Report*, and groundwater data) indicates that the WMA C past leaks assessment has a larger total release estimate (17.5 Ci) than the 200-BP-5 OU RI report estimate (9 Ci). The difference between the two estimates is that the two evaluations use different revisions of the leak assessment report (RPP-RPT-33418, Rev. 2A and Rev. 4). The 200-BP-5 OU RI report (prepared in 2013) used Rev. 2A of the assessment report, while the analysis of past leaks (prepared in 2017) used Rev. 4. However, both estimates are in close agreement regarding the inventory transmitted to groundwater by 2013 (about 3 Ci), which is represented by the initial plume conditions for 2013 as represented in the 200-BP-5 OU RI groundwater simulations. Furthermore, both evaluations report an approximate technetium-99 flux rate to groundwater in the range of 0.1 to 0.2 Ci/yr. Both evaluations also predict that a significant inventory remains in the vadose zone that will continue to impact groundwater for about 60 years (i.e., flux rate to groundwater will continue to maintain a technetium-99 groundwater plume in excess of the DWS). The difference in total activity yet to be released to groundwater in these estimates is primarily attributed to the analysis of past leaks, assuming a larger inventory and volume released from tank 241-C-105 than was assumed when developing the estimate for the 200-BP-5 OU. Significant uncertainty is associated with past leak estimates from tank 241-C-105. It must also be noted that the analysis of past leaks is undergoing a revision, where a larger range of releases from tank 241-C-105 is being evaluated; a report is expected to be issued in calendar year 2019.

The WMA C BRA (RPP-RPT-58329) retained only one radiological contaminant of potential concern (COPC) (technetium-99) and one nonradiological COPC (nitrate). Nitrate was retained based on its presence in groundwater near WMA C, not because there is a continuing vadose zone source associated with WMA C. Nitrate is addressed as a co-contaminant under this interim action. While some uncertainties remain in the groundwater protection evaluation, beta-BHC, lindane, and cadmium are reported above their respective groundwater cleanup levels based on the three-phase equation but need to

be evaluated using the site-specific Subsurface Transport Over Multiple Phases (STOMP)[5] model. No other groundwater protection COPCs are identified in the WMA C performance assessment (RPP-ENV-58782) need to be considered in this interim action. Considering the uncertainties associated with performing such analyses, the releases of technetium-99 estimated in the WMA C performance assessment analysis (17.5 Ci) and in the 200-BP-5 OU RI/FS analysis (9 Ci) (DOE/RL-2009-127) are reasonably close over the timeframe considered.

Integration of the WMA C closure process and the C Farm component of the 200-BP-5 OU interim action will need to continue as these projects progress. As WMA C analyses continue to refine the estimates of technetium-99 inventory released for WMA C, the 200-BP-5 OU evaluations will continue to consider the continuing source contributions in future modeling. If a P&T remedy is selected for the interim action, a remedial design/remedial action work plan (RD/RAWP) will be prepared to plan the implementation. The RD/RAWP will include updated fate and transport modeling to support the extraction system design and will be based on current groundwater conditions. The RD/RAWP will also re-evaluate groundwater impacts from future vadose zone source contributions based on current knowledge as needed, including approved WMA C performance assessment documents.

Near-term (e.g., <5 years) vadose zone source contributions are not expected to impact the initial scope of the C Farm interim action. The technetium-99 plume originating from WMA C has been expanding to the southeast and increasing in size since groundwater began flowing to the southeast in 2011. An extraction system for the C Farm would be designed to capture both the C Farm and A-AX Farms portions of the technetium-99 plume. As contaminated groundwater extraction progresses, it is expected that the plume area would shrink in size to a relatively small area close to the source, where the flux of vadose contamination into groundwater continues. Groundwater extraction rates at this later time would be reduced to rates required for localized source control to prevent plume redevelopment. The remedy would fundamentally continue to be optimized throughout its lifecycle based on system performance and observed conditions, as well as determining whether to accommodate continuing source contributions or other conditions. In this manner, the remedy will be adaptively managed.

1.2.3 Integration with Future Remedial Activities

This FS for interim action will support the development of a PP and an IROD. The 200-BP-5 and 200-PO-1 OUs will need a future (non-interim) ROD to address the remaining groundwater COCs and plumes. The schedule for remaining plume remediation will be determined after contaminant sources are adequately evaluated using source area investigations. To identify and select a final remedy for the 200-BP-5 and 200-PO-1 OUs, the following will be needed:

- This FS will support development of the IROD, which will be implemented to address the identified uranium and technetium-99 plumes.
- Groundwater monitoring data will be collected to assess interim action performance. This information will support the evaluation of P&T as an aquifer restoration technology and the identification of data needs to support future (non-interim) remedial action decisions.
- Routine groundwater monitoring for the 200-BP-5 and 200-PO-1 OUs will continue for the groundwater COCs (as defined in Section 3.1) and the COPCs not specifically targeted in the IROD in accordance with existing RI/FS work plans and associated SAPs. The existing RI/FS work plans

[5] STOMP is a computer model designed to be a general-purpose tool for simulating subsurface flow and transport, that complements other analytical capabilities developed by Pacific Northwest National Laboratory in Richland, Washington. Available at: https://stomp.pnnl.gov/.

and SAPs will be revised, as needed, to address data gaps and data needs to inform future (non-interim) groundwater decisions.

- The waste sites and unsaturated vadose zone above the target plume areas are the primary sources for the existing groundwater contamination and are being investigated as part of the RFI/CMS process or as part of other overlying source OUs that are following the CERCLA RI/FS process. These source investigations will assess potential future impacts to groundwater from remaining contamination in the vadose zone. Remedial action decisions for contaminant sources and associated vadose zone contamination will be made under separate source OU RODs (e.g., 200-EA-1 OU and 200-DV-1 OU). A final ROD for the 200-BP-5 and 200-PO-1 OUs will be pursued when future impacts to groundwater from contaminant sources or vadose zone contributions are better defined.

- When sufficient information and data are available to support future decisions for the Central Plateau groundwater OUs, a new FS, PP, and ROD for final action are anticipated to be developed for the 200-BP-5 and 200-PO-1 OUs to address the remaining plumes and groundwater contaminants warranting remedial action.

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2 Background

This chapter presents existing information on facilities and subsurface conditions associated with the 200-BP-5 and 200-PO-1 OUs. Additional details are available in the 200-BP-5 RI report (DOE/RL-2009-127), the 200-PO-1 RI report (DOE/RL-2009-85), and the 200-PO-1 RI report addendum (DOE/RL-2009-85 ADD1).

2.1 Site Description

The Hanford Site encompasses 1,502 km^2 (580 mi^2) in the Columbia Basin of southeastern Washington State (Figure 2-1). The 200 Areas include the 200 West and 200 East Areas of the Central Plateau, which contain inactive reactor fuel-reprocessing plants and associated waste management facilities. The 200-BP-5 and 200-PO-1 OUs are associated with the 200 East Area. The 200-BP-5 OU extends north from the northern portion of the 200 East Area, through Gable Gap, and to the Columbia River. The 200-PO-1 OU extends southeast and east from the southern portion of the 200 East Area to the Columbia River (Figure 1-1).

To organize groundwater monitoring and RI activities, both OUs were divided into near-field and far-field areas. For the 200-BP-5 OU, the near-field area includes the northern portion of the 200 East Area (southern portion of the 200-BP-5 OU), where the contamination originated and where the highest groundwater contaminant concentrations are detected. The far-field area consists of the broad geographic area extending north between the 200 East Area and the Columbia River, and it is located north and historically downgradient of the source areas and existing groundwater plumes. For the 200-PO-1 OU, the near-field area includes the southern portion of the 200 East Area, where the contamination originated and the highest contaminant concentrations are detected. The far-field area consists of the broad geographic area extending between the 200 East Area and the Columbia River, and it is located downgradient of the groundwater sources.

2.2 Site History

Major process areas in the 200 East Area included B Plant (which overlies the 200-BP-5 OU) and PUREX Plant (which overlies the 200-PO-1 OU). Liquid waste was discharged in the 200 Areas since the inception of plutonium-production activities at the Hanford Site in the 1940s. Waste considered to be uncontaminated (e.g., cooling water and steam condensate) was disposed to open ditches and ponds, while low-level radiologically contaminated process waste and tank supernatant liquids were disposed to cribs and trenches. The liquid waste discharged to surface ponds (e.g., B Pond), cribs, and trenches was then allowed to infiltrate into the soil column. High-level radioactive waste derived from reprocessing reactor fuel was directed to underground tanks, and some of these tanks have been associated with UPRs to the soil column. The estimated liquid waste inventories generated from these sources are provided in the RI reports (Section 4.2 of DOE/RL-2009-127; Chapter 4 of DOE/RL-2009-85). Sources continuing to affect groundwater include the B Farm complex and the C Farm (overlying 200-BP-5 OU) and the cribs associated with the PUREX Plant (overlying 200-PO-1 OU).

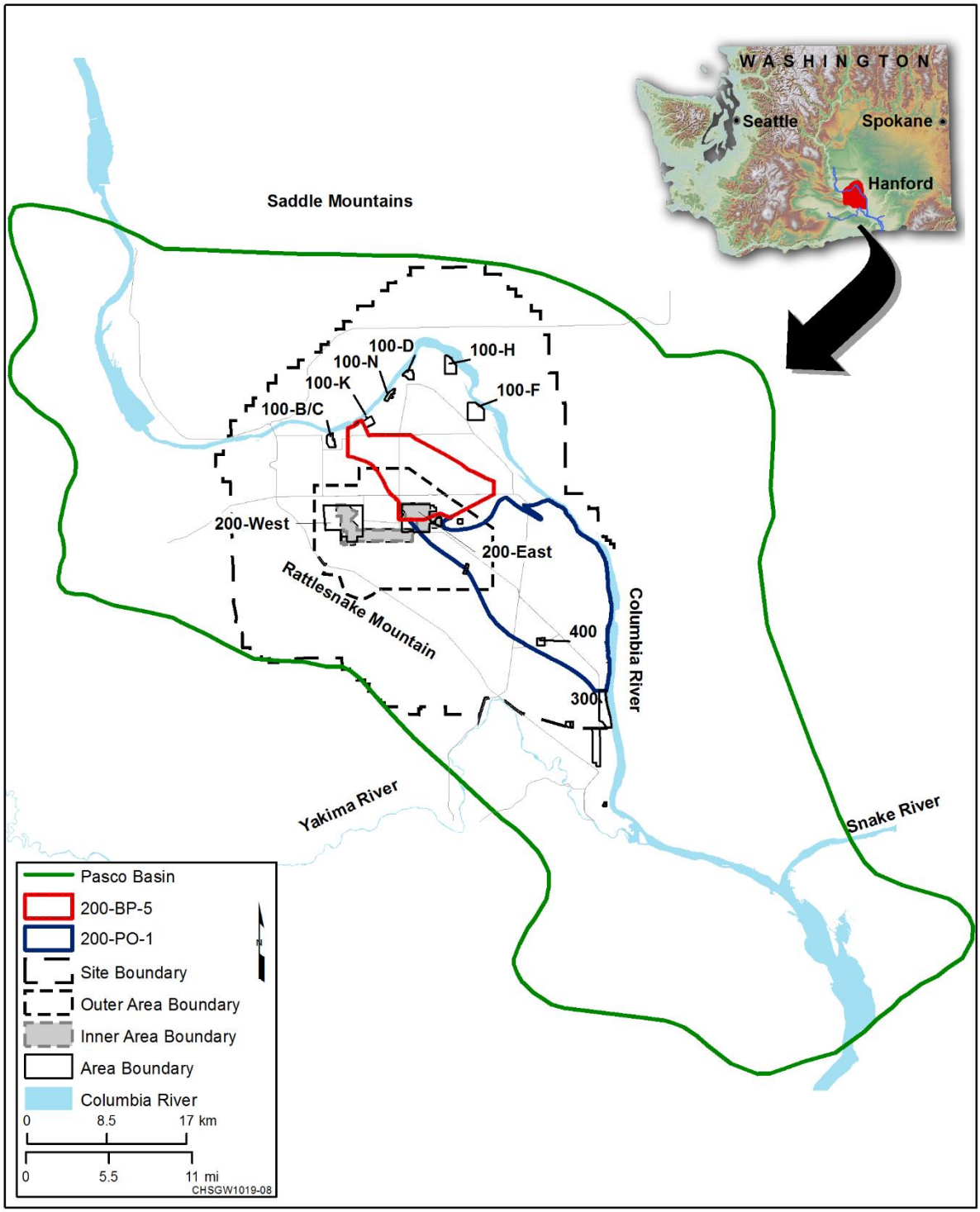


Figure 2-1. Location of the Pasco Basin and the 200-BP-5 and 200-PO-1 OUs

2.3 Geologic Setting

The geology of the Hanford Site has been characterized in previous investigations and by recent environmental restoration activities. Geologic and geophysical investigations within the 200-BP-5 and 200-PO-1 OUs included regional and Hanford Site surface mapping; borehole and well sediment logging; field and laboratory sediment classification and description; surface and borehole geophysical studies (including radiological borehole logging and various seismic, magnetic, and gravity surveys); and in situ and laboratory hydrogeologic properties testing. Details regarding geologic study results and interpretations are provided in the 200-BP-5 OU RI report (DOE/RL-2009-127) and the 200-PO-1 OU RI report (DOE/RL-2009-85).

The Hanford Site lies within the central portion of the Pasco Basin (Figure 2-2), which is located in the Yakima Fold Belt along the western margin of the Palouse Slope. The Saddle Mountains form the northern boundary of the Pasco Basin, and Rattlesnake Mountain forms part of the southern boundary. The Pasco Basin was formed by the deformation of thick sequences of older flood basalts, sedimentary interbeds between basalt flows, and younger suprabasalt sediments.

2.3.1 200-BP-5 Operable Unit

Most the 200-BP-5 OU near-field area lies on the northern flank of the Cold Creek syncline (Figure 2-2). Bedrock in this area generally dips to the south-southwest. Smaller basalt folds directly north of the 200 East Area trend northwest-southeast, extending above the water table in certain areas and creating barriers to groundwater flow in the unconfined aquifer. Seismic data gathered to support DOE/RL-2007-18, *Remedial Investigation/Feasibility Study Work Plan for the 200-BP-5 Groundwater Operable Unit*; and the 200-PO-1 OU RI (DOE/RL-2009-85) were used to refine the top-of-basalt surface throughout the 200 East Area, including the southern portion of the 200-BP-5 OU. Figure 2-3 presents a top-of-basalt interpretation from 2013 for the near-field area and illustrates the complex system of anticlinal and synclinal folds delineated in various geologic studies of this area (PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*).

The basalt flows of the Columbia River Basalt Group were deposited during the Miocene age from source vents in southeastern Washington, northern Oregon, and western Idaho. The Elephant Mountain Member is the uppermost basalt unit, ranging in thickness from 0 to 35 m (0 to 115 ft) beneath the 200-BP-5 OU. The Rattlesnake Ridge interbed of the Ellensburg Formation is present beneath the Elephant Mountain Member and comprises the uppermost basalt-confined aquifer beneath most of the 200-BP-5 OU.

Unconsolidated and partly consolidated sediments of the Miocene through Holocene ages (approximately 8.5 million years ago to present) overlie the basalts (DOE/RL-95-100, *RCRA Facility Investigation Report for the 200-PO-1 Operable Unit*). These sediments contain the uppermost unconfined aquifer system within the 200-BP-5 OU, which is the location of groundwater contamination that is the focus of this FS. The geologic units are generally continuous in the northwestern portion of the OU near the Columbia River. However, in the Gable Gap region and much of the near-field area, some of the units are not present, and the entire suprabasalt sequence thins on the uplifted basalt. The suprabasalt sedimentary sequence is up to 200 m (650 ft) thick in the center of the basin, southwest of the 200-BP-5 OU. Figure 2-4 illustrates the locations of the paleoflood erosional and depositional features.

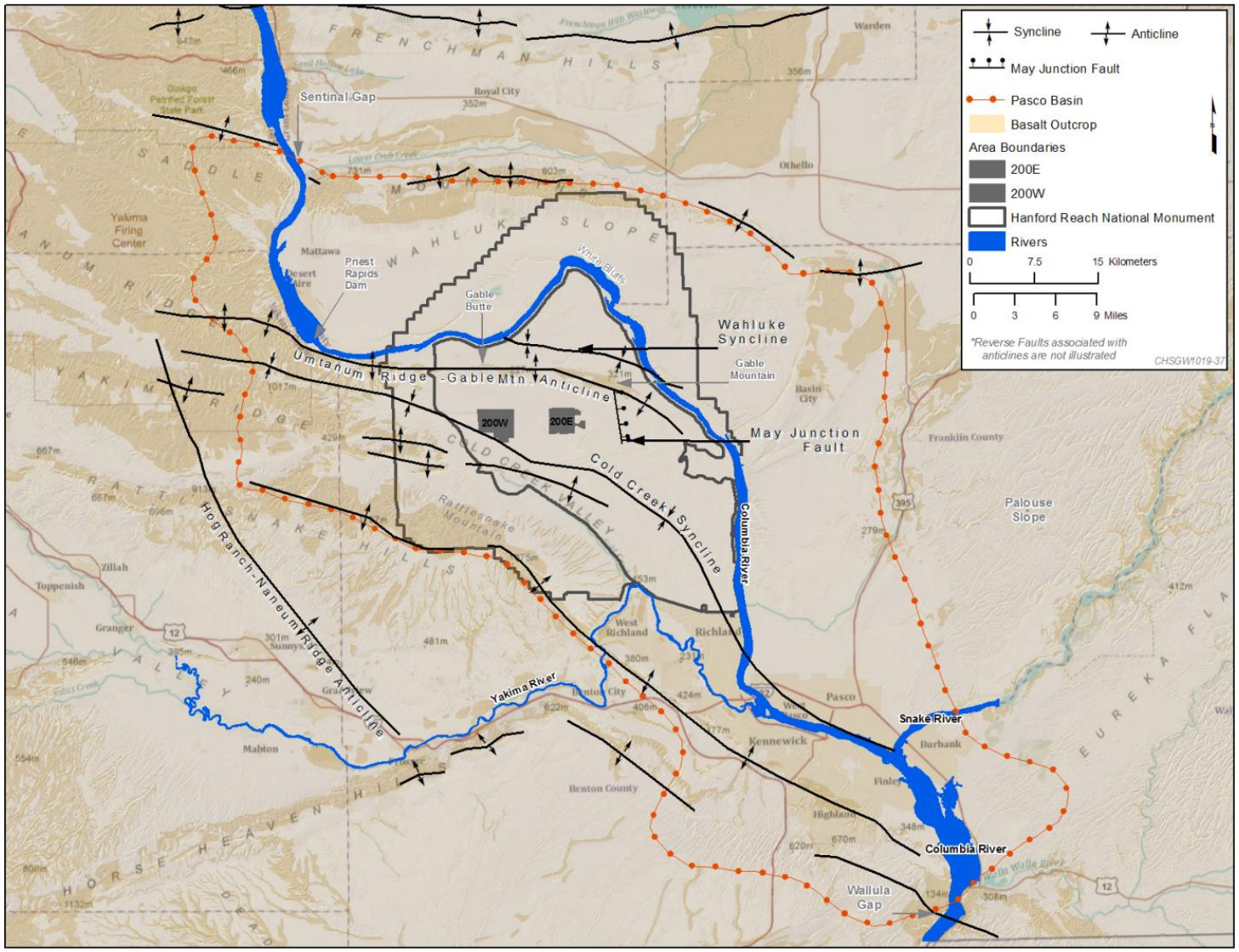
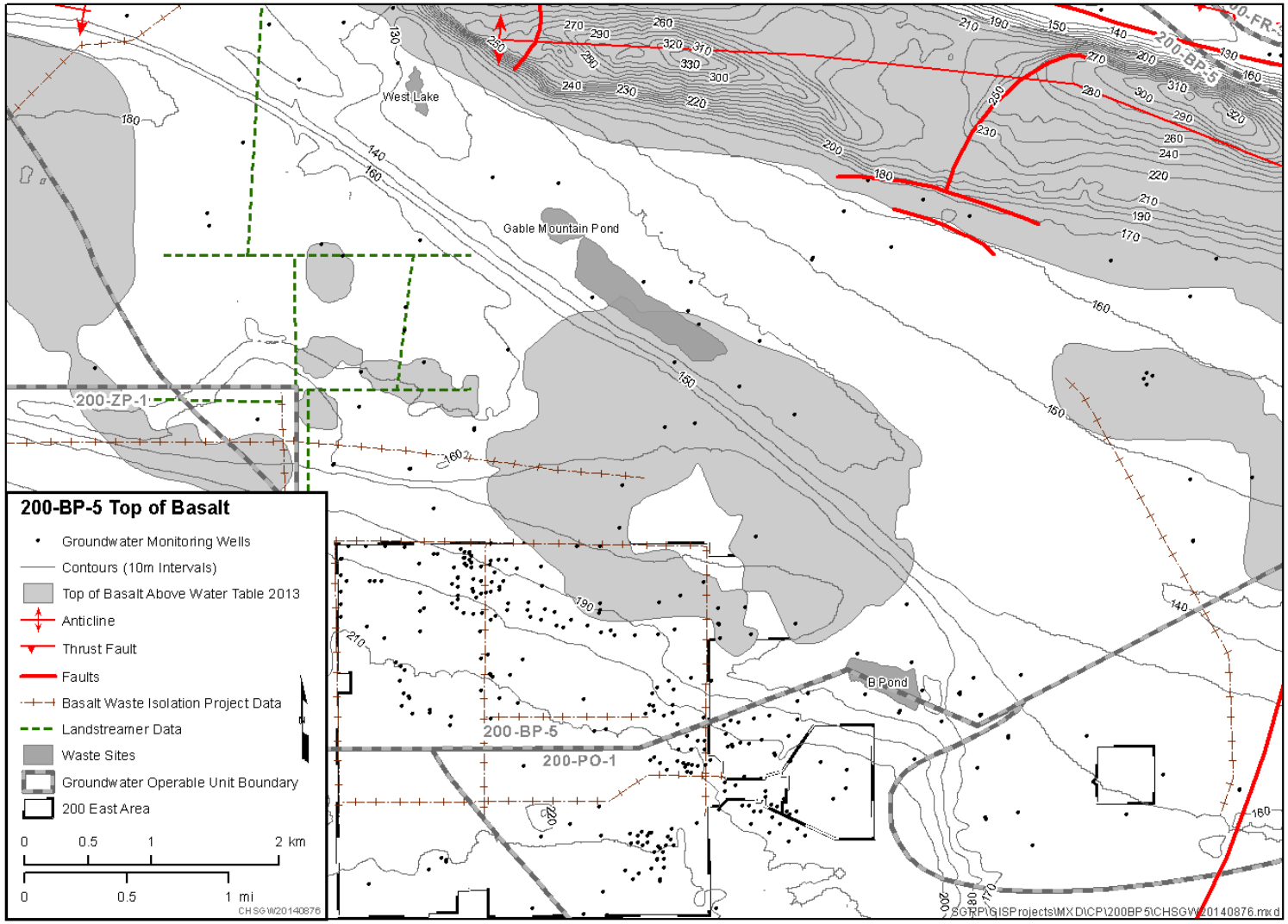


Figure 2-2. General Geologic Structures of the Pasco Basin and the Hanford Site



Reference: PNNL-19702, *Hydrogeologic Model for the Gable Gap Area, Hanford Site*.

Figure 2-3. Top-of-Basalt Structure Map, 200-BP-5 OU Near-Field Area

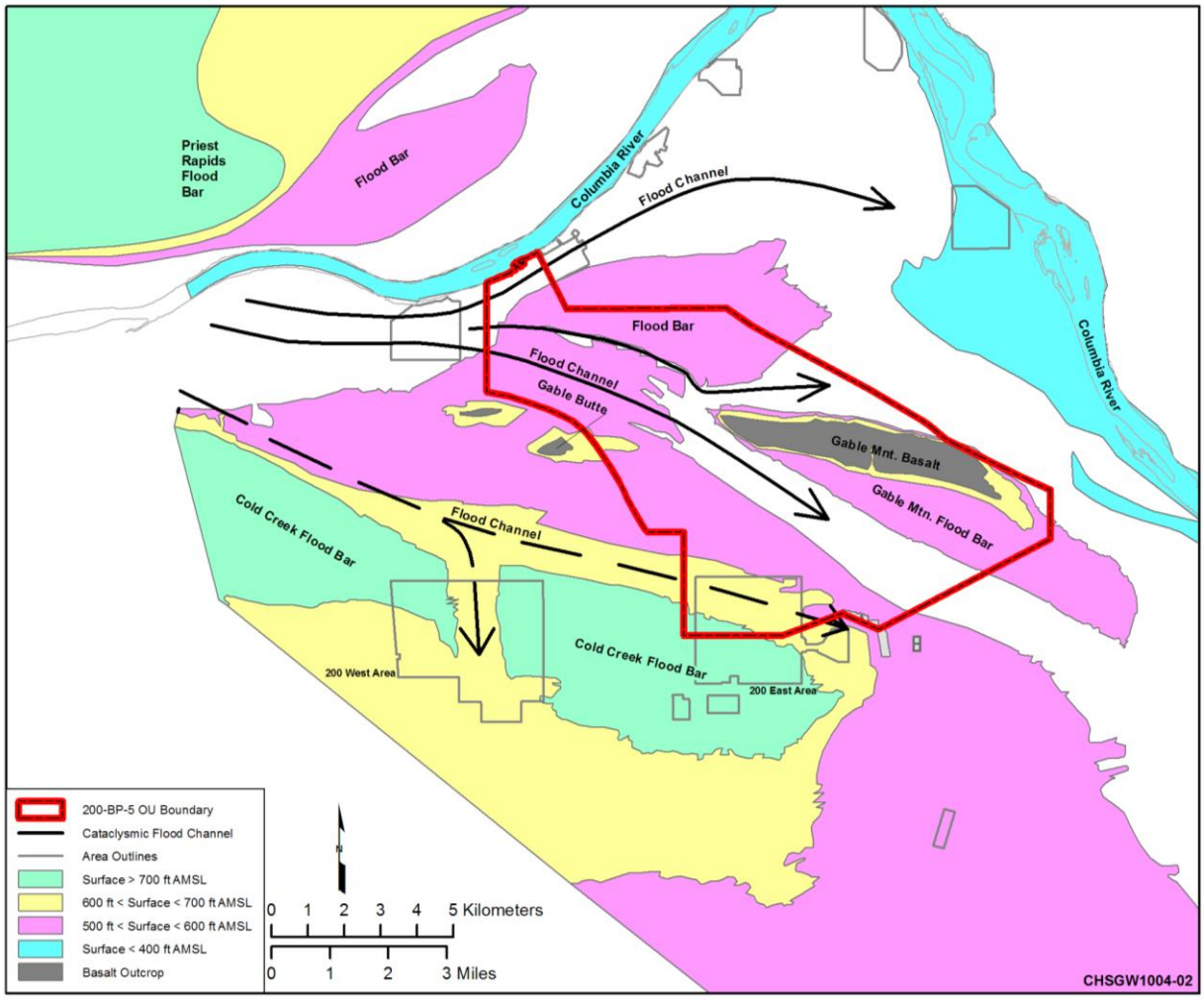
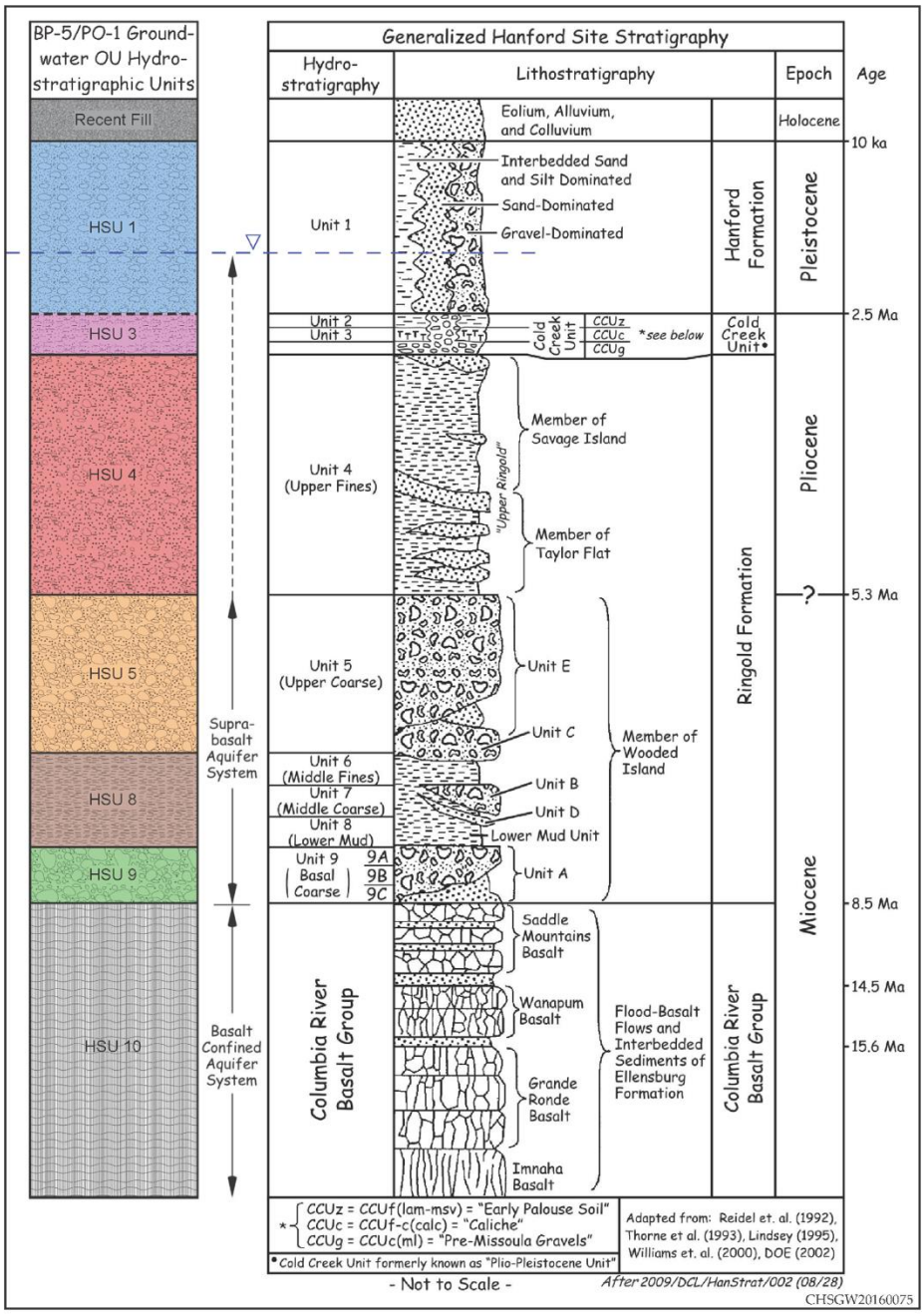


Figure 2-4. Generalized Pleistocene Paleo-Erosional Surface Topography Within the 200-BP-5 OU

The geology of the suprabasalt sediments is relatively well defined in the 200-BP-5 OU near-field area based on geophysical investigations and numerous boreholes drilled to support characterization and facility monitoring. Less confidence exists in the far-field area northwest of the 200 East Area because fewer investigations have occurred. The suprabasalt sediments beneath the 200-BP-5 OU consist of extensive fluvial and slackwater deposits assigned to the Ringold Formation, which are deposited on top of the basalt surface. The Ringold Formation is overlain in some areas by the Cold Creek unit (CCU) (formerly known as the pre-Missoula gravel), which is overlain with coarse-grained, paleoflood deposits of the Hanford formation. Figure 2-5 presents a generalized Hanford Site stratigraphic column for the subsurface area associated with the 200-BP-5 and 200-PO-1 OUs.



References:

DOE (2002) refers to DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*.

Lindsey (1995) refers to BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*.

Reidel et al. (1992) refers to WHC-MR-0391, *Field Trip Guide to the Hanford Site*.

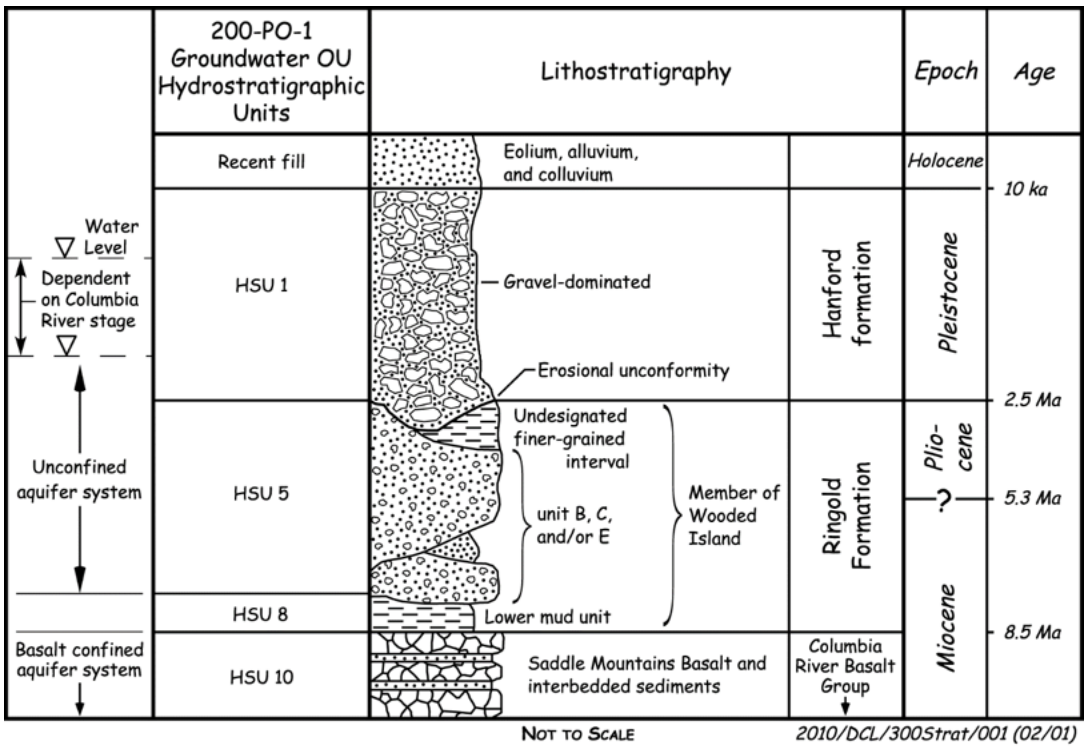
Thorne et al. (1993) refers to PNL-8971, *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 1993 Status Report*.

Williams et al. (2000) refers to PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*.

Figure 2-5. Hydrostratigraphy of the 200-BP-5 and 200-PO-1 OUs

The geologic nomenclature developed during the past several decades for the area north of Gable Mountain (the 100 Area) is simpler and more informal, resulting in a slightly different nomenclature than the near-field area south of Gable Gap. As shown in Figure 2-6, the area north of Gable Gap lies largely within the 100 Area, where the geologic units are grouped into four main hydrostratigraphic unit (HSU) intervals:

- HSU 9, consisting of Ringold Formation member of Wooded Island – unit A (Rwia)
- HSU 8, designated informally as the Ringold upper mud, which is composed of a thick, undifferentiated, fine-grained sequence of sediment consisting of the Ringold Formation member of Wooded Island – lower mud unit (Rlm), with Ringold units B/D stratigraphically included within the Rlm interval, and the younger Ringold Formation upper fine unit
- HSU 5, consisting of Ringold Formation member of Wooded Island – unit E (Rwie)
- HSU 1, which is the undifferentiated Hanford formation



Modified for 300 Area after Reidel et al. (1992), Thorne et al. (1993), Lindsey (1995), Williams et al. (2000), DOE-RL (2002)

References:

DOE-RL (2002) refers to DOE/RL-2002-39 *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*.

Reidel et al. (1992) refers to WHC-MR-0391, *Field Trip Guide to the Hanford Site*.

Thorne et al. (1993) refers to PNL-8971, *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 1993 Status Report*.

Williams et al. (2000) refers to PNNL-12261, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*.

Figure 2-6. Hydrostratigraphy of the 200-BP-5 OU and 200-PO-1 OUs Far-Field Areas Near the Columbia River

Some of the geologic units are combined (to define the primary HSUs supporting groundwater flow and transport analyses) based on similarities in hydraulic properties, to incorporate units that are not continuous or areas where uncertainty exists about the correlation and extent of the geologic units.

2.3.2 200-PO-1 Operable Unit

Previous studies providing geologic interpretations and related maps and cross sections pertaining to the 200-PO-1 OU include DOE/RL-92-19, *200 East Groundwater Aggregate Area Management Study Report*; and DOE/RL-95-100, which included cross sections from BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*.

The basalt bedrock within the 200-PO-1 OU is similar to that described for the 200-BP-5 OU, as well as the geologic units lying above the basalt (Section 2.3.1), which are generally continuous within the thicker portion of the basin located near the center of the 200-PO-1 OU. Figure 2-5 presents a generalized hydrogeologic column for the near-field portion of the 200-PO-1 OU, and Figure 2-6 presents the far-field portion.

Similar to the 200-BP-5 OU, the geology of the suprabasalt sediments is well defined in the 200 East Area (200-PO-1 OU near-field area) based on characterization data obtained from many closely spaced wells. A lower degree of confidence exists in the far-field area due to the wide spacing, age, and shallow (partially penetrating) depths of most boreholes. The suprabasalt sediments beneath the 200-PO-1 OU include the Ringold Formation, the CCU, and the Hanford formation.

The suprabasalt sedimentary sequence ranges up to 215 m (700 ft) in thickness in the center of the basin and contains the uppermost unconfined aquifer, which controls 200-PO-1 OU contaminant migration.

2.4 Hydrogeology

This section describes the basalt and suprabasalt aquifer systems in the 200-BP-5 and 200-PO-1 OUs, as well as the influence of geologic structures, aquifer parameters, and aquifer recharge on groundwater flow and contaminant transport through the OUs.

The primary aquifer system for the 200-BP-5 and 200-PO-1 OUs is the uppermost unconfined aquifer lying within the Hanford formation, CCU, and Rwia and Rwie suprabasalt sediments. The younger CCU and Hanford formation sediments are generally unconsolidated, while the Ringold Formation is generally semiconsolidated. All three contain varying percentages of silt, sand, and gravel.

During the Hanford Site operational period, the 200 East and 200 West Areas had persistent, artificially elevated groundwater mounds from ponds and ditches that received high volumes of wastewater. Since unpermitted discharges of liquid effluent within the Central Plateau were discontinued in the 1980s, the groundwater mounds have continued to dissipate. The following sections describe the stratigraphy, geologic structure, hydrogeology, and land use for the 200-BP-5 and 200-PO-1 OUs.

2.4.1 200-BP-5 Operable Unit

Groundwater conditions in the 200-BP-5 OU include unconfined, semiconfined, and confined aquifers. The unconfined aquifer within the 200 East Area is the primary aquifer impacted by past waste disposal operations and is associated with the suprabasalt sediment of the Ringold Formation, CCU, and Hanford formation (Figure 2-5). The greatest concentration/activity of technetium-99 and uranium occurs within the northwestern portion of the 200 East Area, also referred to as the B Complex (i.e., WMA B-BX-BY and adjacent liquid waste sites). Contaminant plumes extend both to the northwest and southeast within an ancestral Columbia River paleochannel (Cold Creek gravels) that incised into semiconsolidated gravels and cohesive Ringold sediments. The channel was later filled with unconsolidated gravels and fluvial

overbank/eolian sediments. A portion of the Cold Creek and Ringold deposits were later incised by glacial fluvial cataclysmic flooding followed by Hanford sediment deposition (PNNL-19702).

Farther north between Gable Gap, the unconfined aquifer lies not only within the Ringold Formation, CCU, and Hanford formation, but also the Rattlesnake Ridge and Selah interbeds due to basalt erosion (PNNL-19702).

Semiconfined aquifers within the 200-BP-5 OU are present to the east and west of the higher permeability paleochannel. More specifically, the semiconfined aquifers in these areas are found where Ringold unit 9B (Figure 2-5) overlie and the Elephant Mountain Basalt underlie the Ringold unit 9C. Confined aquifers within the OU are located in basalt interbeds and as confining units within the Ringold Formation in the northeastern part of the 200 East Area.

Depths from land surface to the water table in the 200-BP-5 OU range from <1 m (3.3 ft) in the far-field near the Columbia River to 105 m (344.5 ft) in the 200 East Area. The thickness of the unconfined aquifer (e.g., saturated sediments) varies from <1 m (3.3 ft) north of the 200 East Area to >40 m (131.2 ft) in the Gable Gap area.

Perched groundwater occurs in a localized area near the B Complex (B-BX-BY Farms) (Figure 2-7). The perched zone lies above the water table within the deep vadose zone that is part of the 200-DV-1 OU. SGW-53604, *Path Forward Recommendations Report for the Uranium Contamination in the B Area*, discusses a perched water zone conceptual site model, remedial approach, and recommendations for ongoing and future field activities. Removal of contaminated perched water is being conducted as a NTCRA (DOE/RL-2014-34, *Action Memorandum for 200-DV-1 Operable Unit Perched Water Pumping/Pore Water Extraction*).

In the 200-BP-5 OU, uranium and technetium-99 groundwater contaminant concentrations exceeding 10 times the DWSs in the B Complex are also being captured and treated under a NTCRA. This NTCRA consists of pumping groundwater from two extraction wells at a combined rate up to 568 L/min (150 gal/min) to the B Complex pump station (located on the north side of the B Farm), where it is then combined in a transfer tank with perched water from the 200-DV-1 OU perched water NTCRA. The combined groundwater is then conveyed via a cross-site pipeline to the 200 West P&T for treatment. The treated groundwater (effluent) is reinjected into the 200-ZP-1 and 200-UP-1 Groundwater OUs. DOE/RL-2016-41, *Action Memorandum for 200-BP-5 Operable Unit Groundwater Extraction*; and DOE/RL-2017-11, *Removal Action Work Plan for the 200-BP-5 Operable Unit Groundwater Extraction*, provide further discussion on the 200-BP-5 OU NTCRA.

2.4.2 200-PO-1 Operable Unit

Similar to the 200-BP-5 OU, the suprabasalt aquifer system in the 200-PO-1 OU includes localized semiconfined and confined intervals within the deeper portion of the sequence contained within the Ringold Formation, which is composed of silty, sandy gravel interspersed with thick, fine-grained (i.e., silty) intervals (e.g., the Rlm). However, in some regions of the 200-PO-1 OU, the uppermost portion of the unconfined aquifer lies within the lower portion of the Hanford formation and CCU. The younger, more permeable Hanford/CCU can result in preferential groundwater flow because of the relatively higher hydraulic conductivity compared to the underlying Ringold Formation. Preferential flow is especially evident along the southeast-trending paleochannel cutting across the northern and eastern portions of the 200 East Area (Figure 2-4). The Rlm represents the base of the unconfined aquifer throughout the majority of the 200-PO-1 OU, except where the Rlm is absent in the northern and central portions of the 200 East Area, and the uppermost basalt is the base of the aquifer.

throughout the majority of the 200-PO-1 OU, except where the Rlm is absent in the northern and central portions of the 200 East Area, and the uppermost basalt is the base of the aquifer.

The depth from the ground surface to the uppermost unconfined aquifer is >91 m (298.6 ft) near the southern boundary of the 200 East Area and <1 m (3.3 ft) below ground surface at the Columbia River.

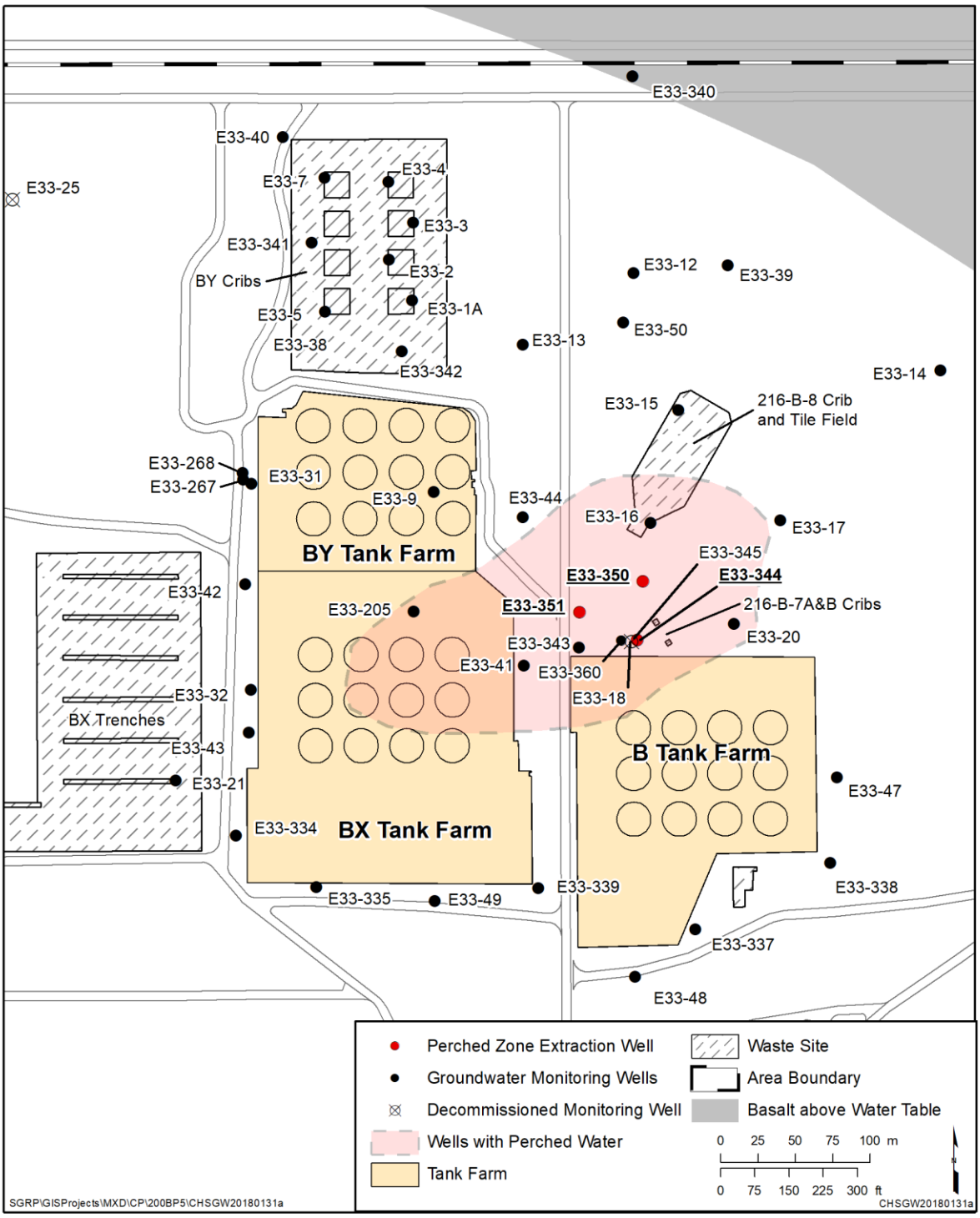


Figure 2-7. Perched Water Zone at the B Complex

In the southern portion of the 200 East Area where the main contaminant sources are located, the groundwater flow direction is primarily southeast in the unconfined aquifer. The southeast flow direction is influenced by the higher groundwater elevations to the west, the more permeable paleochannel (trending southeast) incised in the top of the underlying Ringold Formation, and the Rlm located above the water table near B Pond. In the central to eastern portion of the 200-PO-1 OU, groundwater flow expands to the northeast, east, and southeast as it approaches the Columbia River.

2.4.3 Groundwater Elevation and Flow

During site operations, a large water table mound resulting from large-volume effluent disposal (which ended in the early 1990s) substantially influenced the water table elevation, unconfined aquifer thickness, hydraulic gradients, and contaminant transport rates in portions of the 200-BP-5 and 200-PO-1 OUs.

During and shortly after plutonium-production operations ended, groundwater flow paths and contaminant plumes originating in the 200-BP-5 OU migrated toward the Columbia River in two general directions. Plumes in the northwestern portion of 200-BP-5 OU generally moved to the northwest toward Gable Gap and to the north toward the Columbia River. Plumes further south and in the 200-PO-1 OU migrated southeast toward the Columbia River. In 2011, major groundwater flow changes occurred within the unconfined aquifer south of Gable Mountain, with a 180-degree flow direction change from northwest to southeast due to ongoing water table declines in the 200 East Area (Figure 2-8).

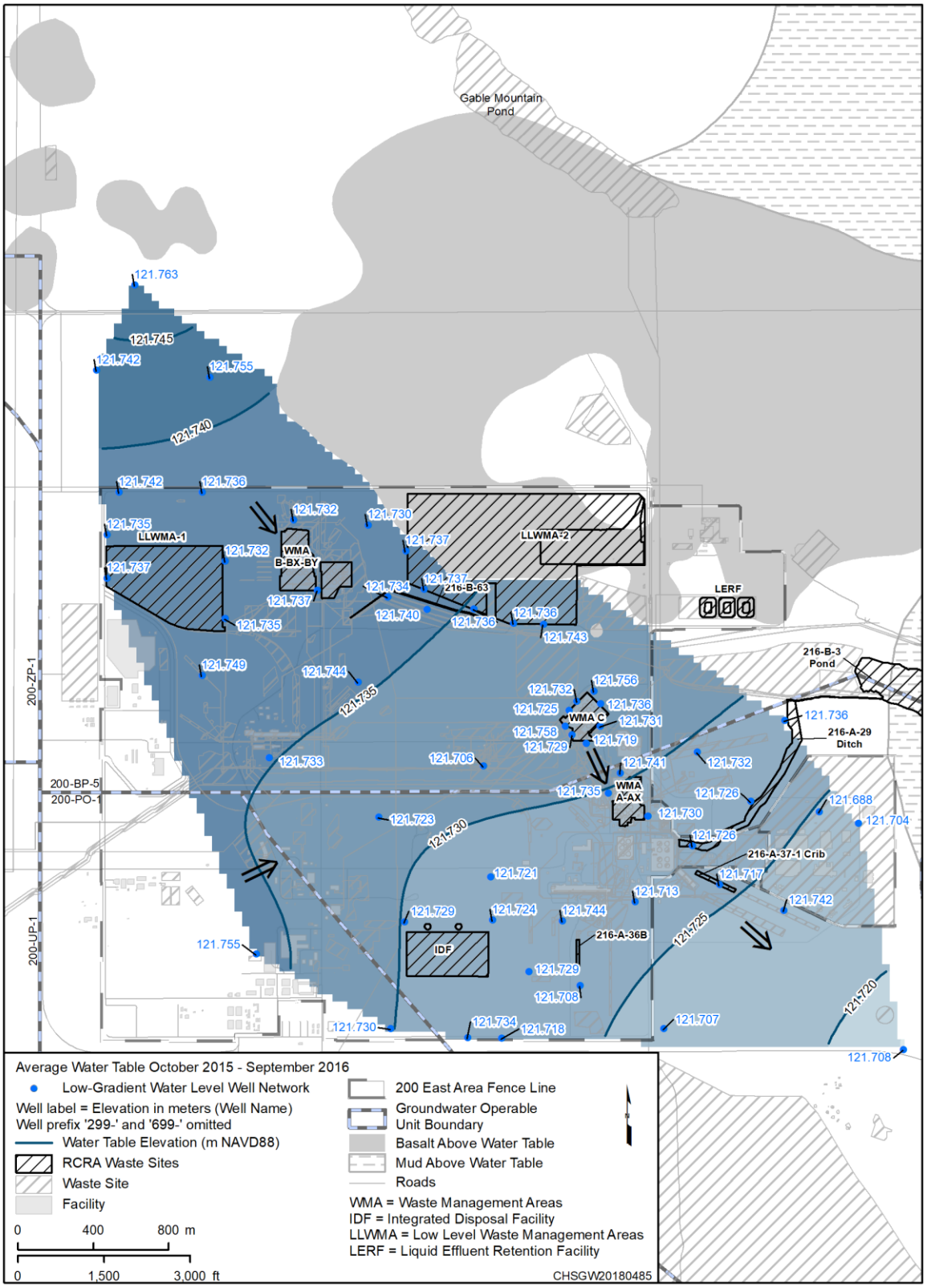
Since 2011, the flow direction across most of the 200 East Area (where the highest contaminant concentrations occur) has been south-southeast (SGW-54165, *Evaluation of the Unconfined Aquifer Hydraulic Gradient Beneath the 200 East Area, Hanford Site*). As groundwater flow moves into the far-field area, there is a northerly flow component in the 200-BP-5 OU and easterly component in the 200-PO-1 OU (Figure 2-9). Current groundwater flow velocities range from 0.02 to 0.6 m/d (0.07 to 1.97 ft/d) in the 200-BP-5 OU (Appendix B of DOE/RL-2014-32, *Hanford Site Groundwater Monitoring Report for 2013*). The regional gradient to the southeast (across the 200-BP-5 and 200-PO-1 OUs) has been estimated at 1.8×10^{-5} (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*).

2.5 Land Use

The following sections discuss current and future land use for the Central Plateau, which includes the 200-BP-5 and 200-PO-1 OUs.

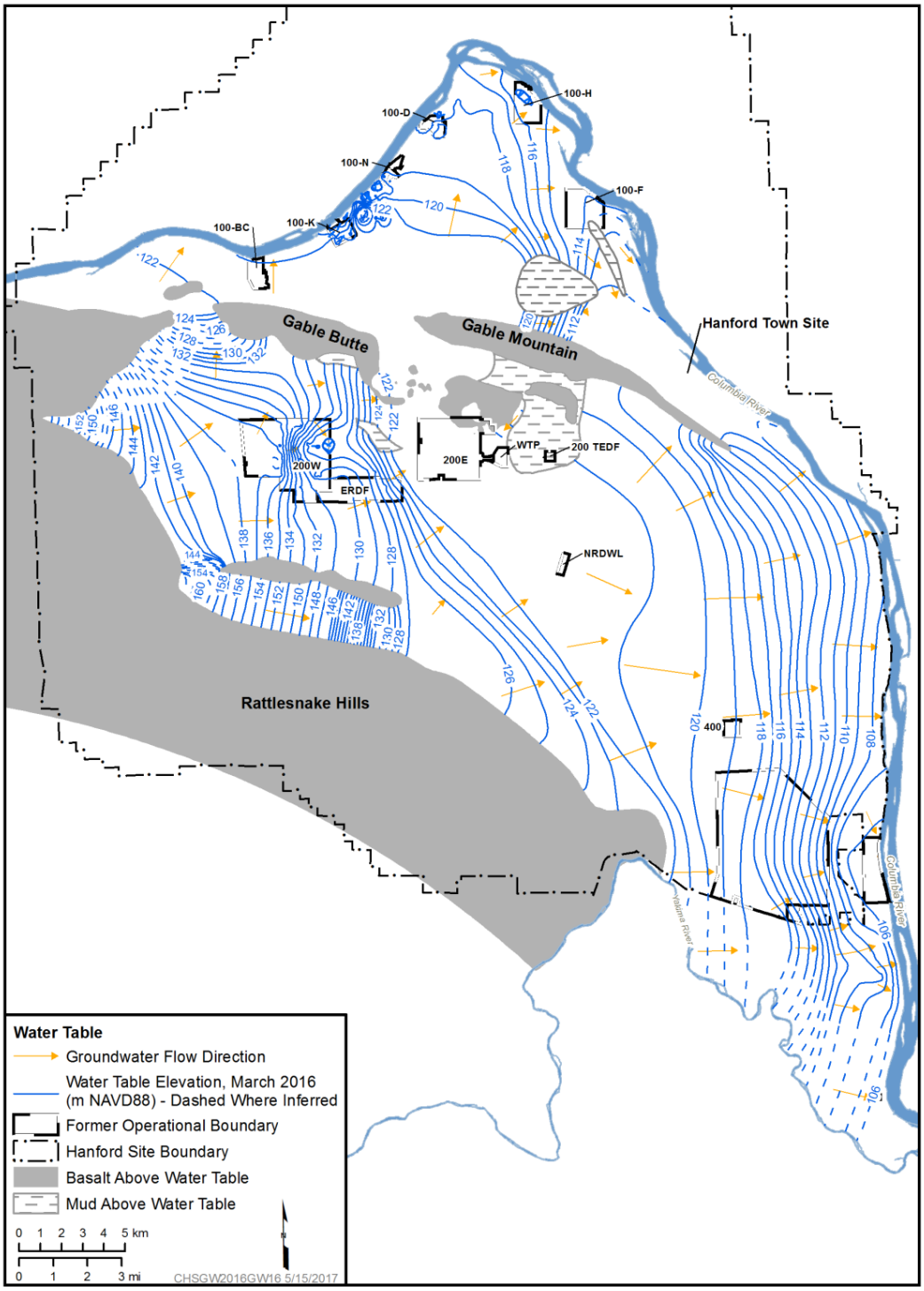
2.5.1 Current and Reasonably Anticipated Future Land Use

Current land use on the Central Plateau is industrial, and public access to the site is restricted (PNNL-15892, *Hanford Site Environmental Report for Calendar Year 2005*). Land use in the 200 West and 200 East Areas is anticipated to remain industrial for the foreseeable future and will be used for ongoing waste disposal operations and infrastructure services.



Modified from: DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016.*

Figure 2-8. Average Water Table and Flow Direction for the 200 East Area, 2016



NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: http://www.ngs.noaa.gov/.

Source: DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*.

Figure 2-9. Groundwater Table at the Hanford Site, 2016

2.5.2 Anticipated Future Land Use

DOE worked for several years with cooperating agencies to define land-use goals for the Hanford Site. The cooperating agencies and stakeholders included the National Park Service, Tribal Nations, the states of Washington and Oregon, local county and city governments, economic and business development interests, environmental groups, and agricultural interests. Drummond, 1992, *The Future for Hanford: Uses and Cleanup – The Final Report of the Hanford Future Site Uses Working Group*, was an early product of the efforts to develop land-use assumptions. The report recognized that the Central Plateau would be used to some degree for waste management activities for the foreseeable future.

Following the report, DOE issued DOE/EIS-0222-F, *Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (HCP EIS), and the associated HCP EIS ROD (64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement") in 1999. The HCP EIS analyzes the potential environmental impacts of alternative land-use plans for the Hanford Site and considers the land-use implication of ongoing and proposed activities. Under the preferred land-use alternative selected in the HCP EIS ROD, the Central Plateau was designated for industrial exclusive use, defined as areas suitable and desirable for treatment, storage, and disposal; and disposal of hazardous, dangerous, radioactive, and nonradioactive waste, as well as related activities.

Subsequent to the HCP EIS, the Hanford Advisory Board (HAB) issued HAB Advice #132 (02-HAB-0006, 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area"). The HAB acknowledged that some waste would remain in the core zone of the Central Plateau when cleanup is complete. The goal identified by the HAB is that the core zone should be as small as possible and not include contaminated areas outside of the Central Plateau fenced areas. The HAB further stated that waste within the core zone should be stored and managed so it is inaccessible to inadvertent intruding humans and biota, and that DOE should maximize the potential for any beneficial use of the accessible areas of the core zone. The HAB advised that risk scenarios for the core zone WMAs should include a reasonable maximum exposure to a worker/day user and to an intruder.

2.6 Nature and Extent of Contamination

Figures 2-10 and 2-11 show the key waste sites overlying the 200-BP-5 and 200-PO-1 OUs and the current distribution of groundwater contaminants. Groundwater has been affected by waste disposal practices, leaks from single-shell tanks, and UPRs associated with B Plant and PUREX Plant operations and the single-shell farms. The following sections discuss the extent of uranium, technetium-99, and other co-contaminants for the 200-BP-5 and 200-PO-1 OUs.

2.6.1 Uranium and Technetium-99

Uranium and technetium-99 are the target contaminants for remediation under this interim action; therefore, the uranium and technetium-99 groundwater plumes in the 200-BP-5 and 200-PO-1 OUs are the target of this FS. Figures 1-2 and 2-11 depict the uranium and technetium-99 groundwater contaminants with concentrations exceeding DWSs.

Source areas of uranium to the groundwater OUs are the B Complex, B Plant, and PUREX Plant. The main uranium plume extends northwest and southeast from the B Complex (Figure 1-2). Smaller, isolated uranium plumes occur southeast of the B Plant and southeast of PUREX.

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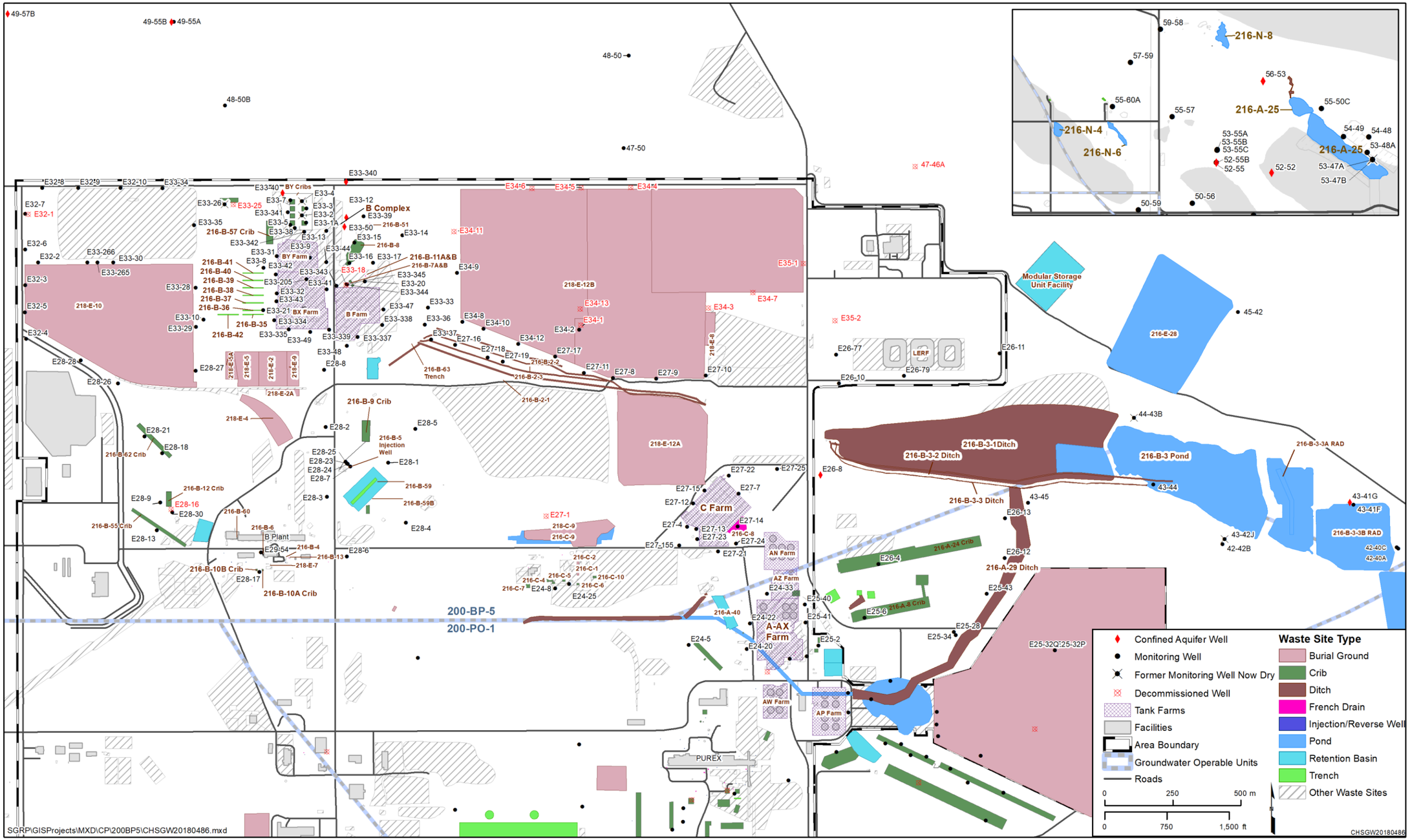
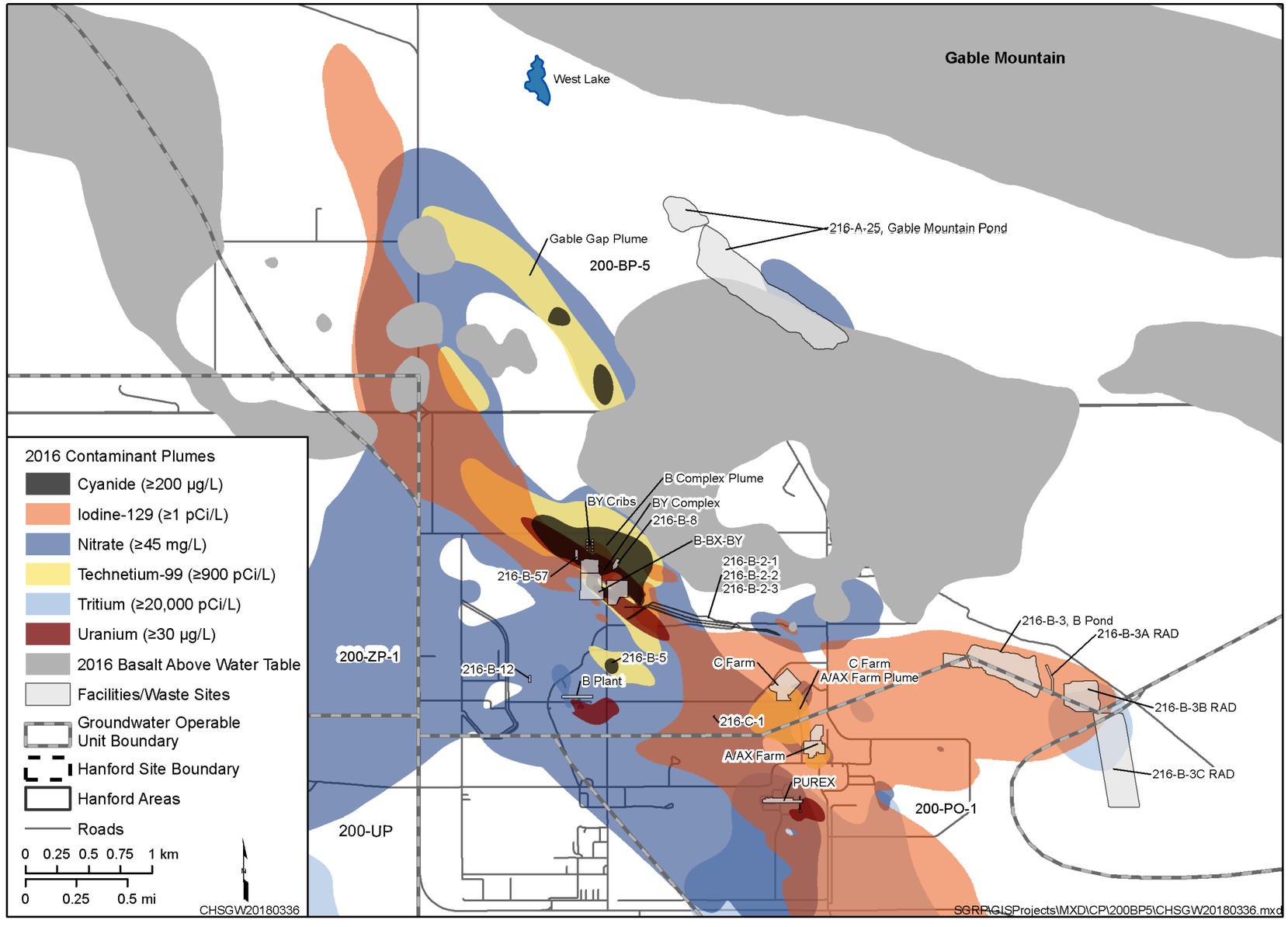


Figure 2-10. Location of Waste Sites and Monitoring Wells in the 200 East Area



Source: DOE/RL-2016-67, *Hanford Site Groundwater Monitoring Report for 2016*.

Figure 2-11. Groundwater Plumes Around the Target Remediation Areas of the 200-BP-5 and 200-PO-1 OUs

Technetium-99 is a fission product common to many of the nuclear fuel reprocessing waste streams. Sources areas of technetium-99 to the groundwater OUs are the B Complex, C Farm, and A-AX Farms. Technetium-99 groundwater plumes exceeding the DWS occur below the B Complex, extending northwest and southeast; north of the B Complex, extending northwest to Gable Gap; and below the C Farm, extending to the A-AX Farms (Figure 1-2).

2.6.2 Co-Contaminants

Groundwater contaminants other than the target COCs (uranium and technetium-99) that are present in the target remediation areas for this interim action are considered to be co-contaminants in this FS. Figure 2-11 shows the groundwater uranium, technetium-99, and co-contaminant plumes with concentrations exceeding DWSs. Nitrate, iodine-129, and cyanide are the main co-contaminants occurring near the target remediation areas for this interim action and, therefore, are the principal co-contaminants expected to be co-extracted under a P&T-based interim action.

Nitrate originated primarily from nitric acid used for nuclear fuel reprocessing and ammonium solutions present in liquids discharged to waste sites overlying the groundwater OUs. The nitrate plume with groundwater contamination exceeding the 45 mg/L DWS equivalent spans a large area and is largely commingled with the uranium and technetium-99 groundwater plumes in the B Complex and Gable Gap areas in the 200-BP-5 OU (Figure 2-11).

Iodine-129 is primarily formed from the fission of uranium in nuclear reactors and is one of the fission products in waste from the separations processes in the 200 Areas, which was discharged to the PUREX Cribs along with other waste products. Iodine-129 exceeding the 1 pCi/L DWS occurs as a broad, dispersed plume underlying the B Complex, C Farm, and A-AX Farms, extending southeast from the 200 East Area.

Cyanide was a component of the cesium-137 scavenging process that consisted of removing cesium-137 and strontium-90 from waste solutions by adding ferrocyanide. Liquid waste associated with the scavenging process was disposed to the BY Cribs. The cyanide groundwater plume, with concentrations exceeding the 200 µg/L DWS in the 200-BP-5 OU, underlies the B Complex.

2.7 Baseline Risk Assessment

Groundwater plumes within the 200-BP-5 and 200-PO-1 OUs were evaluated in their respective RIs (DOE/RL-2009-127; DOE/RL-2009-85). The BRAs included in the RIs for the 200-BP-5 and 200-PO-1 OUs used the EPA tap water (residential) scenario to calculate cumulative cancer risks and noncancer hazards. Cancer risks $>1\times10^{-4}$ or noncancer hazards >1 were used to identify areas and contaminants warranting remedial action. Withdrawal of contaminated groundwater is prohibited as a result of the ICs established by DOE (DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions* [hereinafter referred to as the Sitewide institutional control [IC] plan]). Under current site use conditions, complete human exposure pathways to groundwater do not exist. Groundwater within the 200-BP-5 and 200-PO-1 OUs is not anticipated to become a future source of drinking water until cleanup criteria are met and groundwater is restored to its highest beneficial use.

As stated in Chapter 1, the Tri-Parties are pursuing an IROD for the 200-BP-5 and 200-PO-1 OUs. One of the primary objectives of the interim action is to capture and remove the target COCs (technetium-99 and uranium) from beneath the B Complex, C Farm and A-AX Farms area, and Gable Gap. Table 2-1 summarizes the cancer risks associated with technetium-99 and noncancer hazard quotients (HQs) for uranium associated with these areas. Table 2-1 also identifies the exposure areas, as defined in the BRAs

(DOE/RL-2009-127; DOE/RL-2009-85). It should be noted that the B Complex plume is represented by Low-Level Waste Management Area (LLWMA) 1 and the WMA B-BX-BY Farms area, while the Gable Gap plume is part of the WMA B-BX-BY Farms area. As shown in Table 2-1, cancer risks associated with technetium-99 are $>1\times10^{-4}$ at LLWMA-1, the B Complex (WMA B-BX-BY Farms), and WMA C Farm. The HQ for uranium is >1 at the B Complex (WMA B-BY-BY Farms). The remaining exposure areas evaluated in the BRAs report cancer risks for technetium-99 that are within the risk range of 1×10^{-4} and 1×10^{-6}, and HQs for uranium are <1.

Table 2-1. Summary of Uranium and Technecium-99 Results from the Tap Water (Residential) Exposure Scenario for the 200-BP-5 and 200-PO-1 OUs

Exposure Area	Cancer Risk for Technetium-99	Hazard Quotient for Uranium
200-BP-5 Groundwater OU		
LLWMA-1	1.7×10^{-4}	0.23
WMA B-BX-BY Farms	6.0×10^{-4}	4.2
WMA C Farm	3.1×10^{-4}	0.43
200-PO-1 Groundwater OU		
WMA A-AX Farms	6.8×10^{-5}	0.041

LLWMA = low-level waste management area
OU = operable unit
WMA = waste management area

2.7.1 Groundwater Contaminants of Potential Concern

Groundwater contamination in the 200-BP-5 and 200-PO-1 OUs resulted from liquid waste discharges during the operational period of B Plant and associated facilities in the northern portion of the 200 East Area, as well as the operation of the PUREX Plant and associated facilities in the southern portion of the 200 East Area. Continuing sources of contaminants to groundwater include the B Complex, C Farm, and A-AX Farms.

Table 2-2 lists the COPCs identified in the 200-BP-5 OU RI report (DOE/RL-2009-127) for the three exposure areas (LLWMA-1, WMA B-BX-BY Farms, and WMA C Farm) associated with these plumes. Table 2-2 also lists the COPCs identified in the 200-PO-1 OU RI addendum (DOE/RL-2009-85 ADD1) for the WMA A-AX Farms exposure area.

Table 2-2. Summary of COPCs for the 200-BP-5 and 200-PO-1 OUs BRA by Exposure Area

200-BP-5 Groundwater OU
LLWMA-1: cyanide, gross alpha,[a] iodine-129, nitrate, technetium-99, tritium, and uranium
WMA B-BX-BY Farms: arsenic,[b] carbon tetrachloride, chloroform, cobalt, cobalt-60,[b] cyanide, Cr(VI), gross alpha,[a] iodine-129, manganese,[b] methyl methanesulfonate, n-nitrosodi-n-propylamine, nickel,[b] nitrate, sulfate,[b] technetium-99, tritium, and uranium
WMA C Farm: carbon tetrachloride, Cr(VI), cyanide, iodine-129, nickel, nitrate, sulfate,[b] and technetium-99
200-PO-1 Groundwater OU
WMA A-AX Farms: iodine-129, nitrate, technetium-99, and tritium

References:

DOE/RL-2009-127, *Remedial Investigation/Feasibility Study for the 200-BP-5 Groundwater Operable Unit*.

DOE/RL-2009-85 ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Addendum 1.

a. Gross alpha is an indicator of the presence of uranium.

b. Retained as a COPC due to localized contamination.

COPC = contaminant of potential concern
Cr(VI) = hexavalent chromium
LLWMA = low-level waste management area
OU = operable unit
WMA = waste management area

The COPCs with the broadest distribution are iodine-129, nitrate, technetium-99, and uranium. Cyanide, tritium, and sulfate are localized co-contaminants, where concentrations exceeding DWSs are limited to wells beneath and adjacent to the overlying waste site sources. Of these co-contaminants, sulfate exceeds only the secondary DWS developed for esthetic considerations such as taste, odor, or color. The other COPCs are found beneath source waste sites, and detections are limited to a few wells. Gross alpha is an indicator parameter of uranium and is elevated at wells associated with the B Complex plume.

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3 Contaminants of Concern, Applicable or Relevant and Appropriate Requirements, Remedial Action Objectives, and Preliminary Remediation Goals

This chapter identifies the COCs and applicable or relevant and appropriate requirements (ARARs) and presents the remedial action objective (RAO) and preliminary remediation goals (PRGs) for the 200-BP-5 and 200-PO-1 Groundwater OUs interim action.

3.1 Contaminants of Concern

Several COPCs were identified in the BRAs for the 200-BP-5 and 200-PO-1 OUs (DOE/RL-2009-127; DOE/RL-2009-85), as discussed in Section 2.7 of this FS. Some of these COPCs are not associated with the three groundwater contaminant plume areas or do not contribute significantly to overall risks. As explained in Section 2.6.1, uranium and technetium-99 are high-risk contaminants present in groundwater as groundwater plumes within the OUs (Figure 1-2). This FS has been developed to support remediation of the two target COCs within the three areas of the 200-BP-5 and 200-PO-1 OUs based on the considerations presented in Section 1.1. Other COPCs (nitrate, iodine-129, tritium, and cyanide) identified in the BRAs are considered to be co-contaminants (Section 2.6.2) for this interim action. These co-contaminants will be retained for future groundwater monitoring to provide updated information on the nature and extent of contamination and potential risks, and to support development of a future final (non-interim) ROD. If groundwater monitoring indicates that remedial action is necessary for any of the COPCs, they may become COCs for the final ROD. Since the interim action will require pumping contaminated groundwater and treating the extracted groundwater at the 200 West P&T, discharge limits for this facility will be met, which will require treatment of some co-contaminants in the target remediation areas prior to discharging the effluent via injection wells.

3.2 Applicable or Relevant and Appropriate Requirements

Substantive standards of promulgated regulations pertaining to CERCLA response actions are identified through the ARAR identification process, which is based on CERCLA Section 121(d), “Cleanup Standards,” “Degree of Cleanup”; and EPA CERCLA RI/FS guidance (EPA/540/G-89/004; EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*; and EPA/540/G-89/009, *CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements*). CERCLA Section 121(d) requires, with exceptions, that any promulgated substantive ARAR standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain onsite after completion of remedial action. Additionally, 40 CFR 300.435(b)(2), “National Oil and Hazardous Substances Contingency Plan” (hereinafter referred to as the National Contingency Plan [NCP]), “Remedial Design/Remedial Action, Operation and Maintenance,” requires that ARARs be attained (unless waived) during the remedial action.

3.2.1 Applicable or Relevant and Appropriate Requirements Evaluation Process

The ARARs evaluation prepared for this FS was conducted in accordance with the NCP (40 CFR 300.430(f)(1)(ii)(B)(2), “Remedial Investigation/Feasibility Study and Selection of Remedy”). The identification of ARARs is a two-step process. First, it must be determined what laws or regulations are applicable. If a law or regulation is not applicable, it must then be determined whether the law or

regulation is relevant and appropriate. The terms "applicable" and "relevant and appropriate" are defined in the NCP (40 CFR 300.5, "Definitions") as follows:

- **"Applicable" requirements:** Those substantive standards that specifically address the situation at a CERCLA site. These requirements would legally apply to remedial actions in the absence of CERCLA authority. All jurisdictional prerequisites of the requirement must be met in order for the requirement to be applicable, including specific application to federal agencies (e.g., through a waiver of federal sovereign immunity).

- **"Relevant and appropriate" requirements:** Those environmental requirements such as cleanup standards that address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site (40 CFR 300.400(g)(2), "General"). A requirement that is relevant and appropriate may not meet one or more jurisdictional prerequisites for applicability but still make sense at the site, given the circumstances of the site and the type of release.

In evaluating the relevance and appropriateness of a requirement, the following eight comparison factors, as described in 40 CFR 300.400(g)(2), were considered:

- The purpose of the requirement and the purpose of the CERCLA action
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
- The substances regulated by the requirement and the substances found at the CERCLA site
- The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
- The type of place regulated and affected by the release or CERCLA action
- The type and size of structure or facility regulated and affected by the release or contemplated by the CERCLA action
- Any consideration of use, or potential use, of affected resources in the requirement; and the use, or potential use, of the affected resource at the CERCLA site

To-be-considered (TBC) information is another category of nonpromulgated advisories or guidance issued by federal or state governments that is not legally binding and does not have the status of ARARs. In some circumstances, TBC information is evaluated along with ARARs to determine the remedial actions necessary to protect human health and the environment. The TBC information complements the ARARs in determining protectiveness at a CERCLA site or in assessing implementation of certain actions. For example, because cleanup standards are not available for all contaminants, health advisories (TBC information) may be helpful in defining cleanup levels.

The *Atomic Energy Act of 1954* (AEA), Section 161, "General Provisions," provides DOE with the authority to establish DOE orders containing instructions and operational requirements to protect human health and the environment from nuclear material, source material, and byproduct materials. While the requirements of DOE orders must be met, they are not ARARs and are independent of the TBC and ARARs identification process at the Hanford Site.

Potential ARARs for the 200-BP-5 and 200-PO-1 OUs are examined to determine if they fall into one of three categories (chemical-, location-, and action-specific) and are defined as follows:

- **Chemical-specific:** Health- or risk-based numerical values or methodologies used to derive numerical PRGs. When applied to site-specific conditions, these requirements result in the establishment of public and worker safety levels and site-specific cleanup levels.
- **Location-specific:** Restrictions placed on the residual concentration of hazardous substances or the conduct of certain activities solely because they occur in special geographic areas.
- **Action-specific:** Technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

3.2.2 Waivers from Applicable or Relevant and Appropriate Requirements

The lead agency delegated authority under CERCLA Section 121 may waive ARARs (with EPA concurrence) and select a remedial action that does not attain the same level of cleanup as that identified by the ARARs. Executive Order 12580, *Superfund Implementation*, delegated CERCLA Section 121 authority to DOE for cleanup of DOE facilities. CERCLA Section 121 and the *Superfund Amendments and Reauthorization Act of 1986* identify the following circumstances in which DOE may waive ARARs for onsite remedial actions:

- The remedial action selected is only a part of a total remedial action (e.g., an interim action), and the final remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.
- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

ARAR waivers can be established in the ROD or through a ROD amendment.

3.2.3 Potential Applicable or Relevant and Appropriate Requirements Identified

Table 3-1 presents potential federal and Washington State ARARs. When the final remedy selection is documented in the ROD, all federal and state ARARs with which the final remedy must comply are also finalized. Key potential ARARs are identified in the following discussion.

3.2.3.1 Potential Chemical-Specific ARARs

The chemical-specific ARARs and TBCs that may affect remediation of the 200-BP-5 and 200-PO-1 OUs are the substantive elements of *Washington Administrative Code* regulations that implement the Model Toxics Control Act (MTCA) (WAC 173-340, “Model Toxics Control Act—Cleanup”); and 40 CFR 141, “National Primary Drinking Water Regulations.”

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Groundwater					
***Safe Drinking Water Act of 1974* (Pub. L. 93-523, as amended; 42 USC 300f, et seq.); 40 CFR 141, "National Primary Drinking Water Regulations"**					
40 CFR 141.61, "Maximum Contaminant Levels for Organic Contaminants"	Chemical	Establishes MCLs as criteria for groundwater and surface water that are or may be used for drinking water. The standards are designed to protect human health from adverse effects of organic contaminants in the drinking water.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains contaminants that require remediation. Although groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	ARAR	Groundwater remediation and management activities (e.g., groundwater treatment, discharge of treated groundwater).
40 CFR 141.62, "Maximum Contaminant Levels for Inorganic Contaminants"	Chemical	Establishes MCLs as criteria for groundwater and surface water that are or may be used for drinking water. The standards are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains contaminants that require remediation. Although groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	ARAR	Groundwater remediation and management activities (e.g., discharge of treated groundwater).
40 CFR 141.66, "Maximum Contaminant Levels for Radionuclides"	Chemical	Establishes MCLs as criteria for groundwater and surface water that are or may be used for drinking water. The standards are designed to protect human health from adverse effects of radionuclides in the drinking water.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains contaminants that require remediation. Although groundwater is not currently used for drinking water, it is a potential drinking water source and discharges into the Columbia River, which is used for drinking water.	ARAR	Groundwater remediation and management activities (e.g., discharge of treated groundwater).

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
RCW 90.48, "Water Pollution Control" (as amended); WAC 173-218, "Underground Injection Control Program"					
WAC 173-218-040, "UIC Well Classification Including Allowed and Prohibited Wells" WAC 173-218-120, "Decommissioning of UIC Well"	Action	Establishes criteria and standards for an underground injection control program. Identifies requirements for decommissioning of UIC wells.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains contaminants that require remediation; treated groundwater may be discharged through underground injection wells.	ARAR	Groundwater remedial activities involve underground injection.
RCW 70.105D, "Hazardous Waste Cleanup – Model Toxics Control Act" (as amended); WAC 173-340," Model Toxics Control Act—Cleanup"					
WAC 173-340-720(2), "Potable Groundwater Defined" WAC 173-340-720(4)(b)(i-iii)(A)&(B), "Method B Cleanup Levels for Potable Ground Water" WAC 173-340-720(7), "Adjustments to Cleanup Levels" WAC 173-340-720(8), "Points of Compliance" WAC 173-340-720(9)(b-f), "Compliance Monitoring"	Chemical	Groundwater cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. Method B Equations 720-1 and 720-2 are used to calculate groundwater cleanup levels for noncarcinogens and carcinogens, respectively, only if sufficiently protective, health-based criteria or standards have not been established under applicable state and federal laws. Groundwater cleanup levels are established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards. Adjustment to these cleanup levels maybe made due to site conditions. Points of compliance are established throughout the site. Groundwater sample analysis should be conducted on unfiltered samples, and numeric criteria for remedial actions monitoring is used to establish compliance.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains contaminants that require remediation. The ARAR requires that the groundwater cleanup levels shall be based on the highest beneficial use, both current and potential future site use. The Central Plateau and 200-BP-5 and 200-PO-1 OU groundwater is considered potable under WAC 173-340-720. The substantive requirements are WAC 173-340-720(4)(b)(iii)(A) and (B).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater).

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
RCW 18.104, "Water Well Construction" (as amended); WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"					
WAC 173-160-161, "How Shall Each Water Well Be Planned and Constructed?"	Action	Identifies well planning and construction requirements.	The substantive requirements of these regulations are ARARs to actions that include construction of wells used for groundwater extraction, monitoring, or injection of treated groundwater or waste. The substantive requirements of WAC 173-160-161, WAC 173-160-171, WAC 173-160-181, WAC 173-160-400, WAC 173-160-420, WAC 173-160-430, WAC 173-160-440, WAC 173-160-450, and WAC 173-160-460 are relevant and appropriate to groundwater well construction, monitoring, or injection of treated groundwater or waste in the 200-BP-5 and 200-PO-1 OUs.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-171, "What Are the Requirements for the Location of the Well Site and Access to the Well?"	Action	Identifies the requirements for locating a well.		ARAR	
WAC 173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"	Action	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.		ARAR	
WAC 173-160-400, "What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"	Action	Identifies the minimum standards for resource protection wells and geotechnical soil borings.		ARAR	
WAC 173-160-420, "What Are the General Construction Requirements for Resource Protection Wells?"	Action	Identifies the general construction requirements for resource protection wells.		ARAR	
WAC 173-160-430, "What Are the Minimum Casing Standards?"	Action	Identifies the minimum casing standards.		ARAR	
WAC 173-160-440, "What Are the Equipment Cleaning Standards?"	Action	Identifies the equipment cleaning standards.		ARAR	
WAC 173-160-450, "What Are the Well Sealing Requirements?"	Action	Identifies the well sealing requirements.		ARAR	
WAC 173-160-460, "What Is the Decommissioning Process for Resource Protection Wells?"	Action	Identifies the decommissioning process for resource protection wells.		ARAR	

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Radionuclide ARAR Dose Compliance Concentrations for Superfund Sites					
Luftig and Weinstock, 1997, "Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination" (OSWER Directive 9200.4-18) Luftig and Page, 1999, "Distribution of OSWER Radiation Risk Assessment Q & A's Final Guidance" (OSWER Directive 9200.4-31P)	Chemical	This memorandum presents clarification for establishing protective cleanup levels in media for radioactive contamination at CERCLA sites. EPA has determined that the dose limits established by the Nuclear Regulatory Commission in 62 FR 139, "Radiological Criteria for License Termination" (25 mrem/yr, which is equivalent to 5×10^{-4} increase lifetime risk), will not provide a protective basis for establishing PRGs under CERCLA. A dose of 15 mrem/yr effective dose (approximately equivalent to 3×10^{-4} increase in lifetime risk) is preferred as the maximum dose limit for humans. In the final guidance, EPA further clarifies that 15 mrem/yr is not a presumptive cleanup level under CERCLA. Rather, site decision makers should continue to use the CERCLA risk range when ARARs are not used to set cleanup levels because using dose-based guidance would result in unnecessary inconsistency regarding how radiological and nonradiological (chemical) contaminants are addressed at CERCLA sites.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains radioactive contaminants that, if not remediated, could pose unacceptable risk to human health.	TBC	Development of groundwater cleanup levels.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Surface Water					
***Federal Water Pollution Control Act* (Pub. L. 107-303, as amended; 33 USC 1251, et seq., Section 303c); 40 CFR 131, "Water Quality Standards"**					
40 CFR 131.36(b)(1), "Toxics Criteria for Those States Not Complying with Clean Water Act Section 303(c)(2)(B)"	Chemical	Establishes numeric water quality criteria for the protection of human health and aquatic organisms. Toxic criteria for the protection of aquatic life are provided in the water quality criteria regulations provided in 40 CFR 131.36(b)(1) and supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	Groundwater in the 200-BP-5 and 200-PO-1 OUs contains water quality criteria contaminants that require remediation. The Columbia River is a current and future source of drinking water. The use designations for the Columbia River include use by aquatic life (spawning and rearing), primary contact recreation, water supply (drinking, irrigation, and agriculture), and miscellaneous uses (wildlife habitat, harvesting, commerce, boating, and aesthetics).	ARAR	Groundwater remediation activities that impact surface water (e.g., discharge of treated groundwater).
Solid Waste					
***Toxic Substances Control Act of 1976* (Pub. L. 107-377, as amended; 15 USC 2605, et seq.); 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions"**					
40 CFR 761.50(b)1, 2, 3, 4, and 7, "Applicability," "PCB Waste" 40 CFR 761.50(c), "Applicability," "Storage for Disposal"	Action	Establishes general PCB disposal requirements for the storage and disposal of PCB waste, including liquid PCB waste, PCB items, PCB remediation waste, PCB bulk product waste, and PCB/radioactive waste at concentrations >50 ppm.	PCB waste encountered and/or generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Soil excavation and remediation, equipment and debris handling and disposal, and IDW management and disposal.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
40 CFR 761.60(a), "Disposal Requirements," "PCB Liquids" 40 CFR 761.60(b), "Disposal Requirements," "PCB Articles" 40 CFR 761.60(c), "Disposal Requirements," "PCB Containers"	Action	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers encountered and or generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.
40 CFR 761.61, "PCB Remediation Waste"	Action	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation waste encountered and/or generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Soil remediation, RTD, and IDW management and disposal.
RCW 70.105, "Hazardous Waste Management" (as amended); WAC 173-303, "Dangerous Waste Regulations"					
WAC 173-303-016, "Identifying Solid Waste" WAC 173-303-017, "Recycling Processes Involving Solid Waste"	Action	Establishes criteria for solid and recycled solid waste.	Solid waste and/or recycled solid waste will be generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Investigative and remediation activities.
WAC 173-303-070, "Designation of Dangerous Waste"	Action	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste will be generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Investigative and remediation (including waste treatment) activities that generate waste (e.g., drums, barrels, tanks, containers, bulk waste, debris, and contaminated soil).
WAC 173-303-077, "Requirements for Universal Waste"	Action	Identifies the waste exempted from regulation under WAC 173-303-140, "Land Disposal Restrictions"; and WAC 173-303-170, "Requirements for Generators of Dangerous Waste," through WAC 173-303-9907, "Reserved" (excluding WAC 173-303-960, "Special Powers and Authorities of the Department"). This waste is subject to regulation under WAC 173-303-573, "Standards for Universal Waste Management."	Universal waste has the potential to be generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Remediation activities (disposal, storage, recycling, and onsite treatment) that manage universal waste consistent with *Washington Administrative Code* requirements.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-303-120, "Recycled, Reclaimed, and Recovered Wastes" WAC 173-303-120(3) WAC 173-303-120(5)	Action	Defines the requirements for the recycling of materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Recycled, reclaimed, and recovered waste have the potential to be generated during well installation at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Remediation recycling activities consistent with *Washington Administrative Code* requirements and not otherwise subject to CERCLA as hazardous substances.
WAC 173-303-140, "Land Disposal Restrictions"	Action	Establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates, by reference, WAC 173-303-140(2)(a), the federal land disposal restrictions of 40 CFR 268, "Land Disposal Restrictions," that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3).	Onsite land disposal will be a selected remedy for the 200-BP-5 and 200-PO-1 OUs dangerous waste and debris.	ARAR	Investigative and remediation waste destined for onsite land disposal.
WAC 173-303-170, "Requirements for Generators of Dangerous Waste"	Action	Establishes the requirements for dangerous waste generators. WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Use and Management of Containers"; and WAC 173-303-640, "Tank Systems," by reference. Specifically, the substantive standards for management of dangerous/mixed waste are applicable to the management of dangerous waste that will be generated during the remedial action.	Dangerous waste will be generated from remedial actions in the 200-BP-5 and 200-PO-1 OUs.	ARAR	IDW and remediation waste (contaminated soil and groundwater, personnel protective gear, and treatment chemicals).
WAC 173-303-200, "Accumulating Dangerous Waste On-Site"	Action	Establishes the requirements for accumulating waste onsite. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630 and WAC 173-303-640, by reference.	Dangerous waste will be generated from remedial actions in the 200-BP-5 and 200-PO-1 OUs.	ARAR	Management of dangerous waste during remedial and investigative actions.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-303-64620(4), "Requirements"	Action	Establishes the standards for implementing corrective action for releases of dangerous waste and constituents under the HWMA. Corrective action is implemented by requiring corrective action follow certain sections of WAC 173-340 and WAC 173-303-64620(4).	Corrective action applies to all releases of dangerous waste and dangerous constituents during Hanford Site operations as stated in WAC 173-303-64620(1). CERCLA may be the authority being used to clean up the release; the cleanup must be "consistent with" corrective action. The substantive portions of WAC 173-340 establish minimum requirements for HWMA corrective action.	ARAR	Corrective action applies to environmental media at the Hanford Site where dangerous waste and dangerous constituents have been placed, whether intentional or unintentional, during Hanford Site operations.
RCW 70.95, "Solid Waste Management—Reduction and Recycling" (as amended); WAC 173-350, "Solid Waste Handling Standards"					
WAC 173-350-025, "Owner Responsibilities for Solid Waste" WAC 173-350-040, "Performance Standards" WAC 173-350-300, "On-Site Storage, Collection and Transportation Standards" WAC 173-350-900, "Remedial Action"	Action	Establishes minimum functional performance standards for the proper handling and disposal of solid waste. Requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations, and other sources and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Solid nondangerous waste will be generated during implementation of remedial actions in the 200-BP-5 and 200-PO-1 OUs.	ARAR	Investigative and remedial actions that generate solid, nondangerous waste.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Air					
RCW 70.94, "Washington Clean Air Act" (as amended); WAC 173-400, "General Regulations for Air Pollution Sources"					
WAC 173-400, "General Regulations for Air Pollution Sources"	Action	Defines control methods to be used to minimize the release of air contaminants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of best available control technology.	Groundwater remedial actions implemented at the 200-BP-5 and 200-PO-1 OUs have the potential to emit emissions subject to these standards because contaminants detected at these two OUs include covered hazardous air pollutants.	ARAR	Actions performed at 200-BP-5 and 200-PO-1 OUs that result in emission of hazardous air pollutants, including drilling, decontamination, demolition, and excavation activities implemented during a remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
WAC 173-400-040, "General Standards for Maximum Emissions"	Action	All sources and emission units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emissions detrimental to health and property, sulfur dioxide, and fugitive dust.	Groundwater remedial actions implemented at the 200-BP-5 and 200-PO-1 OUs have the potential to emit emissions subject to these standards because hazardous contaminants detected at these two OUs include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-400-075, "Emission Standards for Sources Emitting Hazardous Air Pollutants"	Action	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, NESHAP (40 CFR 61, "National Emissions Standards for Hazardous Air Pollutants") and appendices.	Groundwater hazardous contaminants detected at the 200-BP-5 and 200-PO-1 OUs include covered regulated hazardous air pollutants.	ARAR	Actions performed at the 200-BP-5 and 200-PO-1 OUs that result in emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during the remedial action that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
RCW 70.94, "Washington Clean Air Act" (as amended); WAC 173-460, "Controls for New Sources of Toxic Air Pollutants"					
WAC 173-460-060, "Control Technology Requirements" WAC 173-460-150, "Table of ASIL, SQER and de Minimis Emission Values"	Action	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality to protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in WAC 173-460-150. Three major requirements of this regulation are implementation of best available control technology for toxics, quantification of toxic air pollutant emissions, and demonstration of health and safety protection.	Hazardous contaminants detected in groundwater at the 200-BP-5 and 200-PO-1 OUs include constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities, such as 200-BP-5 and 200-PO-1 OU treatment systems with the potential to emit hazardous air emissions that would be considered a new source.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
RCW 70.94, "Washington Clean Air Act" (as amended); WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides"					
WAC 173-480-040, "Ambient Standard"	Action	Defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standards under 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (NESHAP); and 40 CFR 61, Subpart I, "National Emission Standards for Radionuclide Emissions from Federal Facilities Other Than Nuclear Regulatory Commission Licensees and Not Covered by Subpart H," are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	Hazardous contaminants detected in soil and groundwater at the 200-BP-5 and 200-PO-1 OUs include radionuclides that could be emitted to ambient air during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, well installation, demolition, ventilation, and vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.
WAC 173-480-050, "General Standards for Maximum Permissible Emissions"	Action	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas; control equipment of sites operating under ALARA shall be defined as reasonably available control technology and ALARA control technology.	The potential for fugitive and diffuse emissions because of demolition and excavation and related activities will require efforts to minimize those emissions.	ARAR	Investigative and remediation activities (e.g., excavation, well installation, demolition, ventilation, and vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 173-480-070(2), "Emission Monitoring and Compliance Procedures"	Action	Requires that radionuclide emissions shall be determined by calculating the dose to members of the public using Department of Health-approved sampling procedures at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	The substantive requirements of this standard are ARARs to remedial actions involving disturbance or ventilation of radioactively contaminated areas or structures, because airborne radionuclides may be emitted to unrestricted areas where any member of the public may be.	ARAR	Investigative and remediation activities (e.g., excavation, well installation, demolition, ventilation, and vacuuming/ exhaust) that have the potential to emit radionuclides to unrestricted areas above maximum acceptable levels.
WAC 173-480-060, "Emission Standards for New and Modified Emission Units"	Action	Requires that construction, installation, or establishment of new air emission control units use best available radionuclide control technology.	Hazardous contaminants detected in soil and groundwater at the 200-BP-5 and 200-PO-1 OUs include radionuclides that could be emitted from air emission control units during remedial actions.	ARAR	Investigative and remediation activities (e.g., excavation, well installation, demolition, ventilation, and vacuuming/ exhaust) that require air pollution control equipment and have the potential to emit radionuclides.
RCW 70.98, "Nuclear Energy and Radiation" (as amended); WAC 246-247, "Radiation Protection—Air Emissions"					
WAC 246-247-035(1)(a)(i), "National Standards Adopted by Reference for Sources of Radionuclide Emissions," adopts, by reference, provisions of 40 CFR 61, Subpart A, "General Provisions"; and 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities"	Action	Identifies prohibition of any owner or operator of any stationary source subject to a national emission standard for hazardous air pollutants from constructing or operating the new or existing source in violation of any such standard.	Substantive requirements of this standard are applicable because the remedial actions at the 200-BP-5 and 200-PO-1 OUs may be subject to NESHAP air pollutant standards; and resulting requirements have the potential to be detected in, and potentially emitted from, structures, components, debris, soil, or groundwater involved in the remedial action.	ARAR	Investigative and remedial activities.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
WAC 246-247-040(2), (3), and (4), "General Standards"	Action	Requires that emissions be controlled to ensure ALARA-based and best available controls standards are not exceeded.	Hazardous contaminants that would be subject to radionuclide air emission standards and resultant requirements have the potential to be detected in, and emitted from, structures, components, debris, soil, or groundwater involved in the remedial actions at the 200-BP-5 and 200-PO-1 OUs.	ARAR	Investigative and remedial groundwater monitoring systems, decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums that produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.
WAC 246-247-075(2), (4), and (8) – (14), "Monitoring, Testing and Quality Assurance"	Action	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Emissions from nonpoint and fugitive sources of airborne radioactive material will be measured. Measurement techniques may include but are not limited to sampling, calculation, smears, or other reasonable method for identifying emissions as determined by the lead agency.	Substantive requirements of this standard are ARARs when fugitive and nonpoint source emissions of radionuclides to the ambient air may result from activities, such as operation of exhauster and vacuums, performed during a remedial action. This standard exists to ensure compliance with emission standards.	ARAR	Investigative and remedial groundwater monitoring systems, decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums that produce airborne emissions of hazardous radionuclide pollutants to unrestricted areas.
40 CFR 60, Subpart IIII, "Standards of Performance for Stationary Compression Ignition Internal Combustion Engines" 40 CFR 60, Subpart JJJJ, "Standards of Performance for Stationary Spark Ignition Internal Combustion Engine" 40 CFR 63, Subpart ZZZZ, "National Emission Standard for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines"	Action	The requirements for stationary engines include timers, maintenance plans, and meeting monitoring requirements.	This applies to all stationary engines.	ARAR	Anywhere a stationary engine is used at the facility.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Historical and Archeological Resources					
***National Historic Preservation Act of 1966* (Pub. L. 89-665, as amended, 16 USC 470, et seq.)**					
36 CFR 800, "Protection of Historic Properties"	Location	Legislation intended to preserve historical and archaeological sites in the United States. Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.	Archeological and historical sites have been identified within the 200 Areas; therefore, the substantive requirements of this act are applicable to actions that might disturb these sites.	ARAR	Investigation and remediation activities that occur in areas near cultural or historical sites.
***Native American Graves Protection and Repatriation Act of 1990* (Pub. L. 101-601, as amended, 25 USC 3001, et seq.); 43 CFR 10, "Native American Graves Protection and Repatriation Regulations"**					
43 CFR 10, "Native American Graves Protection and Repatriation Regulations"	Location	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Requires Native American/Tribal consultation in the event of discovery.	Substantive requirements of this act are applicable if remains and sacred objects are found during remediation.	ARAR	Investigations and remediation activities that affect Native American archaeological, cultural areas, and historical sites that contain associated remains and objects.
***Archeological and Historic Preservation Act of 1974* (Pub. L. 93-291, as amended; 16 USC 469a-1 through 469a-2(d))**					
"Applicant Requirements" (16 USC 469a-1 through 469a-2(d))	Location	Requires that remedial actions do not cause the loss of any archaeological or historical data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.	Archaeological and historical sites have been identified within the 200 Areas; therefore, the substantive requirements of this act are applicable to actions that might disturb these sites.	ARAR	Investigation and remediation activities that occur in areas near archeological or historical sites.

Table 3-1. Potential Federal and Washington State ARARs and TBCs for the 200-BP-5 and 200-PO-1 OUs

Regulatory Citation	ARAR Category	Description of Regulatory Requirement	Rationale for Including	Potential Relevancy	Possible Application
Natural and Ecological Resources					
***Endangered Species Act of 1973* (Pub. L. 93-205, as amended; 7 USC 136; 16 USC 1531, et seq.)**					
Endangered Species Act of 1973, as amended (16 USC 1531-1544, specifically Sections 7 and 9(a)) 50 CFR 17 (listings, prohibitions) 50 CFR 402, 50 CFR 222-224 (endangered and threatened marine species) 50 CFR 226.212 (critical habitat for Northwest salmon and steelhead)	Location	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, to protect the resource.	Substantive requirements of this act are applicable if threatened or endangered species are identified in areas where remedial actions will occur.	ARAR	Remedial actions and investigation activities that occur within critical habitats or designated buffer zones of federal listed species.
***Migratory Bird Treaty Act of 1918* (16 USC 703-712; Ch. 128; July 13, 1918; 40 Stat. 755, as amended)**					
Migratory Bird Treaty Act of 1918 (16 USC 703-712) 50 CFR 10 and 21	Location	Protects all migratory bird species and prevents "take" of protected migratory birds, their young, or their eggs."	Migratory birds occur in the 200 Areas.	ARAR	Remedial actions that require mitigation measures to deter nesting by migratory birds on, around, or within a remedial action site and methods to identify and protect occupied bird nests.

*Complete reference citations are provided in Chapter 7.

ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
EPA = U.S. Environmental Protection Agency
HWMA = Hazardous Waste Management Act
IDW = investigation-derived waste
MCL = maximum contaminant level
NESHAP = National Emission Standards for Hazardous Air Pollutants
OU = operable unit
PCB = polychlorinated biphenyl
ppm = parts per million
PRG = preliminary remediation goal
RTD = removal, treatment, and disposal
TBC = to-be-considered
UIC = underground injection control

These standards are in the form of risk-based concentrations, or are established by modeling, and help to establish groundwater cleanup standards for nonradioactive contaminants. Additional federal regulations include the following:

- Ambient water quality criteria developed under the *Federal Water Pollution Control Act* (Section 304)
- *Toxic Substances Control Act of 1976*, implemented via 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions"
- 40 CFR 61, "National Emissions Standards for Hazardous Air Pollutants"

3.2.3.2 Potential Location-Specific ARARs

Potential location-specific ARARs that have been identified for the 200-BP-5 and 200-PO-1 OUs include those that protect cultural, historical, and Native American sites and artifacts under the *Native American Graves Protection and Repatriation Act of 1990*, the *Archeological and Historic Preservation Act of 1974*, and the *National Historic Preservation Act of 1966*. In addition, those ARARs protect federally listed endangered and threatened species or their critical habitat under the *Endangered Species Act of 1973*. The *Migratory Bird Treaty Act of 1918* has been identified as substantive standards for DOE compliance in executive orders and in DOE and USFWS, 2006, *Memorandum of Understanding Between the United States Department of Energy and the United States Fish and Wildlife Service Regarding Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds*," and is pertinent to CERCLA response actions when there is a potential to adversely affect protected bird species.

3.2.3.3 Potential Action-Specific ARARs

Action-specific ARARs that could be pertinent to possible remediation activities for the 200-BP-5 and 200-PO-1 OUs relate to waste management activities, solid and dangerous waste regulations (for management of characterization and remediation waste and performance standards for waste left in place), and radioactive waste management under AEA regulations. The other major category of action-specific ARARs concern standards for controlling emissions to the environment.

3.2.4 Waste Management Standards

The remedial action alternatives proposed in Chapter 5 of this FS have the potential to produce a variety of waste that contains both radioactive and chemical constituents. It is anticipated that most of the waste will be designated as low-level. However, quantities of PCB-contaminated waste, and asbestos and asbestos-containing material, could be included in remediation waste. The majority of the waste will be in a solid form.

The storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste resulting from the remedial action would be subject to the substantive provisions of RCRA. In Washington State, RCRA is implemented through WAC 173-303, "Dangerous Waste Regulations," which is an EPA-authorized state RCRA program. Treatment standards for dangerous or mixed waste that are subject to RCRA land disposal restrictions are specified in WAC 173-303-140, "Land Disposal Restrictions," which incorporates 40 CFR 268, "Land Disposal Restrictions," by reference. Radioactive waste is managed by DOE under the authority of the AEA. EPA has regulatory authority over release of radioactive waste in context of a CERCLA action.

The Toxic Substances Control Act of 1976 and regulations in 40 CFR 761 generally govern the management and disposal of PCB waste. The *Toxic Substances Control Act of 1976* regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. PCBs are also considered underlying hazardous constituents under RCRA and, thus, could be subject to the requirements of WAC 173-303 and 40 CFR 268.

Waste generated through CERCLA remedial actions and designated as low-level radioactive waste that meets ERDF acceptance criteria (EDRF-00011, *Environmental Restoration Disposal Facility Waste Acceptance Criteria, formerly WCH-191 Rev 4*) is planned to be disposed at ERDF. ERDF is considered to be onsite for Hanford Site remedial actions for the purpose of waste management and/or disposal.[6]

Waste generated through CERCLA remedial actions and designated as dangerous or mixed waste is treated (as appropriate) to meet land disposal restrictions and ERDF acceptance criteria, and it is disposed at ERDF. ERDF is an engineered facility that provides a high degree of protection for human health and the environment and meets RCRA minimum technical requirements for landfills, including standards for a double liner, a leachate collection system, leak detection, monitoring, and final cover. Construction and operation of ERDF was authorized by a separate CERCLA ROD (EPA/ROD/R10-95/100, *Declaration of the Interim Record of Decision for the Environmental Restoration Disposal Facility* [hereinafter referred to as the ERDF ROD]; EPA/AMD/R10-02/030, *Record of Decision Amendment: U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area Benton County, Washington*). EPA/ESD/R10-96/145, *Explanation of Significant Differences: USDOE Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington* (hereinafter referred to as the ERDF ESD), modified the ERDF ROD to clarify the eligibility of waste generated during Hanford Site cleanup.

CERCLA Section 104(d)(4), "Response Authorities," "Coordination of Investigations," allows the lead agency to treat these related facilities as one for response purposes. This allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit. ERDF is considered to be onsite for response purposes under this remedial/removal/removal action. It should be noted that the scope of work covered in this remedial/removal/removal action is for a facility and waste contaminated with hazardous substances. Materials encountered during implementation of the selected remedial/removal/removal action that are not contaminated with hazardous substances are outside the authority of CERCLA and will be dispositioned by DOE.

In accordance with the ERDF ESD (EPA/ESD/R10-96/145), ERDF is eligible for disposal of any low-level waste, mixed waste, and hazardous/dangerous waste generated as a result of cleanup actions (e.g., remedial/removal action waste and investigation-derived waste), provided the waste meets ERDF waste acceptance criteria (ERDF-00011) and appropriate CERCLA decision documents are in place.

3.2.5 Standards Controlling Emissions to the Environment

Remedial action alternatives proposed in this FS have the potential to generate airborne emissions of both radioactive and toxic/criteria airborne emissions. Implementation of these activities and associated air monitoring will be discussed in the RD/RAWP for the 200-BP-5 and 200-PO-1 OUs IROD.

[6] CERCLA Section 104(d)(4) states, "…where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the President may, at his discretion, treat these facilities as one." The preamble to the NCP (40 CFR 300) clarifies the stated EPA interpretation that when noncontiguous facilities are reasonably close to one another, and waste at these sites are compatible for a selected treatment or disposal approach.

3.2.6 Radiological Air Emissions

The federal *Clean Air Act of 1990* and amendments, and RCW 70.94, "Washington Clean Air Act," each require regulation of radioactive air emissions. The state implementing regulation, WAC 173-480, "Ambient Air Quality Standards and Emission Limits for Radionuclides," sets standards that are as stringent or more so than the standards under the federal *Clean Air Act of 1990* and amendments, including the federal implementing regulation under 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities" (hereinafter referred to as National Emissions Standards for Hazardous Air Pollutants [NESHAP]). The EPA partial delegation of NESHAP Subpart A, "General Provisions," and Subpart H authority to the state of Washington includes all substantive emissions monitoring, abatement, and reporting aspects of the federal regulation. These state standards protect the public by conservatively establishing exposure standards applicable to the maximally exposed public individual. Members of the public can travel on the Columbia River through the Hanford Reach, but they cannot "abide or reside" there (DOE/EIS-0222-SA-01, *Supplement Analysis: Hanford Comprehensive Land-Use Plan Environmental Impact Statement*).

WAC 173-480 limits emissions of radionuclides to the ambient air by requiring that radionuclide emissions in the air shall not cause a maximum effective dose equivalent >10 mrem/yr to the whole body to any member of the public. Under Washington State implementing regulations, WAC 246-247-030(15), "Radiation Protection–Air Emissions," "Definitions, Abbreviations, and Acronyms," defines the member of the public (real or hypothetical) who abides or resides in an unrestricted area. This member of the public may receive the highest effective dose equivalent from the emission unit(s) under consideration, taking into account all exposure pathways affected by the radioactive air emissions. In addition, by its adopting the federal standard in the NESHAP (40 CFR 61.92, "Standard"), the state limits radionuclide airborne emissions from the Hanford Site (i.e., facility) to not exceed amounts that would cause an exposure to any member of the public of >10 mrem/yr effective dose equivalent. The state implementing regulation (WAC 246-247), which adopts WAC 173-480 standards and the NESHAP standard (40 CFR 61, Subpart H), requires verification of compliance with the 10 mrem/yr standard and would be applicable to the remedial action.

WAC 246-247 further addresses sources emitting radioactive airborne emissions by requiring monitoring of such sources (emission units). Such monitoring may involve various methods, depending upon the configuration of the source. Most stacks or vents are monitored by extracting a sample of the effluent stream from the stack or vent and analyzing the sample. Emissions that do not pass through a stack, vent, or other orifice are termed as "diffuse emissions," and these are normally monitored by extracting a sample of the ambient air, with subsequent laboratory analysis. The substantive provisions of WAC 246-247 that require monitoring of radioactive airborne emissions would potentially be applicable to remedial action and would generally be an "applicable" ARAR.

The preceding state implementing regulations further require control of radioactive airborne emissions to the extent economically and technologically feasible (WAC 246-247-040[3] and [4], "General Standards"). To cover the substantive aspect of these requirements, best or reasonably achieved control technology could be addressed by ensuring that applicable emission control technologies (i.e., those successfully operated in similar applications) would be used when economically and technologically feasible (i.e., based on cost/benefit). Controls will be administered as appropriate using the best methods from among those that are reasonable and effective.

3.2.7 Criteria/Toxic Air Emissions

Under WAC 173-400, "General Regulations for Air Pollution Sources"; and WAC 173-460, "Controls for New Sources of Toxic Air Pollutants," requirements are established for regulation of criteria/toxic air pollutant emissions. The primary nonradioactive emissions resulting from remedial actions will be fugitive particulate matter. In accordance with WAC 173-400-040, "General Standards for Maximum Emissions," reasonable precautions must be taken to prevent the release of air contaminants associated with fugitive emissions resulting from excavation, materials handling, or other operations and prevent fugitive dust from becoming airborne from fugitive sources of emissions. The use of treatment technologies that would result in emissions of toxic air pollutants subject to the substantive applicable requirements of WAC 173-460 are not anticipated to be a part of remedial actions selected for the 200-BP-5 and 200-PO-1 OUs.

If treatment of waste encountered during the remedial action is required to meet ERDF waste acceptance criteria (ERDF-00011), the type of treatment anticipated would consist of solidification/stabilization techniques such as macroencapsulation or grouting, and WAC 173-460 would not be considered an ARAR. If more aggressive treatment is required that would result in the emission of regulated air pollutants, the substantive requirements of WAC 173-400-113(2), "New Sources in Attainment or Unclassifiable Areas–Review for Compliance with Regulations"; and WAC 173-460-060, "Control Technology Requirements," would be evaluated to determine potential applicability.

Air emissions will be minimized during remedial action implementation by using standard industry practices such as the application of water sprays and fixatives. These techniques are considered reasonable precautions to control fugitive emissions as required by the regulatory standards.

3.2.8 Groundwater Beneficial Use

The NCP (40 CFR 300) states that EPA expects a remedy to return groundwater to its highest beneficial use whenever practicable and within a reasonable timeframe. Federal decisions for groundwater cleanup generally defer to state determinations of current and future groundwater uses, as described in EPA/540/G-88/003, *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites*, and the memorandum regarding OSWER Directive 9283.1-09 (Fields, 1997, "The Role of CSGWPPs in EPA Remediation Programs"). Washington State has determined that groundwater in the 200-BP-5 and 200-PO-1 OUs meets the state potable groundwater definition, and the highest beneficial use for the groundwater is as a potential source of domestic drinking water.

3.2.9 Surface Water Beneficial Use

Although groundwater within the 200-BP-5 and 200-PO-1 OUs currently discharges to the Columbia River through upwelling and seeps, surface water beneficial uses are not considered for this FS because the interim action to be described in the IROD is not intended to address groundwater contaminant plumes in the far-field or near-river areas.

3.3 Remedial Action Objectives and Interim Action Objectives

The RAOs are general statements of medium- or OU-specific goals for protecting human health and the environment. RAOs are defined as specifically as possible to address the following:

- Media of interest
- Types of contaminants (radionuclides and chemical constituents)
- Potential receptors (human and ecological)
- Exposure pathways (e.g., dermal contact, ingestion, and inhalation)

The RAOs provide a basis for evaluating the capability of a specific remedial alternative to achieve compliance with ARARs and/or an intended level of risk protection in accordance with the NCP (40 CFR 300.430(e)(2)(i)) and EPA/540/G-89/004. Under CERCLA and the NCP (40 CFR 300), a groundwater remedy must be protective of human health and the environment and meet ARARs (or satisfy ARAR waiver criteria). Based on these requirements and NCP expectations for groundwater restoration, the RAO for the interim action in the IROD for the 200-BP-5 and 200-PO-1 OUs is as follows.

- **RAO #1:** Prevent unacceptable risk to human health from exposure to 200-BP-5 and 200-PO-1 OU groundwater containing technetium-99 and uranium contaminant concentrations above federal and state standards and risk-based thresholds.

In addition to this RAO, the interim action to be described in the IROD has the overall purpose and specific objectives stated in Section 1.1 of this FS.

Since the IROD will address only specific groundwater COCs and remedial action target areas (rather than all of the COPCs within the 200-BP-5 and 200-PO-1 OUs), achievement of RAO #1 will also need to rely on access restrictions/ICs to prevent human exposure. The final (non-interim) ROD may specify additional RAOs.

3.4 Preliminary Remediation Goals

The PRGs constitute a core component of the overall technology screening and remedial action alternative evaluation process. PRGs are numerical values expressed as concentrations for chemicals and radionuclides present in groundwater. A remedial action alternative that achieves PRGs will leave residual contamination that does not pose a threat to human health and the environment (40 CFR 300.430(e)(2)(i)). Table 3-2 lists the groundwater concentrations measured during the recent RI, federal DWSs, MTCA cleanup levels, and the proposed 200-BP-5 and 200-PO-1 OU PRGs. The table is split between the target contaminants and co-contaminants. The values for the target contaminants apply to residual levels in groundwater when the interim action is complete, as well as to the levels in treated groundwater that is reinjected. In contrast, the values for co-contaminants apply only to reinjection of contaminated groundwater since it is not the objective of the interim action to remediate the groundwater OUs with respect to the co-contaminants. The final remediation goals for the interim action will be developed from these PRGs and specified in the IROD, along with the selected interim action alternative.

Table 3-2. 200-BP-5 and 200-PO-1 OU PRGs for COCs

COC or Co-Contaminant	Units	95 UCL Groundwater Concentrations [a]		Federal DWS [b]	MTCA Method B Cleanup Levels		200-BP-5 and 200-PO-1 PRGs [c]
		200-BP-5 OU	200-PO-1 OU		Noncarcinogens at HQ = 1	Carcinogens at 1×10^{-5} Risk Level	
Target Contaminants for the Interim Action (COCs)							
Uranium	µg/L	422	26	30	48	—	30
Technetium-99	pCi/L	11,391	1,291	900	—	—	900
Co-Contaminants							
Cyanide	µg/L	320	—[d]	200	4.8	—	200 [e]
Iodine-129	pCi/L	4.6	5.0	1	—	—	1

Table 3-2. 200-BP-5 and 200-PO-1 OU PRGs for COCs

COC or Co-Contaminant	Units	95 UCL Groundwater Concentrations [a]		Federal DWS [b]	MTCA Method B Cleanup Levels		200-BP-5 and 200-PO-1 PRGs [c]
		200-BP-5 OU	200-PO-1 OU		Noncarcinogens at HQ = 1	Carcinogens at 1×10^{-5} Risk Level	
Nitrate (as NO_3)	mg/L	599	57.7	45 [f]	113.6	—	45
Tritium	pCi/L	12,770	179,470	20,000	—	—	20,000

Note: See the risk evaluation section of Chapter 6 of this feasibility study for excess lifetime cancer risk and hazard index risk values (DOE/RL-2009-127, *Remedial Investigation/ Feasibility Study for the 200-BP-5 Groundwater Operable Unit*; DOE/RL-2009-85 ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Addendum 1).

a. For the 200-BP-5 OU, based on maximum exposure point concentrations from Tables G-11 to G-22 in Appendix G of DOE/RL-2009-127. For the 200-PO-1 OU, based on exposure point concentrations from Tables E-11 through E-1 in Appendix E of DOE/RL-2009-85 ADD1.

b. Federal DWS from 40 CFR 141, "National Primary Drinking Water Regulations," with iodine-129 and technetium-99 values from EPA 816-F-00-002, *Implementation Guidance for Radionuclides*. Includes values derived from the maximum contaminant level for beta particle/photon emitters of 4 mrem/yr.

c. The final cleanup levels achieved at the conclusion of the remedial action will correspond to an excess lifetime cancer risk of $<1\times10^{-5}$ and a hazard index of <1.

d. Cyanide is not detected in the 200-PO-1 OU.

e. The DWS is 200 µg/L free cyanide analyzed as total cyanide. The Washington State groundwater cleanup level of 4.8 µg/L for free cyanide is calculated based on the WAC 173-340, "Model Toxics Control Act—Cleanup," Method B value.

f. The federal and state DWS for nitrate as nitrogen (NO_3-N) is 10 mg/L; the mathematical equivalent expressed as NO_3 is approximately 45 mg/L.

95 UCL = 95th percentile upper confidence limit
COC = contaminant of concern
DWS = drinking water standard
HQ = hazard quotient
MTCA = Model Toxics Control Act
OU = operable unit
PRG = preliminary remediation goal

4 Technology Identification and Screening

This chapter presents general response actions (GRAs), and it identifies and screens remedial technologies and associated process options for remediating groundwater contamination in accordance with the 200-BP-5 and 200-PO-1 OU interim action objectives presented in Section 1.1 of this FS.

4.1 General Response Actions

The GRAs consistent with the interim action objectives were identified to address the groundwater plumes and target COCs in the 200-BP-5 and 200-PO-1 OU target remediation areas. GRAs are basic actions that might be performed to remediate a site. For each GRA, multiple remedial technologies may exist, which can be further divided into one or more process options.

Candidate remedial technologies were identified for screening based on their potential ability to achieve the interim action objectives. Technologies and process options identified for screening were assessed individually based on their effectiveness, implementability, and relative cost in accordance with CERCLA RI/FS guidance (EPA/540/G-89/004) and the NCP (40 CFR 300.430(e)). The overall remedial technology screening process consists of the following steps:

1. Identify GRAs that can meet remedial objectives, either individually or in combination with other GRAs.
2. Identify, screen, and evaluate remedial technology types for each GRA.
3. Select representative process options.

The GRAs identified for the interim action at the 200-BP-5 and 200-PO-1 OUs are as follows:

- No action
- Access restrictions/ICs
- Collection/capture (a component of a groundwater P&T system)
- Ex situ treatment (a component of P&T)
- Discharge (a component of P&T)

Other GRAs such as monitored natural attenuation, containment, and in situ treatment were not selected for this FS because they do not address the objectives of this interim action (Section 1.1), although they might be part of a final remedy for the OUs. The technology screening performed for this FS was streamlined because it is well understood that P&T is the most viable option for addressing the groundwater plumes and target COCs present in the target remediation areas and for achieving the interim action objectives (2018-002).

4.1.1 Target Remediation Areas

In accordance with CERCLA RI/FS guidance (EPA/540/G-89/004), the FS is required to identify the areas or volumes of media to which GRAs might be applied. Table 4-1 lists the estimated area, thickness, and pore volumes for uranium and technetium-99 plumes present in the 200-BP-5 and 200-PO-1 OUs that exceed PRGs.

Table 4-1. Estimated Groundwater Plume Area, Thickness, and Pore Volume for Technetium-99 and Uranium in the 200-BP-5 and 200-PO-1 OUs

COC	Porosity[a]	Target Remediation Area	Plume Area (ha)	Estimated Plume Thickness[b] (m)	Estimated Plume Pore Volume (m^3 [million gal])
Tc-99	0.2	B Complex	89	4	712,000 (188)
	0.2	C Farm and A-AX Farms	21	15	630,000 (166)
	0.2	Gable Gap	61	4	488,000 (129)
Uranium	0.2	B Complex	26	4	208,000 (54.9)

a. Porosity of 0.2 from Table D-58 in DOE/RL-2007-28, *Feasibility Study Report for the 200-ZP-1 Groundwater Operable Unit*.

b. Average plume thicknesses estimated from plume cross-section depictions in DOE/RL-2009-127, *Remedial Investigation/Feasibility Study for the 200-BP-5 Groundwater Operable Unit*; and DOE/RL-2009-85 ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, Addendum 1.

COC = contaminant of concern

4.2 Identification and Screening of Technology Types and Process Options

This section presents the remedial technologies and process options that are subsets of the GRAs potentially capable of achieving the interim action objectives for uranium and technetium-99 in groundwater in the target 200-BP-5 and 200-PO-1 OU remediation areas. The identified remedial technologies were screened based on their effectiveness, implementability, and relative cost. The technologies retained from the screening are combined into remedial alternatives in Chapter 5 of this FS.

4.2.1 Identification and Screening of Technologies

Remedial technologies and process options were identified using the following sources of information:

- PNNL-15917, *Screening of Potential Remediation Methods for the 200-BP-5 Operable Unit at the Hanford Site*
- PNNL-16761, *Evaluation and Screening of Remedial Technologies for Uranium at the 300-FF-5 Operable Unit, Hanford Site, Washington*
- SGW-34562, *Alternative Remediation Technology Study for Groundwater Treatment at 200-PO-1 Operable Unit at Hanford Site*
- SGW-37783, *Literature Survey for Groundwater Treatment Options for Nitrate, Iodine-129, and Uranium, 200-ZP-1 Operable Unit, Hanford Site*
- Technology information websites

The following sections describe the remedial technologies and process options associated with the identified GRAs. Although no action and access restrictions/ICs are not remedial technologies, they are important response actions to be considered for any remediation approach. Table 4-2 summarizes the technology identification and screening results and presents a retained or rejected determination for each technology/process option.

Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action

General Response Actions	Remedial Technology	Process Option	COC or Co-Contaminant Applicability[a]	Description	Effectiveness[b]	Implementability[c]	Relative Capital Cost[d]	Relative O&M Cost[e]	Sustainability[f]	Retained/ Rejected[g]	Screening Comment
No action	No action	No action	All	COCs and co-contaminants are not treated, nor is monitoring performed to assess concentration reductions that occur through natural attenuation processes.	Low Concentrations/activity decline over time due to natural attenuation processes, albeit slowly. Uranium reductions are due to physical processes such as dispersion, blending, and sorption, whereas Tc-99 reductions are due to radioactive decay. Modeling of a no action alternative indicates times to reach MCLs in the target remediation areas of 41 years for uranium and 19 to 850 years for Tc-99.	High While readily implemented from a technical perspective, does not address CERCLA threshold criteria and, therefore, may be administratively infeasible.	Low	Low	No greenhouse gas or energy requirements.	Retained	Retained as a basis for comparison per the NCP (40 CFR 300.430(e)(6)).
Access restrictions (institutional controls)	Active/passive controls, proprietary/ governmental controls, structural/ nonstructural controls, and informational tools	Land-use and groundwater-use controls, drilling permits, procedural requirements for access, and groundwater monitoring	All	See Table 4-3 for process option discussion.	Moderate	High	Low	Low	Little impact	Retained	Retained per the NCP (40 CFR 300.430(e)(3)).
Collection (a component of P&T)	Groundwater extraction	Vertical wells	All	Vertical wells used to extract contaminated groundwater for treatment.	Moderate to high for target COCs Effective with appropriate design, installation, and maintenance. High effectiveness for mobile contaminants (tritium, cyanide, Cr(VI), nitrate, and Tc-99); moderately effective for less mobile contaminants (uranium); low effectiveness for low-mobility contaminants (Sr-90).	High Use extensively at the Hanford Site.	Moderate to high Cost determined by number of wells required and depth of the wells. Wells at the Hanford Site are typically expensive.	Moderate Requires periodic maintenance and pump electricity.	Waste generation from soil cuttings, greenhouse gas and energy consumption for installation and pumping.	Retained	Retained due to effectiveness and widespread use at the Hanford Site. Co-contaminants present would be extracted along with the target COCs (uranium and Tc-99) and may require treatment prior to discharge.
Ex situ treatment (a component of P&T)	Treatment – chemical	IX	Uranium and Tc-99; potentially applicable for nitrate and cyanide using appropriate IX resins	Extracted groundwater is passed through a vessel filled with IX media (resin) where contaminants are removed via exchange with nontoxic ions on the resin surface. Different types of contaminants require different IX resins for removal, so groundwater containing multiple contaminant types might require multiple IX units for effective treatment.	High for target COCs The effectiveness of this technology has been thoroughly studied for most of the identified contaminants. Performance of the IX technology for removing uranium and Tc-99 is well demonstrated at the Hanford Site. Some removal of cyanide by IX has been measured at the 200 West P&T. Use of IX for removal of co-contaminants would likely require different IX resins (i.e., additional treatment vessels).	High Vendors and equipment are readily available. IX is currently used for removing uranium and Tc-99 at the existing Hanford Site 200 West P&T.	Moderate to high Moderate if the existing 200 West P&T has sufficient surplus capacity to accommodate the groundwater. High if construction of a new treatment train is required.	Moderate to high Depends on frequency of media changeout. Includes chemical use (if regenerated), media replacement, waste management, electrical power, and operator labor.	Waste generation from contaminated regeneration fluid (if the IX resin is regenerated) and/or spent media disposal. Energy consumption from process equipment.	Retained	Technology demonstrated effective at the Hanford Site for the target COCs; retained for treatment of uranium and Tc-99.
		Chemical reduction and precipitation/ co-precipitation	Possibly uranium, Tc-99	Reduction typically involves addition of a chemical reducing agent (e.g., a reduced sulfur compound) to water in a mixed reactor to effect reduction of the target species, for subsequent precipitation. Some contaminants may be removed by co-precipitation, but the level of treatment is uncertain.	Low for target COCs Effectiveness for other contaminants would have to be assessed through bench and/or pilot-scale testing.	Moderate Vendors and equipment readily available but no full-scale experience with the technology at the Hanford Site. Large sludge volumes may be produced, requiring management/ disposal. Sludge volume would depend on contaminant influent concentrations, reagent requirements, and the presence of other constituents.	Moderate to high Would require construction of a new treatment process.	Moderate to high Includes chemical use, sludge management, electrical power, and operator labor.	Waste generation from chemical precipitation. Energy consumption from process equipment.	Rejected	Low effectiveness likely for target COCs. Potential implementability/ cost issues with management/disposal of contaminant-laden sludge.

Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action

General Response Actions	Remedial Technology	Process Option	COC or Co-Contaminant Applicability[a]	Description	Effectiveness[b]	Implementability[c]	Relative Capital Cost[d]	Relative O&M Cost[e]	Sustainability[f]	Retained/ Rejected[g]	Screening Comment
		Chemical oxidation	Cyanide	A strong oxidant, such as chlorine, is added to water in a mixed reactor to convert cyanide to cyanate, and ultimately to CO_2 and N_2 (if sufficient oxidant is used). Most rapid and complete at high pH (e.g., alkaline chlorination).	Low for target COCs Good performance of this technology has been demonstrated elsewhere for treatment of cyanide in industrial wastewaters, but performance in the presence of other contaminants and ability to meet MCL would have to be evaluated through bench and/or pilot-scale testing.	Moderate Technology is used in industrial wastewater treatment applications.	Moderate to high Would require construction of a new treatment process.	Moderate Includes chemical use, electrical power, and operator labor.	Energy consumption by process equipment.	Rejected	Low/no effectiveness for target COCs. No experience with this technology for the contaminant mixture and groundwater chemistry present at the Hanford Site.
	Treatment – biological/ biochemical	Constructed wetlands/ phyto-irrigation	Nitrate; possibly cyanide	**Constructed wetlands:** Extracted groundwater is conveyed to a constructed wetland where contaminants are biologically reduced, oxidized, taken up by plants and algae, or physically absorbed. Anaerobic constructed wetlands include an organic media layer and are usually designed for vertical flow; they are also typically followed by aerobic polishing wetlands. **Phyto-irrigation:** Use of plants and their associated rhizospheric microorganisms to remove, reduce/degrade, or contain chemical contaminants in groundwater by applying it as irrigation water.	Low for target COCs Effective for bioreduction of nitrate (denitrification), however may need to verify effectiveness for other contaminants. Various species of bacteria, fungi, algae, yeasts, and plants, as well as their associated enzymes and amino acids, are known to oxidize cyanide naturally. The predominant mechanism of bio-oxidation is the metabolic conversion of cyanide to cyanate (OCN^-), a species less toxic than cyanide. Plants used for remediating radionuclides (except tritium) would require harvesting.	Low to moderate Land requirement is likely high and long-lived. Contaminated plant material will require proper disposal.	Low to moderate Low for phyto-irrigation if existing area is available onsite. Moderate for construction of large wetlands.	Low to moderate Low for performance monitoring, electricity for pumping, and occasional maintenance. Moderate if harvesting and disposal of radionuclide-contaminated plants is required.	Impacts include large amount of land required for wetland construction and waste generated consisting of contaminated plant material. Contaminated media or soil may require management (e.g., capping or removal and disposal) at the end of the project. Energy consumption for pumping.	Rejected	Low effectiveness for target COCs. Effectiveness for contaminants other than nitrate is uncertain and expected to be limited. Implementability challenges associated with large area requirements. Radionuclides would accumulate in the plants, posing risks to ecological receptors.
		Subgrade BCRs – passive or semipassive treatment	Nitrate	Extracted groundwater is conveyed to a lined, media-filled, in-ground basin designed to create anaerobic conditions. Anaerobic conditions are created using organic media materials (e.g., wood mulch and/or other organic materials), zerovalent iron, and/or an organic chemical liquid feed. Nitrate is biochemically reduced as water passes through the media to nitrogen gas. Anaerobic BCRs are typically followed by an aerobic polishing stage to remove undesirable byproducts (e.g., reduced iron, sulfide, organics, and nutrients) and solids prior to effluent reinjection or discharge to surface water.	Low for target COCs Effective for reducing and removing nitrate.	Low to moderate Land requirement is likely high and long-lived. Occasional removal and replacement of large volumes of BCR media and the disposal of spent material will likely be required.	Moderate Moderate for construction of large BCRs.	Low to moderate Low for performance monitoring, electricity for pumping, and occasional maintenance. Moderate if media replacement is required more often than every several years (e.g., decade).	Effects include large amount of land required, possible occasional disposal of spent media during the project, disposal of spent media at the end of the project, and/or capping and closure in-place.	Rejected	Low/no effectiveness for target COCs. Treatment of co-contaminants using this technology is not particularly compatible with treatment of COCs at the 200 West P&T. Implementability issues with occasional disposal of spent BCR media containing contaminants.

Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action

General Response Actions	Remedial Technology	Process Option	COC or Co-Contaminant Applicability[a]	Description	Effectiveness[b]	Implementability[c]	Relative Capital Cost[d]	Relative O&M Cost[e]	Sustainability[f]	Retained/ Rejected[g]	Screening Comment
		Bioreactors – active treatment	Nitrate, cyanide	Extracted groundwater is conveyed to a treatment vessel where contaminants are biologically treated by a culture of microorganisms. There are numerous bioreactor sub-options, including systems that use anoxic, anaerobic, and aerobic conditions, and suspended-growth, fixed bed, and FBR types. Fixed beds are media-filled vessels that the water passes through to be treated by attached biomass. FBRs also accomplish treatment via attached biomass but use media (e.g., GAC) that is readily expanded (i.e., fluidized) by upflowing water. AMTs consist of suspended-growth reactor vessels with membrane modules for solids/liquid separation. For anoxic/anaerobic treatment, an organic substrate is provided as a chemical feed if the influent wastewater lacks an adequate supply of readily degradable organics. Aerobic bioreactors include an aeration system (e.g., diffused air) to provide dissolved oxygen for aerobic metabolism.	Low for target COCs Anoxic/anaerobic bioreactors are effective for bioreduction of nitrate (denitrification). Aerobic bioreactors are potentially effective for treatment of cyanide.	High Vendors and equipment readily available. Anoxic/anaerobic FBRs and aerobic AMTs are used at the existing Hanford Site 200 West P&T for removing nitrate and Cr(VI), and potentially some degradation of cyanide.	Moderate to high Moderate if the existing 200 West P&T has sufficient surplus capacity to accommodate the groundwater. High if construction of a new treatment train is required.	Moderate to high Includes chemical use, waste management (contaminated biosolids), electrical power, and operator labor. Biological treatment processes typically require more operator attention than physical/chemical systems.	Waste generation from biological sludge. Energy consumption by process equipment.	Retained	Low/no effectiveness for target COCs. Retained for treatment of co-contaminants such as nitrate and cyanide if present in extracted groundwater. Technology demonstrated effective at the Hanford Site for treatment of nitrate and Cr(VI).
	Treatment – physical	GAC	Cyanide; possibly some incidental removal of other contaminants	Water is conveyed through one or more vessels containing GAC, where amenable contaminants are removed by sorption. Commonly used for removal of hydrophobic organic contaminants.	Low effectiveness for target COCs Effective for low concentrations of cyanide but depends on cyanide speciation. Modification of the activated carbon used may increase effectiveness.	High Widely used technology. Media and vessels are readily available.	Moderate	Moderate Depends on frequency of media changeout. Includes media replacement, waste management (spent media), electrical power, and operator labor.	Waste generation from spent GAC. Energy consumption by process equipment.	Rejected	Low/no effectiveness for target COCs or co-contaminants.
		Membrane separation	All	This technology includes, in order of decreasing size of constituents retained by the membrane: microfiltration, UF, NF, and RO; however, RO is the focus of this evaluation because it is most applicable for the groundwater contaminants. Pressure is used to force water through a semipermeable membrane, leaving contaminants behind. The clean water stream (permeate) is reinjected or discharged to the environment, while the concentrated water stream (concentrate or brine) is managed as waste. Pre-treatment (e.g., by UF prior to RO) is often needed to mitigate fouling of the downstream process membranes.	High With the appropriate design, RO can be effective for most, or all, of the contaminants.	Low Vendors and equipment are readily available. However, management/ disposal of the large-volume concentrate stream (typically 20% to 30% of the influent flow) can make this technology impractical. Concentrate management may be limited to disposal as a liquid waste or evaporation/crystallization in conjunction with disposal of the residual solids. Membrane filtration for suspended solids removal is used in conjunction with the AMT system at the 200 West P&T.	High	High Includes chemical use (membrane cleaning fluids and antiscalants), membrane module replacement, waste treatment/ management (concentrate stream or concentrate residuals), considerable electrical power, and operator labor.	Waste generation in the form of liquid concentrate or residual solids after evaporation. High energy consumption from process equipment (e.g., high-pressure pumps). Extremely high energy use if evaporation/ crystallization is used for concentrate treatment.	Rejected	Implementability/cost challenges with managing the large-volume concentrate stream associated with UF, NF, and RO.

Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action

General Response Actions	Remedial Technology	Process Option	COC or Co-Contaminant Applicability[a]	Description	Effectiveness[b]	Implementability[c]	Relative Capital Cost[d]	Relative O&M Cost[e]	Sustainability[f]	Retained/ Rejected[g]	Screening Comment
Discharge (a component of P&T)	Onsite discharge	Reinjection into saturated zone	All	Treated groundwater is injected into onsite wells.	High Effective method of discharge. Can be used to enhance contaminant flushing, hydraulic control, and plume capture if located properly.	High Readily implementable at the Hanford Site. Currently used successfully in existing P&T systems at a number of locations at the Hanford Site. Injection wells may be subject to clogging due to chemical or biofouling, requiring maintenance or replacement.	Low	Low to moderate	Waste generation from soil cuttings for well installation. Energy consumption by discharge pumps (if required).	Retained	Injection wells widely used at the Hanford Site for onsite discharge of treated water.
		Surface infiltration	All	Treated groundwater is infiltrated into the vadose zone via onsite trenches, located outside of zones with known waste sites.	High Effective method of discharge. Can enhance contaminant flushing, hydraulic control, and plume capture if located properly. May require infiltration tests to assess feasibility. Not an option if vadose zone contamination is present. Not used elsewhere at the Hanford Site for CERCLA remedial actions.	Moderate to high Infiltration would be easy to engineer and implement.	Low Trenches are lower cost than reinjection wells.	Low to moderate	Little impact. Energy consumption by discharge pumps (if required).	Rejected	Trenches require large footprints that may adversely affect cultural or ecologically sensitive areas. Not used elsewhere at the Hanford Site for CERCLA remedial actions.
		Beneficial reuse of treated water	All	Use of treated water for a beneficial use such as irrigation or dust control.	High Effective means of treated water disposal.	Moderate May be simple to implement for dust control for nearby earthwork. May not be administratively implementable. No reuse opportunities identified at this time. Not used elsewhere at the Hanford Site for CERCLA remedial actions. May not be acceptable if treated water retains contaminants (e.g., tritium or iodine-129).	Low to moderate Depends on the distance of reuse point relative to treatment location.	Low	Energy use for treated water transport/ conveyance to the reuse point.	Rejected	May not be administratively implementable. Not used elsewhere at the Hanford Site for CERCLA remedial actions.
	Offsite discharge	Discharge to surface water	All	Discharge of treated groundwater directly to the river at a pipeline and outfall or a stormwater or natural channel. If this method were used, the NPDES program would be an ARAR, and the substantive requirements of a NPDES waste discharge permit would need to be met.	High Effective means of treated water disposal.	Low to moderate Technically implementable but may not be administratively implementable. Although surface water discharge is the most common method of discharging treated municipal and industrial wastewater, no new outfalls are allowed on the Hanford Reach National Monument.	Low	Low	Little impact. Energy consumption for discharge pumps (if required).	Rejected	Although surface water discharge is commonly practiced for treated effluent, new outfalls are not allowed on the Hanford Reach National Monument (i.e., not administratively implementable).

Reference: 40 CFR 300.430, "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy."

a. Indicates the contaminants that can be addressed by a technology based on geochemical properties. A contaminant of potential concern applicability of "All" indicates that implementation of a technology is not dependent on the nature of a chemical.

b. Effectiveness is the degree to which a technology reduces toxicity, mobility, or volume through treatment; minimizes residual risks and affords long-term protection; complies with ARARs; minimizes short-term impacts; and how quickly it achieves protection. Technologies providing significantly less effectiveness than other more promising alternatives may be eliminated. Alternatives that do not provide adequate protection of human health and the environment will be eliminated from further consideration.

c. Implementability focuses on the technical feasibility and availability of the technology and the administrative feasibility of implementation. Technologies that are technically or administratively infeasible, or that would require equipment, specialists, or facilities that are not available within a reasonable period of time, may be eliminated from consideration.

d. Relative cost is the cost of construction and the long-term costs to operate and maintain a technology. Technologies with costs that are grossly excessive compared to the overall effectiveness may be considered as one of several factors used to eliminate a technology. Technologies providing effectiveness and implementability similar to that of another technology by using a similar method of treatment or engineering control, but at greater cost, may be eliminated.

e. Operations and maintenance cost details are provided in Appendix B of this feasibility study.

f. Sustainability includes potential effects to the environment that could arise from implementing a technology (e.g., greenhouse gas emissions, waste generation, water use and resource impacts, and energy use). Alternative design will dictate the sustainability of an approach; however, sustainability was not considered as a criterion for retaining or rejecting the process options.

g. Additional details of rejected technologies are provided in Appendix A of this feasibility study.

Table 4-2. Remedial Technology Screening for 200-BP-5 and 200-PO-1 OU Interim Action

General Response Actions	Remedial Technology	Process Option	COC or Co-Contaminant Applicability[a]	Description	Effectiveness[b]	Implementability[c]	Relative Capital Cost[d]	Relative O&M Cost[e]	Sustainability[f]	Retained/ Rejected[g]	Screening Comment

ARAR = applicable or relevant and appropriate requirement
AMT = aerated membrane tank
BCR = biochemical reactor
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC = contaminant of concern
Cr(VI) = hexavalent chromium
FBR = fluidized bed reactor
GAC = granular activated carbon
IX = ion exchange
MCL = maximum contaminant level
NCP = National Contingency Plan
NF = nanofiltration
NPDES = National Pollution Discharge Elimination System
O&M = operations and maintenance
OU = operable unit
P&T = pump and treat
RO = reverse osmosis
UF = ultrafiltration

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4.2.1.1 No Action

"No action" means no further action to remove, remediate, monitor, or restrict access to contaminated groundwater is performed, and any ongoing interim action is discontinued. CERCLA RI/FS guidance (EPA/540/G-89/004) and the NCP (40 CFR 300) require this response to remain in the FS process for comparative purposes, where it is used as a baseline against which the other alternatives are compared. The No Action alternative may, or may not, provide adequate reduction of site risks.

4.2.1.2 Access Restrictions

Access restrictions can include ICs and engineering controls (ECs). Table 4-3 identifies DOE categories of ICs and ECs; provides examples of ICs and ECs currently in use at the Hanford Site; and identifies the administrative, legal, and active controls retained in this FS.

Institutional Controls. ICs, such as administrative and/or legal restrictions, are imposed on land use to minimize the potential for human exposure to contamination and/or protect the integrity of a remedy. The ICs work by limiting land or resource use and/or by providing information that helps modify or guide human behavior at the site.

As DOE identifies ICs, they are applied and implemented in an integrated manner so mechanisms in place will ensure that the ICs are effective, implemented as planned, properly maintained, inventoried, periodically re-evaluated, and modified as necessary to reflect changes in conditions. DOE will maintain the ICs as long as necessary to perform their intended protective purposes (DOE P 454.1 Chg 1 Admin Chg, *Use of Institutional Controls*).

The Sitewide IC plan (DOE/RL-2001-41) describes how the DOE Richland Operations Office (DOE-RL) will implement and maintain the OU-specific ICs specified in CERCLA decision documents. The Sitewide IC plan is updated based on final CERCLA decision documents within 180 days of their issuance. The plan addresses the elements of EPA 540-F-00-005, *Institutional Controls: A Site Manager's Guide to Identifying, Evaluating and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups*. DOE-RL also conducts IC reviews during the CERCLA 5-year review process.

Engineering Controls. ECs are active physical measures that prevent or minimize exposure to hazardous substances. They generally include fences, signs, and security to protect against inadvertent exposure to contamination until cleanup levels are achieved. Access restrictions (including IC and EC technologies and associated process options) are collectively referred to as ICs in this FS for interim action.

4.2.1.3 Collection/Capture

Groundwater collection/capture, a component of P&T, involves extracting contaminated groundwater through vertical wells (horizontal wells are not applicable for groundwater extraction in the target remediation areas due to the large depth to groundwater). The groundwater is conveyed to a treatment facility via a pipeline for COC removal prior to discharge.

Groundwater extraction is best applied where contaminant source-control measures have been implemented and contaminants are relatively mobile in groundwater. Contaminant mobility affects the ability of an extraction system to remove contaminants from the aquifer. Contaminants with high mobility (e.g., uranium and technetium-99) readily flow with groundwater toward extraction wells for removal. Contaminants with low mobility (e.g., plutonium isotopes) adhere to the aquifer sediments and are more difficult to remove from the aquifer using groundwater extraction.

Table 4-3. Categories and Types of Current Hanford Access Restrictions/ICs

DOE Categories of ICs [a]	DOE Categorical Description	Types of Current Hanford ICs	Examples of ICs
Active/passive controls	These controls have long been understood to apply to the long-term management of radioactive waste. Active controls require clear institutional and human responsibilities and the active performance of responsibilities such as controlling access to a disposal site by means such as guards, performing maintenance operations or remedial actions at a site, controlling or cleaning up releases from a site, or monitoring parameters related to disposal system performance. Passive controls are defined by their dependence on the design of controls and structures such as permanent markers placed at a disposal site, public records and archives, government ownership and regulations regarding land or resource use, and other methods of preserving knowledge about the location design and contents of a disposal system.	**Warning notices:** Provide visual identification and warning of hazardous or sensitive areas. A mechanism of warning notices includes signs that provide visual identification and warning of hazardous or sensitive areas. **Entry restrictions:** Prevent or limit the access of humans to particular hazardous or sensitive areas. Procedural requirements for access warning signs (in conjunction with an engineering control such as fencing) can be implemented to provide entry restrictions. **Excavation permits:** Prevent unplanned disturbance or infiltration; inform and protect workers regarding potential exposure to hazardous waste; avoid the creation of potential pathways for migration of hazardous waste.	**Warning notices and entry restrictions:** Requirement for placement of permanent signs and/or markers at specific areas of the site. Procedural requirements for access excavation/drilling permits. Applies to all COPCs. **Effectiveness:** High. Reduces or eliminates the potential for direct contact with radiological contamination and contaminated groundwater for the duration of elevated risk period, and for preserving knowledge about a specific area or design. Protects integrity of active remedies. **Implementability:** Very high. Readily implemented, requires periodic surveillance and maintenance. **Cost:** Low.
Proprietary/ government controls	This type of control is based on the legal authority of landowners to control the use of their land. Proprietary controls (e.g., easements) are based on the rights associated with ownership of an interest in land. Government controls rely on the powers of governments to protect the public health and safety through zoning, legislation, land ownership, or permit programs.	**Land use management:** Ensures that use of the land is compatible with any hazards that exist. As presented in DOE/RL-2001-41, "DOE will restrict the use of land on waste sites and prohibit activities that would interfere with the remedial activity in accordance with the ICs requirements of the CERCLA decision documents and as described in applicable work plans." Implementation of land use management controls can ensure that any changes in use of the land are assessed before being allowed, and that ICs are maintained beyond change of ownership, as appropriate. Mechanisms include land use and real property controls (e.g., proprietary controls, including easements and covenants), including irrigation restrictions and excavation permits. Land use and real property controls ensure that the use of land is in accordance	**Land use management:** Land-use and real property controls (e.g., proprietary controls, including easements and covenants). Applies to all COPCs. **Effectiveness:** High. Reduces or eliminates the potential for direct contact with contaminated groundwater when well implemented and maintained for the duration of elevated risk period. Ensures compatible land use. **Implementability:** Very high. Readily implemented; must identify and comply with all necessary legal requirements. **Cost:** Low. **Groundwater-use management:** Groundwater controls. Applies to all COPCs.

Table 4-3. Categories and Types of Current Hanford Access Restrictions/ICs

DOE Categories of ICs [a]	DOE Categorical Description	Types of Current Hanford ICs	Examples of ICs
		with Hanford Site plans and CERCLA decision documents. Site evaluations are required before any land disturbance activity, and excavation permits are required for excavations on the Hanford Site to prevent unplanned disturbance or infiltration as prohibited by CERCLA decision documents. Irrigation restrictions would be placed on sites that have a groundwater/surface water protection risk if irrigation were applied. **Groundwater-use management:** Ensures proper use of groundwater through groundwater controls. As described in DOE/RL-2001-41, groundwater use on the Hanford Site is generally restricted, except for limited research purposes and for monitoring and treatment, as approved by EPA or Ecology, or as authorized in EPA- or Ecology-approved documents. Excavation permits and the land-use process also control groundwater use.	**Effectiveness:** High. Ensures no improper use of groundwater. **Implementability:** Very high. Readily implemented, but will likely require ongoing oversight and coordination with state water resource managers. **Cost:** Low.
Informational tools[b]	Provide information or notification about whether a remedy is operating as designed and/or that residual or contained contamination may remain onsite. Information devices include state registries, deed notices, and advisories.	**Waste site information management:** This is an administrative mechanism implemented to maintain and provide access to information on the location and nature of contamination. The WIDS database identifies waste management units on the Hanford Site, their location, waste type, and status. Other descriptive information contained in the WIDS database includes size, extent, and appearance; testing or sampling efforts; regulatory information; bibliographic references; images; change history; and data validation. DOE-RL maintains the system in accordance with the WIDS database change control system, which documents and traces additions, deletions, and/or other changes dealing with the status of waste management units.	**Waste site information management:** Administrative. Applies to all COPCs. **Effectiveness:** High. Ensures access to information on the location and nature of contamination. **Implementability:** Very high. Readily implemented but requires maintenance of the information management system. **Cost:** Low.

Table 4-3. Categories and Types of Current Hanford Access Restrictions/ICs

DOE Categories of ICs [a]	DOE Categorical Description	Types of Current Hanford ICs	Examples of ICs

a. DOE/RL-2001-41, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*.

b. An "informational tool" is an EPA category of an IC that is used at the Hanford Site, as discussed in DOE/RL-2001-41.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC = contaminant of potential concern
DOE = U.S. Department of Energy
DOE-RL = DOE Richland Operations Office
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
IC = institutional control
WIDS = Waste Information Data System

4.2.1.4 Ex Situ Treatment

Ex situ treatment comprises the treatment component of P&T and includes a variety of methods that are specific to contaminant types and their physical/chemical characteristics. Ex situ treatment may involve the use of chemical, biological, or physical treatment technologies to remove, degrade, or transform contaminants to less toxic or nontoxic forms. Ex situ treatment process options include the following.

- Chemical treatment
  - Ion exchange (IX)
  - Chemical reduction and precipitation
  - Chemical oxidation
- Biological treatment
  - Constructed wetlands/phyto-irrigation
  - Subgrade biochemical reactors
  - Bioreactors
- Physical treatment
  - Granular activated carbon (GAC) adsorption
  - Membrane separation (e.g., reverse osmosis [RO])

4.2.1.5 Discharge

Discharge is the component of P&T that follows treatment to return treated water to the environment. Discharge process options include the following:

- Onsite discharge
  - Reinjection
  - Surface infiltration
  - Beneficial reuse
- Offsite discharge
  - Discharge to surface water

4.2.2 Evaluation of Technologies and Selection of Representative Technologies

Table 4-2 presents the technology and process identification and screening results for the 200-BP-5 and 200-PO-1 OU interim action. In accordance with the CERCLA process, technologies and process options were screened against three criteria: effectiveness, implementability, and relative cost. The technologies identified in Section 4.2.1, when used in combination, may be expected to provide reduction of contaminant toxicity, mobility, or volume (TMV). Other factors considered in the evaluation include the state of technology development, site conditions, waste characteristics, nature and extent of contamination, and presence of other chemical constituents or co-contaminants that could limit the effectiveness of a technology. Table 4-2 also includes information about the sustainability of remedial technology process options. However, sustainability was not considered as a criterion for retaining or rejecting a technology or process option.

Effectiveness refers to the ability of the process option to perform as part of a comprehensive remediation plan to meet interim action objectives, and ultimately the final RAO, under the conditions and limitations present at the site. Additionally, the NCP (40 CFR 300) defines effectiveness as the "…degree to which an alternative reduces TMV through treatment; minimizes residual risk; affords long-term protection;

complies with ARARs; minimizes short-term impacts; and how quickly it achieves protection." This is a relative measure for comparing process options that perform the same or similar functions. Section 4.2.5 of CERCLA RI/FS guidance (EPA/540/G-89/004) states that the evaluation of process options with respect to effectiveness should focus on "…(1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the RAOs; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site."

Implementability refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed by the site. As suggested by CERCLA RI/FS guidance (EPA/540/G-89/004), process options and entire technology types can be eliminated from further consideration if a technology or process option cannot be effectively implemented at the site. As discussed in Section 4.2.5 of the CERCLA RI/FS guidance, "…technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site." Institutional or administrative implementability, which includes "…the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology…" is also considered in the initial screening.

For the initial screening of technology types and process options, the cost criterion is relative. It compares processes and technologies that perform similar functions and have similar effectiveness. Section 4.2.5 of CERCLA RI/FS guidance (EPA/540/G-89/004) states that, "…cost plays a limited role in the screening of process options. Relative capital and operations and maintenance (O&M) costs are used rather than detailed estimates. At this stage in the process, the cost analysis is made on the basis of engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type." For this evaluation, cost is used to screen out process options that have a high relative cost if there are other choices that perform similar functions with similar effectiveness. The cost criterion includes a cursory consideration of the rough order of magnitude costs of construction and any long-term costs to operate and maintain the technologies.

Technologies that are not technically feasible based on effectiveness, implementability, and relative cost were screened out (rejected). Technical implementability is the first screening criteria evaluated as part of this process in accordance with CERCLA RI/FS guidance (EPA/540/G-89/004). However, for technologies with significant technical implementability challenges, an evaluation of effectiveness and cost was still completed to support a more complete evaluation. Technologies that were considered technically impracticable based on unsuccessful case studies at the site, challenges associated with existing site conditions (e.g., lithology), potential for increased worker safety risk, or greater complexity relative to other technologies of comparable effectiveness were screened out. Technologies were also removed from further consideration if they were considered to have limited treatment effectiveness or ability to achieve the PRGs for the target COCs and co-contaminants, or exhibit performance uncertainty. Remedial technology types and process options retained from the screening are carried forward into the development of alternatives (discussed in Chapter 5 of this FS).

The assessment of individual technologies and their associated process options was performed based on the criteria described above using a relative grading scale using a "low," "moderate," or "high" rating. To create greater separation, or where the feasibility of a technology/process option could vary for different reasons, a blended rating such as "low to moderate" or "moderate to high" was used. Additional comments were added to the screening table (Table 4-2) to indicate an assigned grade for the technology/process option for the COCs targeted in the interim action (uranium and technetium-99)

versus co-contaminants. After the assessment against each of the three criteria was completed, a "retained" or "rejected" determination was made.

Technologies retained from the screening outlined in Table 4-2 included the following:

- **ICs:** Retained to control the exposure pathway until interim action objectives are achieved or until a final remedy is selected. Typical IC components include the following:
  - Active/passive controls
  - Proprietary/governmental controls
  - Informational tools
- **P&T:** Consisting of groundwater collection/capture, ex situ treatment, and discharge.
  - Collection via groundwater extraction using vertical wells
  - Ex situ treatment via chemical treatment using IX for uranium and technetium-99
  - Ex situ treatment via biological treatment using bioreactors for co-contaminant treatment if present above PRGs (e.g., nitrate and cyanide)[7]
  - Discharge onsite using injection wells to return water to the saturated zone and to potentially provide flow-path/gradient control

The no action GRA is also retained in accordance with the NCP (40 CFR 300).

[7] The existing 200 West P&T will be used to treat groundwater extracted from the 200-BP-5 and 200-PO-1 OUs. The 200 West P&T includes IX and biological treatment processes designed to treat uranium, technetium-99, and nitrate (among other contaminants), and some removal of cyanide is also achieved. With the exception of tritium and iodine-129, the 200 West P&T currently has the capability to treat target COCs and co-contaminants to concentrations below the respective DWSs. There is no effective treatment method for tritium or iodine-129; however, blending of 200-BP-5 OU groundwater with other contaminated groundwater at the 200 West P&T has achieved the facility's effluent requirements.

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5 Development and Screening of Alternatives

This chapter presents remedial action alternatives for the 200-BP-5 and 200-PO-1 Groundwater OUs interim action. In Sections 5.1 and 5.2, the remedial technologies retained from screening discussed in Section 4.2 are combined into an array of remedial action alternatives to address the uranium and technetium-99 (target) groundwater plumes. With the exception of the No Action alternative, the remedial action alternatives were developed with the intent of achieving the interim action objectives and the RAO identified in Sections 1.1 and 3.3, respectively. In Section 5.3, the assembled alternatives are then screened against the CERCLA criteria of effectiveness, implementability, and cost, as defined in 40 CFR 300.430(e)(7). The remedial action alternatives retained from the initial screening are carried forward for detailed analysis in Chapter 6 of this FS.

5.1 Development of Remedial Alternatives

The NCP [40 CFR 300.430(a)(1)(iii)] sets the following expectations for remedial action alternative development:

- Use treatment to address the principal threats posed by a site wherever practical. Principal threats for which treatment is most likely to be appropriate include liquids, areas contaminated with high concentrations of toxic compounds, and highly mobile materials.
- Use ECs such as containment for waste that poses a relatively low long-term threat or where treatment is impractical.
- Use ICs such as water use and deed restrictions to supplement ECs as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants. ICs may be used during the conduct of the RI/FS and implementation of the remedial action, and where necessary as a component of the completed remedy. The use of ICs shall not substitute for active response measures (e.g., treatment and/or containment of source material or restoration of groundwater to beneficial use) as the sole remedy unless such active measures are determined not to be practicable based on the balancing of trade-offs among alternatives that is conducted during selection of the remedy.
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment. In appropriate site situations, treatment of the principal threats posed by a site (with priority placed on treating waste that is liquid, highly toxic, or highly mobile) will be combined with ECs (e.g., containment) and ICs, as appropriate, for treatment residuals and untreated waste.
- Consider using innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance than demonstrated technologies.
- Return useable groundwater to beneficial use wherever practical and within a timeframe that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial use is not practical, EPA expects to prevent further migration of the plume, prevent exposure to contaminated groundwater, and evaluate further risk reduction.

The NCP (40 CFR 300.430(e)(4)) also sets the expectation that, for groundwater response actions, a limited number of remedial alternatives should be developed to achieve site-specific remediation levels within different restoration periods using one or more technologies. Where the contaminated groundwater is not currently used or an alternate water source is readily available, and there is no near-term future need for the resource, it will likely be appropriate to consider a longer timeframe for achieving restoration cleanup levels (EPA 540-R-98-031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*).

Because it is well understood that P&T is the most viable approach for achieving the interim action objectives at the 200-BP-5 and 200-PO-1 OUs, the remedial alternatives (excluding the No Action alternative) rely upon the technologies of groundwater collection, ex situ treatment, and effluent discharge (i.e., groundwater P&T) in conjunction with ICs. The remedial action alternatives developed for the 200-BP-5 and 200-PO-1 OUs interim action are as follows:

- **Alternative 1 – No Action:** Assumes no active remedy is operating and cleanup is due solely to natural attenuation processes.
- **Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms:** Consists of operating groundwater extraction wells at the B Complex for uranium and technetium-99 and at the C Farm and A-AX Farms for technetium-99. Extracted groundwater is treated at the 200 West P&T.
- **Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap:** Consists of operating groundwater extraction wells at the B Complex for uranium and technetium-99, at the C Farm and A-AX Farms for technetium-99, and in Gable Gap for technetium-99. Extracted groundwater is treated at the 200 West P&T.

The remedial action alternatives were developed to the level of detail necessary to define the quantities required to prepare a +50%/−30% level of accuracy cost estimate to support comparison of the alternatives. More detailed information on the selected remedy for the interim action in the 200-BP-5 and 200-PO-1 OUs will be developed during remedial design, after the IROD has been signed. An RD/RAWP will be prepared to define, in detail, the design and implementation process for the selected interim action.

5.1.1 Development and Evaluation of Groundwater Extraction and Injection Pumping Scenarios

Groundwater flow and contaminant fate and transport modeling, using an iterative process, was performed to support remedial action alternative development and evaluation. This process evaluated the effectiveness of various extraction well locations and pumping rates in terms of projected cleanup times (i.e., the time required for simulated concentrations of uranium and technetium-99 to decline and remain below their respective PRGs [30 µg/L for uranium and 900 pCi/L for technetium-99] within each of the target remediation areas). This section provides a summary of the fate and transport modeling performed for the remedial alternatives, including the methodology used, a description of the scenarios simulated, and the modeling results. The modeling is more fully documented in ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this FS).

System design is driven by the complicated intersection of the geologic heterogeneity of the 200 East Area and the dynamic superposition of natural and anthropogenic hydrologic regimes. Water levels have been declining in the 200 East Area since nuclear materials production operations ceased (DOE/RL-2014-32). This has resulted in a greatly diminished saturated thickness in some contaminated areas. Additionally, the presence of the basalt and Ringold mud at and above the water table impose hydrogeologic complexity by restricting flow (and access to contaminated groundwater) and creating no-flow boundaries that increase drawdown from groundwater extraction in certain locations.

While the COC plumes that are the target of this interim action are distinct and localized, it was generally not possible to address any single plume independently of other plumes. P&T simulation in any one portion of the model caused hydraulic effects elsewhere within the model domain. As a result, an incremental approach was used to develop the P&T scenarios, focused on achieving cleanup levels for uranium and technetium-99. At each step, these effects could be evaluated to determine the most appropriate incremental step in order to achieve the desired cleanup targets. The elements of this approach are as follows:

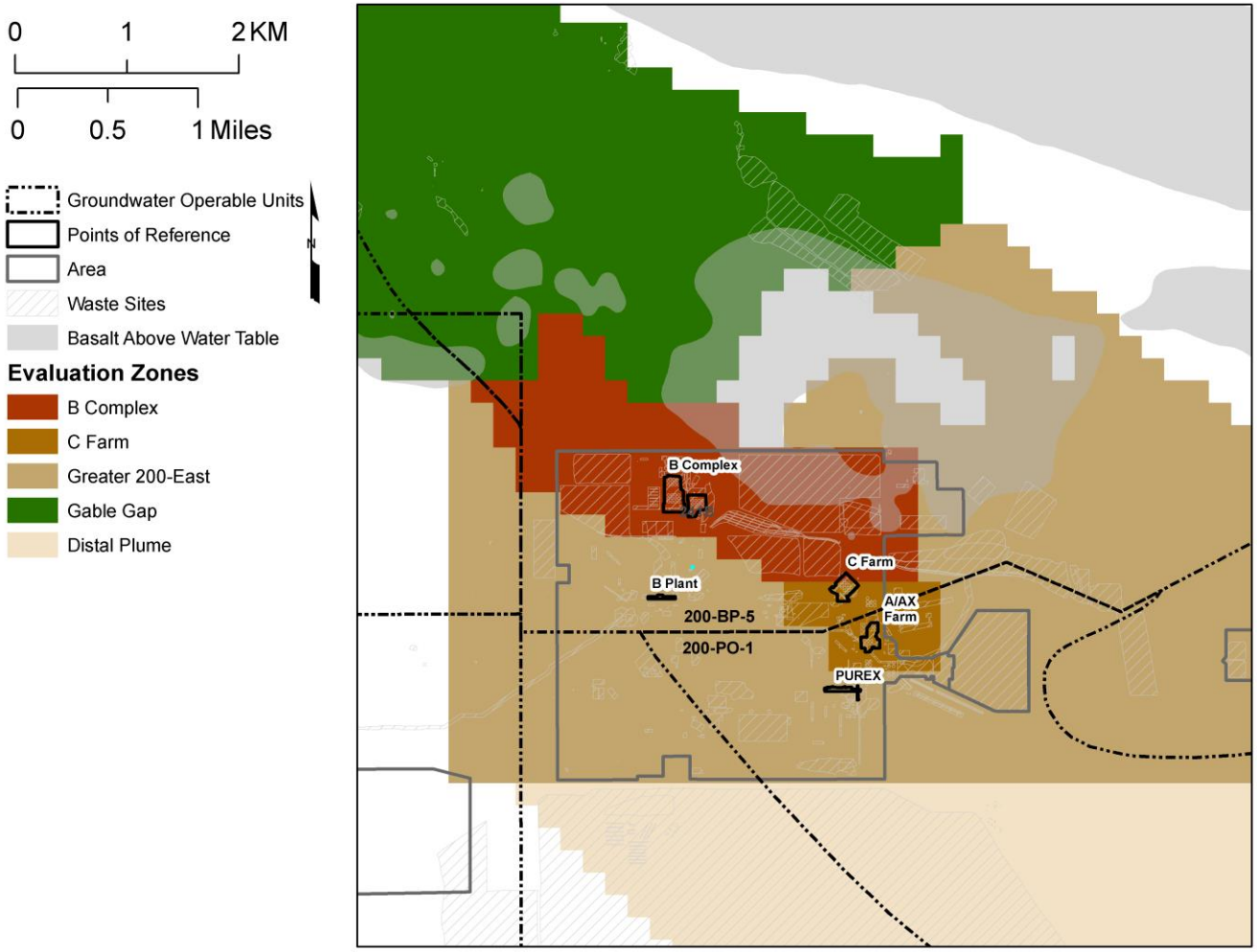
1. **Divide the model domain into distinct evaluation areas corresponding to plume locations.** Figure 5-1 shows the evaluation areas. The evaluation areas partition the model domain into plume-defined subdivisions. Dividing the model domain into subdivisions allows summary statistics to be calculated for the evaluation areas, thus providing a metric of how well P&T scenarios are performing.

2. **Target the COCs in each evaluation area for the interim action.** Some contaminants impact only a limited number of evaluation areas. For example, uranium is significant in the vicinity of the B Complex but not in Gable Gap or the C Farm and A-AX Farms area. Technetium-99 drives cleanup timeframes in the B Complex, Gable Gap, and C Farm and A-AX Farms but has little effect on the area near B Plant.

3. **Begin with a single evaluation area and expand to the other target evaluation areas.** Developing P&T scenarios to address a single localized plume and then building out to other plumes allows information from each scenario to be carried forward successively, preserving lessons learned and providing a methodological framework for continued improvement. Additionally, hydraulic effects from each evaluation area can be evaluated and the systems adjusted accordingly. This approach allows for the identification of elements necessary for successful implementation in each area.

5.1.1.1 Fate and Transport Modeling Methodology

Model simulations to develop and evaluate remedial alternatives were performed using the Plateau-to-River Groundwater Transport Model (P2RGWM). The P2RGMW is documented in CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model Version 7.1*, and is the same model applied to evaluate baseline future groundwater conditions in the 200-BP-5 OU and 200-PO-1 OU RI reports (DOE/RL-2009-127 and DOE/RL-2009-85, respectively).



Note: Modified from ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-1. Subregions Used to Evaluate Groundwater Modeling Simulation Results

The P2RGWM is a transient, three-dimensional, seven-layer model simulating groundwater conditions from the Central Plateau to the Columbia River. The model consists of two parts: (1) a hydraulic model to simulate groundwater flow, and (2) a transport model for contaminant migration and fate. The hydraulic model is implemented using MODFLOW 2000, a finite difference groundwater-flow model code developed by the U.S. Geological Survey (Harbaugh et al., 2000, *MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process*). The transport model is implemented using MT3DMS, a three-dimensional transport model code simulating advection, dispersion, and chemical reactions (Zheng and Wang, 1999, *MT3DMS: A Modular Three-Dimensional Multispecies Transport Model for Simulation of Advection, Dispersion, and Chemical Reactions of Contaminants in Groundwater Systems; Documentation and User's Guide*). Both models have been modified to incorporate minimum saturated thickness features needed for transient conditions in the unconfined aquifer. A brief summary of the P2RGWM is provided in the following discussion, and additional details are provided in CP-57037.

The P2RGWM encompasses the 200 East and 200 West Areas and extends eastward to the Columbia River. The domain is discretized into grid cells with a uniform spacing of 200 m by 200 m (656.2 ft by 656.2 ft). Vertically, the model is discretized into seven layers, and the geology is based on ECF-Hanford-13-0029, *Development of the Hanford South Geologic Framework Model, Hanford Site, Washington*. The base of the model is basalt bedrock.

Recharge to the model consists of precipitation infiltration and artificial recharge (e.g., Treated Effluent Disposal Facility). At the edges of the model, specified head boundary conditions are used on the west, southwest, and the northern gaps between basalt ridges to represent water recharging or discharging from the model domain, as appropriate. The eastern boundary of the model is the Columbia River, which is primarily a discharge boundary.

Hydraulic properties of the model grid cells were determined by model calibration conditioned by the results of hydraulic testing, including pumping tests, slug tests, and tracer tests. Within the 200 East Area and to the north (the focus region for the P&T systems), sediments predominantly consist of the highly permeable Hanford formation and CCU, which have a calibrated hydraulic conductivity of 17,000 m/d (55,774 ft/d) and a specific yield of 0.2.

Parameters are needed for transport modeling to describe the processes of contaminant mobility, advective migration, mixing during transport, and degradation/decay. Some contaminants sorb to aquifer sediments by various processes such as surface adsorption and/or chemical precipitation. When this occurs, the contaminant mobility is reduced. Contaminant mobility is described by a distribution coefficient (K_d), which is the ratio of the sorbed concentration to the dissolved concentration assuming equilibrium between the dissolved and sorbed phases. Uranium sorbs to aquifer sediments and can exhibit a range of K_d values depending on geochemical conditions and sediment size. A best value determined for gravel-dominated sediments of 0.4 mL/g was used (PNNL-18564, *Selection and Traceability of Parameters To Support Hanford-Specific RESRAD Analyses – Fiscal Year 2008 Status Report*), consistent with the baseline modeling performed for the 200-BP-5 OU RI (DOE/RL-2009-127). Technetium-99 occurs in groundwater as the pertechnetate anion (which is nonsorbing), so the K_d was set to zero also consistent with the modeling for the 200-BP-5 OU RI. Both of these constituents are radioactive, and half-lives of 211,000 years for technetium-99 and 4.47 billion years for uranium were used. However, these half-lives are very long compared to the simulation durations, so decay was not a substantial factor. The effective porosity of the Hanford formation and CCU is 0.2. Mixing processes consist of dispersion and diffusion. The P2RGWM uses a longitudinal dispersivity of 6.2 m (20.3 ft) and a transverse dispersivity of 1.2 m (3.9 ft). Molecular dispersion is set to zero.

Initial plume conditions were based on the plume interpretations developed for the 2013 annual groundwater report (DOE/RL-2014-32), consistent with the 200-BP-5 OU RI (DOE/RL-2009-127). Translation of these plumes onto the P2RGWM model grid is documented in ECF-HANFORD-13-0030, *Initial Groundwater Plume Development to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*.

The simulation results used to evaluate the remedial alternatives (described in Section 5.2 of this FS) assume that there are no continuing sources of contamination to the aquifer. However, the effect of potential continuing sources was evaluated with additional model simulations using estimates of the mass flux to groundwater from continuing sources (ECF-HANFORD-13-0037, *Development of Source Terms for Inclusion in Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*). Simulations with these sources were performed for informational purposes and are discussed in Section 5.1.1.4 of this FS.

5.1.1.2 Scenario Descriptions

Fate and transport modeling was performed for a no action scenario and two P&T scenarios corresponding to the remedial alternatives presented in Section 5.1:

- **Alternative 1 – No Action:** Assumes that no active remedy is operating, and cleanup is due solely to natural attenuation processes.
- **Alternative 2 – P&T for B Complex, C Farm and A-AX Farms; 300 gal/min:** Consists of six extraction wells for capturing and removing technetium-99 and uranium from beneath the B Complex area and technetium-99 from the C Farm and A-AX Farms area.
- **Alternative 3 – P&T for B Complex, C Farm and A-AX Farms, and Gable Gap; 400 gal/min:** Consists of seven extraction wells and two injection wells for capturing and removing technetium-99 and uranium from beneath the B Complex area, technetium-99 from the C Farm and A-AX Farms area, and technetium-99 from Gable Gap.

The P&T scenarios for each remedial alternative were developed through an iterative process of running simulations, reviewing the results, and developing new scenarios based on the analysis goals and the information obtained from the previous simulations. ECF-HANFORD-18-0023 documents these scenarios, as well as two additional P&T scenarios representing earlier iterations.

As described in Section 1.1, the P&T remedies focus on three areas that warranted consideration for near-term remediation: techentium-99 and uranium at the B Complex, technetium-99 at the C Farm and A-AX Farms area, and technetium-99 at Gable Gap north of the 200 East Area. The P&T scenarios consist of operating sets of extraction and injection wells at specified flow rates within these areas and differ only in whether P&T is performed at Gable Gap. For remedy evaluation purposes, the duration of pumping in each scenario was 25 years, and each simulation was run for 50 years, which was deemed as sufficient evaluate each P&T scenario as an interim action. Final action decisions will be made in the future, and it is expected that the modeling scenarios supporting the final actions will have longer timeframes.

The remedial alternatives assume that extracted groundwater would be treated at the 200 West P&T, which was originally expected to operate for 25 years beginning in 2012. However, recent evaluations of the P&T remedy in the 200 West Area indicate that the system, as currently operating, may not achieve mass recovery goals within the expected 25-year time period, and options for modifying the 200 West P&T remedy are currently being evaluated (DOE/RL-2017-68, *Calendar Year 2017 Annual Summary Report for Pump-and-Treat Operations in the Hanford Central Plateau Operable Units*.

Pumping durations and treatment options for the 200-BP-5 OU interim action are constrained by the operational needs of the 200 West P&T to address remedies in the 200 West Area. Thus, any modifications to the 200 West P&T will need to be considered during the remedy design phase for the 200-BP-5 OU interim action.

The modeling scenarios correspond to the remedial alternatives, which are summarized in Table 5-1 and described further in the following sections. Figure 5-2 shows the locations of the groundwater extraction and injection wells used in the modeling scenarios. Well locations were selected to target areas with the highest uranium and technetium-99 concentrations and to mitigate stagnation areas. Figures 5-3 and 5-4 show the initial plume conditions for uranium and technetium-99, respectively.

Table 5-1. Modeling Scenario Extraction/Injection Wells and Flow Rates

Well Name[a]	Well Coordinates		Flow Rates (L/min [gal/min]) Extraction (<0) and Injection (>0)		
	Easting (m)	Northing (m)	Alternative 1 No Action	Alternative 2 300 gal/min	Alternative 3 400 gal/min
B Complex					
299-E33-360	573772.1	137386.9	0	-189 (-50)	-189 (-50)
299-E33-361	574069.3	137122.3	0	-284 (-75)	-284 (-75)
BC_E_1	574900.0	137100.0	0	-284 (-75)	-284 (-75)
		Total extraction	**0**	**-757 (-200)**	**-757 (-200)**
		Total injection	**0**	**0**	**0**
C Farm and A-AX Farms					
WC_E_1	575100.0	136300.0	0	-126 (-33.3)	-126 (-33.3)
WC_E_2	575300.0	136500.0	0	-126 (-33.3)	-126 (-33.3)
WC_E_3	575500.0	135900.0	0	-126 (-33.3)	-126 (-33.3)
		Total extraction	**0**	**-379 (-100)**	**-379 (-100)**
		Total injection	**0**	**0**	**0**
Gable Gap					
GG_E_1	573300.0	139700.0	0	0	-379 (-100)
GG_I_1	573300.0	138900.0	0	0	189 (50)
GG_I_2	573500.0	138700.0	0	0	189 (50)
		Total extraction	**0**	**0**	**-379 (-100)**
		Total injection	**0**	**0**	**379 (100)**

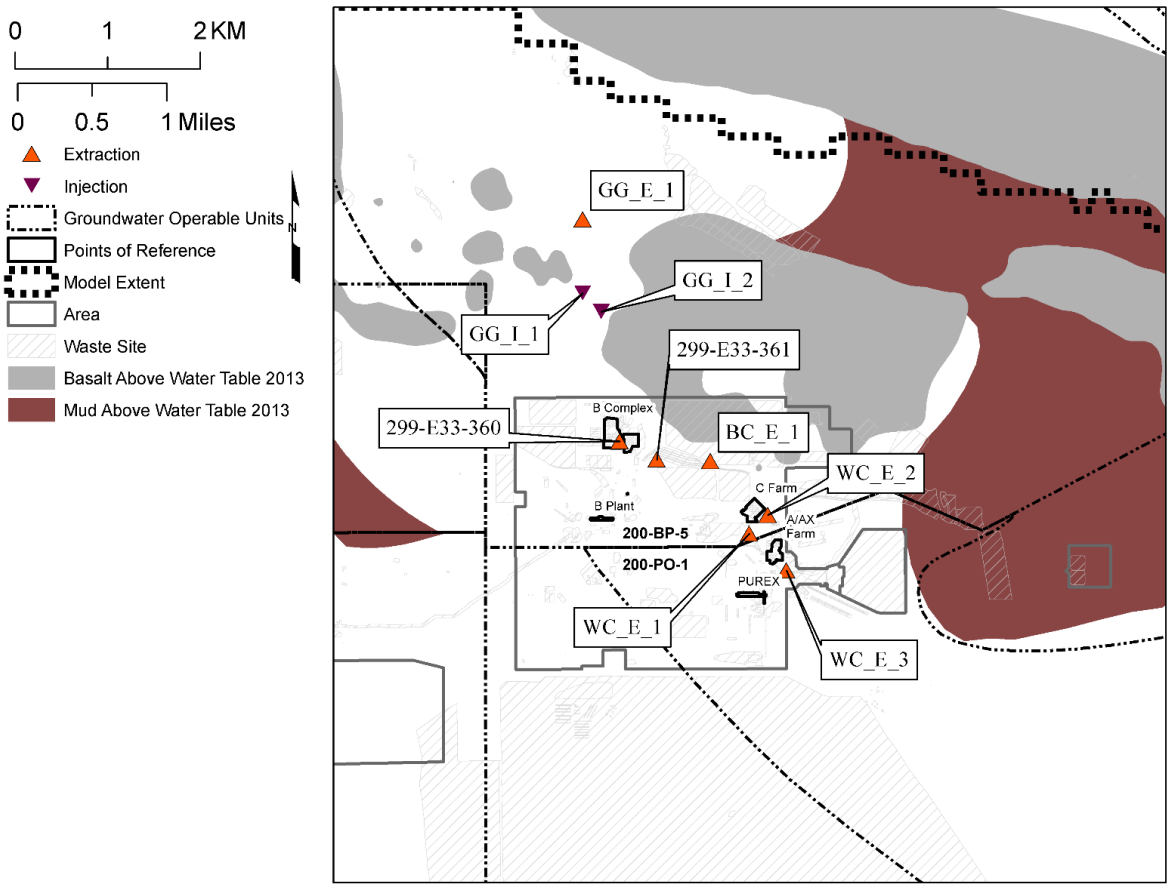
Table 5-1. Modeling Scenario Extraction/Injection Wells and Flow Rates

Well Name[a]	Well Coordinates		Flow Rates (L/min [gal/min]) Extraction (<0) and Injection (>0)		
	Easting (m)	Northing (m)	Alternative 1 No Action	Alternative 2 300 gal/min	Alternative 3 400 gal/min
Totals (All Subregions)					
Total extraction			**0**	**-1,136 (-300)**	**-1,514 (-400)**
Total injection[b]			**0**	**0**	**379 (100)**

Note: Modified from ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

a. Well locations are shown in Figure 5-2. Wells 299-E33-360 and 299-E33-361 are existing wells; all other wells are hypothetical for remedy evaluation purposes.

b. The balance of the flow (i.e., total extraction minus the total injection shown) is injected in the 200 West Area.



Note: Modified from ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-2. Extraction/Injection Well Locations Used in Modeling

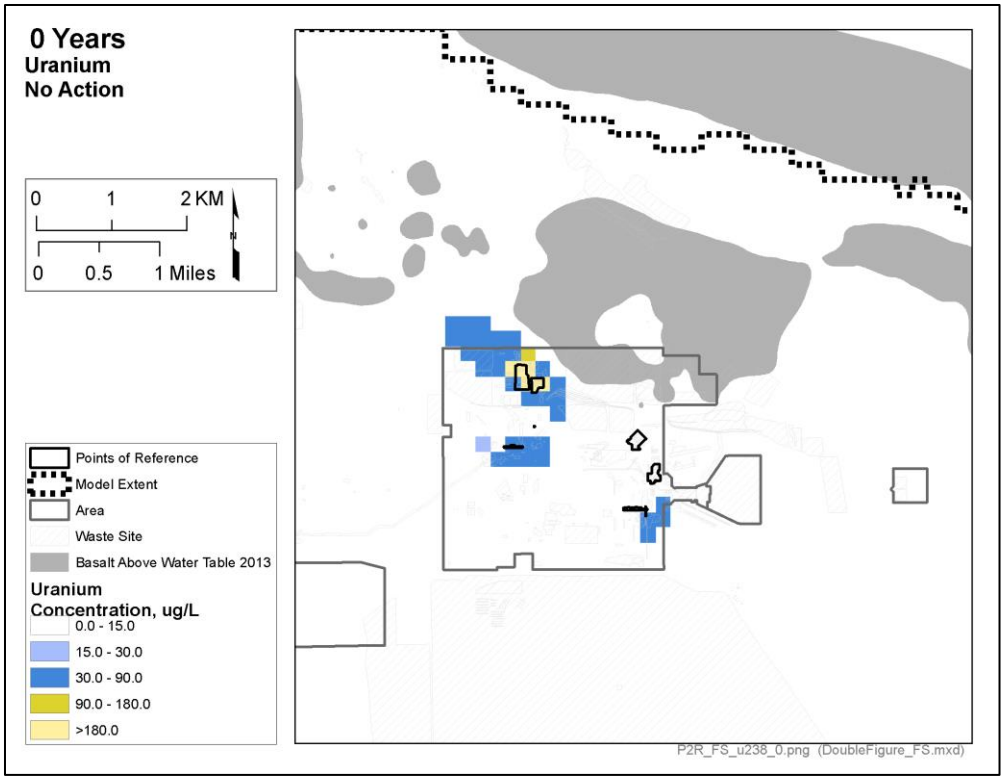


Figure 5-3. Uranium Plume at Year 0 of Alternative 1 (No Action) (Initial Conditions)

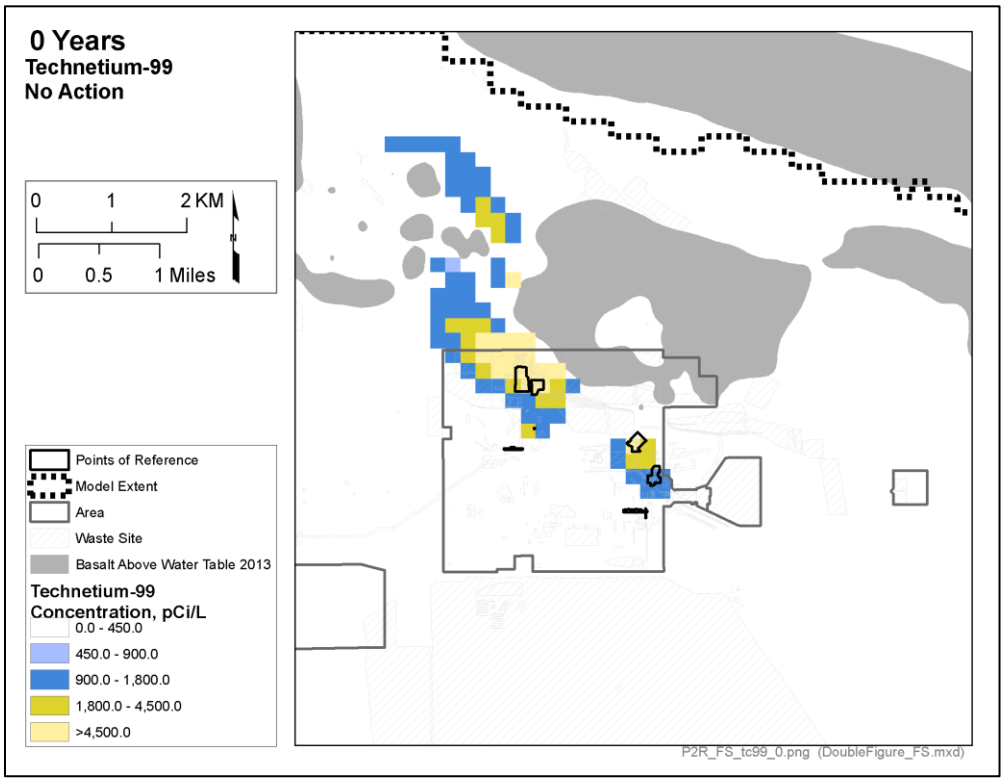


Figure 5-4. Techentium-99 Plume at Year 0 of Alternative 1 (No Action) (Initial Conditions)

Continuing sources of contamination to the aquifer are not included in the modeling scenarios described in the following sections. The purpose of these scenarios is to evaluate P&T effectiveness in remediating the aquifer contaminant plumes and to support the selection of a preferred alternative for further design/implementation. However, as described in Section 5.1.1.1, the effects of potential continuing sources were evaluated with additional model simulations using estimates of potential source mass flux to groundwater. The results are summarized in Section 5.1.1.4. and are also documented in ECF-HANFORD-18-0023.

Alternative 1 – No Action (0 gal/min). This scenario assumes that an active remedy is not operating and reflects cleanup due solely to natural attenuation processes. It provides the baseline results for technetium-99 and uranium for comparison to the P&T remedy scenarios. The results of this scenario are very similar to the baseline fate and transport simulations presented in the 200-BP-5 OU RI report (DOE/RL-2009-127).

Alternative 2 – P&T for B Complex, C Farm and A-AX Farms (300 gal/min). This scenario targets capture and removal of technetium-99 and uranium from beneath the B Complex area, and technetium-99 from the C Farm and A-AX Farms area. It simulates the use of two existing extraction wells (299-E33-360 and 299-E33-361) at the B Complex with pumping rates of 189 L/min (50 gal/min) for well 299-E33-360 and 284 L/min (75 gal/min) for well 299-E33-361, and includes one new extraction well (BC_E_1 in Figure 5-1) in the B Complex area operated at 284 L/min (75 gal/min). Three new extraction wells in the C Farm and A-AX Farms area are operated with pumping rates of 126 L/min (33.3 gal/min) each. The total extraction well flow rate for this scenario is 1,135 L/min (300 gal/min).

Alternative 3 – P&T for B Complex, C Farm and A-AX Farms, Gable Gap (400 gal/min). This scenario is the same as Alternative 2 in that it targets capture and removal of technetium-99 and uranium from beneath the B Complex area and technetium-99 from the C Farm and A-AX Farms area, but it also includes operation of extraction and injection wells in Gable Gap for technetium-99. One new extraction well in Gable Gap pumping at 379 L/min (100 gal/min) and two new injection wells in Gable Gap injecting at 189 L/min (50 gal/min) each are included. The total extraction well flow rate for this scenario is 1,514 L/min (400 gal/min).

5.1.1.3 Fate and Transport Modeling Results

The following discussion presents the results of the fate and transport modeling. To facilitate evaluation of the results, the model domain was divided into five distinct subregions to allow evaluations at both the local and full model domain scales. Figure 5-1 shows the evaluation areas, which include the following:

- **B Complex:** This area encompasses the B Complex, including BY Cribs, BX Trenches, B-7-A&B Crib, B-8 Crib and Tile Field, B-11A&B french drains, B-51 french drain, and B-57 Crib, as well as the three single-shell farms within WMA B-BX-BY. It is bounded to the north by the Gable Gap evaluation area, to the east by the WMA C evaluation area, and to the south by the greater 200 East evaluation area. The primary contaminants of interest are technetium-99 and uranium. In the B Complex area, the water table and contaminated groundwater are within the Hanford formation.

- **C Farm and A-AX Farms:** This area encompasses the C Farm and A-AX Farms. It is bounded to the west by the B Complex evaluation area and on all other sides by the greater 200 East evaluation area. The primary contaminant of interest is technetium-99. In the C Farm and A-AX Farms area, the water table and contaminated groundwater are within the Hanford formation.

- **Gable Gap:** This area is north of the B Complex and south of Gable Mountain, and it includes Gable Mountain Pond. The primary contaminant of interest is technetium-99. Within this area, the water table and contaminated groundwater are within the Hanford formation.
- **Greater 200 East (including B Plant and PUREX):** This evaluation area lies adjacent to the B Complex, C Farm and A-AX Farms, and Gable Gap evaluation areas to the south and includes the B Plant. This evaluation area is not a target of the interim remedial action.
- **Distal:** The distal evaluation area encompasses the remainder of the model domain not occupied by the other evaluation areas. This evaluation area is not a target of the interim remedial action.

The modeling results for each scenario were evaluated using two metrics: the C_{max} and the 95th percentile upper confidence limit (95 UCL) on the mean plume concentration. The 95 UCL is the same method recommended for calculating groundwater plume exposure point concentrations in superfund risk assessment guidance (OSWER 9285.6-10, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*). The advantage of the 95 UCL is that it provides a comprehensive evaluation of plume concentrations in a single metric. It is calculated statistically using Student's t-distribution, as described in ECF-HANFORD-18-0023.

Table 5-2 presents the estimated cleanup times (in years) based on the 95 UCL and C_{max} for simulated uranium and technetium-99 concentrations to decrease and remain below their respective PRGs. The results do not include simulations of continuing sources; these are addressed in Section 5.1.1.4.

Table 5-2. Projected Cleanup Times Based on 95 UCL and C_{max} Assuming No Continuing Sources

Scenario	Extraction/ Injection Flow Rate (gal/min)	Cleanup Time (years), Based on 95 UCL and C_{max}*			
		Uranium		Technetium-99	
		95 UCL	C_{max}	95 UCL	C_{max}
B Complex					
Alternative 1 – No Action	0/0	>50	>50	17	25
Alternative 2 – 300 gal/min	-200/0	28	29	7	7
Alternative 3 – 400 gal/min	-200/0	22	23	5	6
C Farm and A-AX Farms					
Alternative 1 – No Action	0/0	0	0	5	5
Alternative 2 – 300 gal/min	-100/0	0	0	5	5
Alternative 3 – 400 gal/min	-100/0	0	0	5	5

Table 5-2. Projected Cleanup Times Based on 95 UCL and C_{max} Assuming No Continuing Sources

Scenario	Extraction/ Injection Flow Rate (gal/min)	Cleanup Time (years), Based on 95 UCL and C_{max}*			
		Uranium		Technetium-99	
		95 UCL	C_{max}	95 UCL	C_{max}
Gable Gap					
Alternative 1 – No Action	0/0	0	25	>50	>50
Alternative 2 – 300 gal/min	0/0	0	0	>50	>50
Alternative 3 – 400 gal/min	-100/100	0	0	10	19
Totals (Flow) and Maximums (Cleanup Times) (All Subregions)					
Alternative 1 – No Action	0/0	>50	>50	>50	>50
Alternative 2 – 300 gal/min	-300/0	28	29	>50	>50
Alternative 3 – 400 gal/min	-400/100	22	23	10	19

Note: Modified from ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

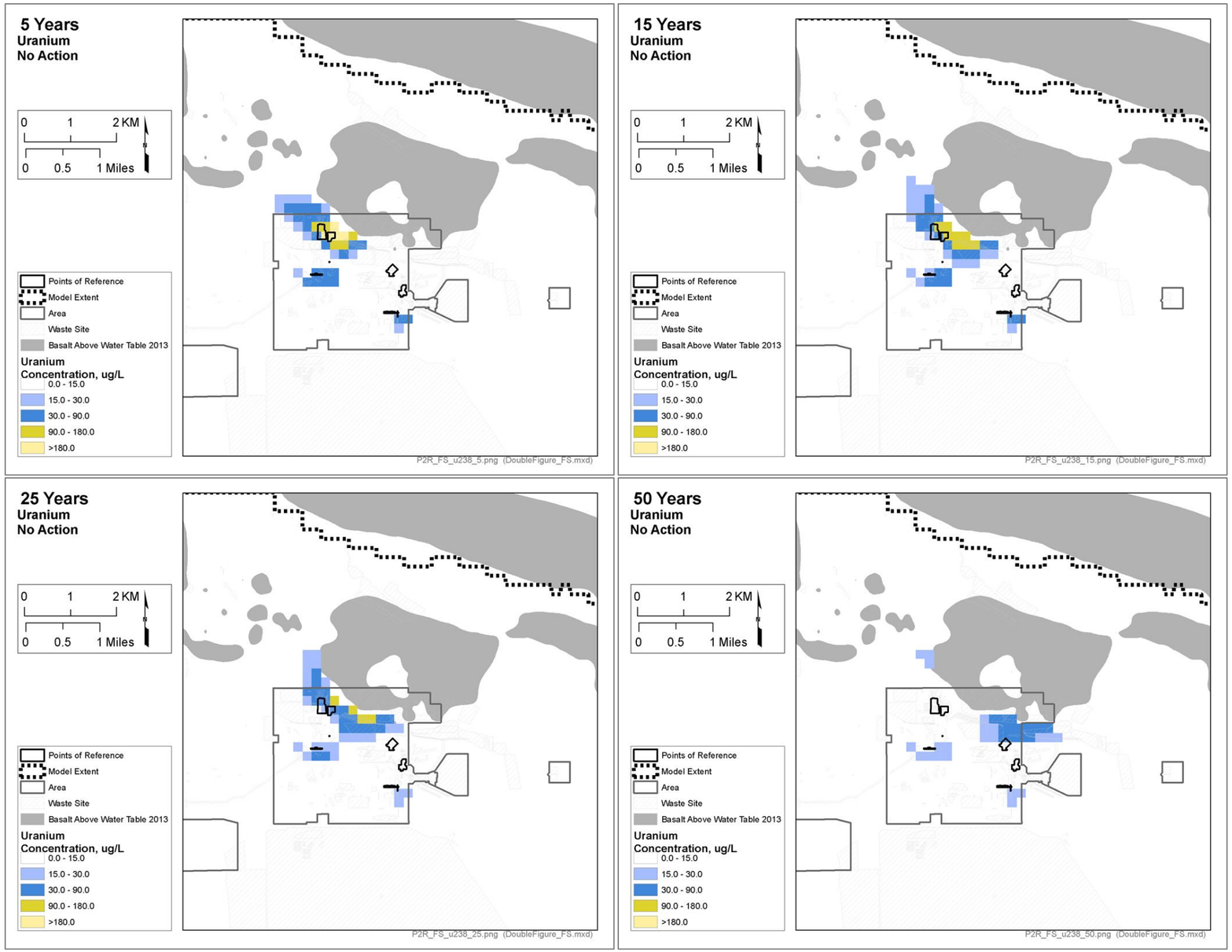
*Time for 95 UCL or C_{max} to decline and remain below the preliminary remediation goal. Cleanup times are predicted by modeling scenarios considering no continuing sources of the target contaminants from the vadose zone to groundwater. While there is no continuing source in the Gable Gap area, there are known sources in the B Complex and C Farm areas. Consequently, although not evident from the cleanup times shown in this table, there is value to implementing pump and treat in the C Farm and A-AX Farms area under Alternatives 2 and 3 (compared to Alternative 1 [No Action]) for minimizing the size of the technetium-99 dissolved-phase plume because the source area continues to contribute technetium-99 to groundwater.

95 UCL = 95th percentile upper confidence limit

C_{max} = maximum concentration

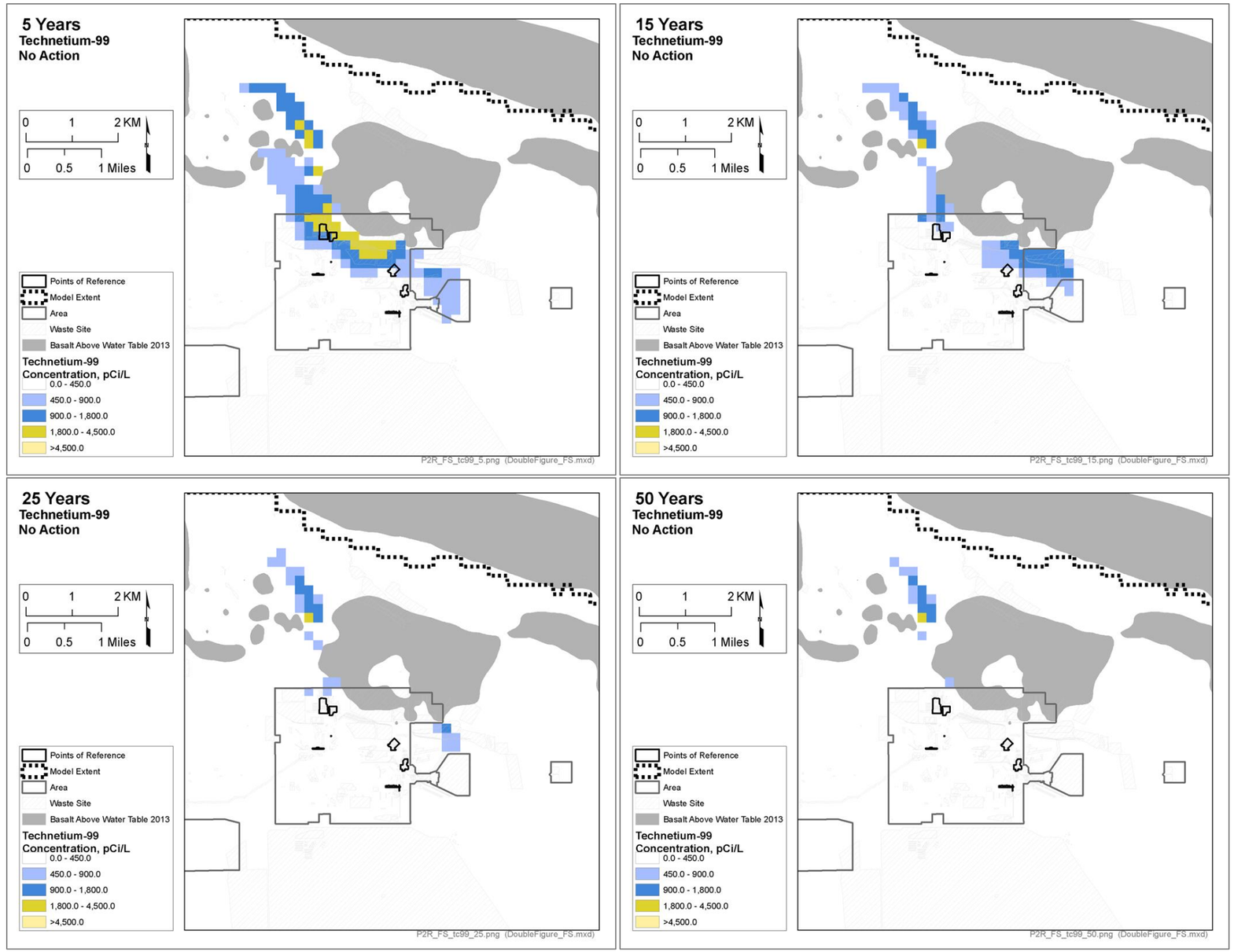
Alternative 1 – No Action (0 gal/min). Results of modeling for this scenario are shown as a series of plume maps through year 50 for uranium and technetium-99 in Figures 5-5 and 5-6, respectively. The results for uranium (Figure 5-5) show that the B Complex plume migrates toward the east-southeast, but concentrations remain above the 30 µg/L PRG at year 50. The technetium-99 plumes (Figure 5-6) decline to below the 900 pCi/L PRG within 50 years, except for the plume at Gable Gap. The results for each subregion are summarized as follows:

- **B Complex:** Uranium and technetium-99 are projected to require >50 years and 17 years, respectively, to reach respective PRGs based on the 95 UCL and >50 and 25 years based on C_{max}.
- **C Farm and A-AX Farms:** The technetium-99 PRG is projected to be achieved within 5 years based on both the 95 UCL and C_{max}.



Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-5. Alternative 1 (No Action) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources



Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-6. Alternative 1 (No Action) Technetium-99 Plume at Years 5, 15, 25, and 50 with No Continuing Sources

- **Gable Gap:** Technetium-99 is projected to require >50 years to reach the PRG based on both the 95 UCL and C_{max} (note that modeling performed for the 200-BP-5 OU RI [DOE/RL-2009-127] indicated that the technetium-99 plume in Gable Gap might take 800 years to clean up through natural attenuation processes). The projected cleanup timeframe for uranium in this area is 25 years based on the C_{max} (the 95 UCL is below the PRG at the start of the simulation); however, uranium concentrations generally do not exceed the PRG in most of Gable Gap. The uranium in the southern part of this area is part of the B Complex plume.

Alternative 2 (B Complex, C Farm and A-AX Farms, 300 gal/min). This scenario simulated operation of extraction wells at the B Complex and at the C Farm and A-AX Farms area at a total flow rate of 1,135 L/min (300 gal/min). Simulated plume maps are shown in Figures 5-7 and 5-8 for uranium and technetium-99, respectively. Projected cleanup times based on the 95 UCL and C_{max} are estimated to be as follows:

- **B Complex:** The projected cleanup times for uranium and technetium-99 are 28 and 7 years, respectively, based on the 95 UCL concentration; and 29 and 7 years, respectively, based on C_{max}.

- **C Farm and A-AX Farms:** Technetium-99 concentrations are projected to reach the PRG within 5 years based on both the 95 UCL and C_{max}. This scenario indicates that P&T does not result in a faster cleanup timeframe for technetium-99 in the C Farm and A-AX Farms area compared to Alternative 1 (No Action). This is because operation of the extraction wells causes a downgradient stagnation zone to develop and slow the groundwater flow rate, which in turn slows the dispersion of the plume in that area. However, this does not indicate that extraction well operation is not effective. The No Action scenario (Alternative 1) indicated that the plume in the aquifer would disperse to below the PRG within 5 years, assuming no further contributions of contaminant mass from the vadose zone. However, the plume is expected to persist for longer because C Farm is a known source of technetium-99 contamination (see Section 5.1.1.4). A P&T system in the C Farm and A-AX Farms area would remove contaminant mass from the aquifer and capture arriving mass from the vadose zone not considered as part of Scenario 1. This objective is not reflected in the time to cleanup metric but indicates the benefit of operating a P&T system in this area.

- **Gable Gap:** Because an active remedy was not simulated under this alternative for the Gable Gap area, the projected cleanup timeframe for technetium-99 is essentially the same as for the no action scenario (Alternative 1), which is >50 years based on both the 95 UCL and C_{max}.

Alternative 3 (B Complex, C Farm and A-AX Farms, Gable Gap, 400 gal/min). This scenario is the same as the previous scenario, except extraction and injection wells are operated in Gable Gap. The total extraction well flow rate for this scenario is 1,540 L/min (400 gal/min), and the projected plume maps are shown in Figures 5-9 and 5-10 for uranium and technetium-99, respectively.

- **B Complex:** The projected cleanup times for uranium and technetium-99 are 22 and 5 years, respectively, based on the 95 UCL concentration; and 23 and 6 years, respectively, based on C_{max}. These are slightly less than when pumping in Gable Gap was not included (Alternative 2), indicating that operation of injection wells in Gable Gap has a slight beneficial hydraulic effect on mass removal in the B Complex area.

- **C Farm and A-AX Farms:** Technetium-99 concentrations are projected to reach the PRG within 5 years based on both the 95 UCL and C_{max}, which is the same as Alternative 2.

- **Gable Gap:** The projected cleanup time for technetium-99 is 10 years based on the 95 UCL concentration and 19 years based on C_{max}.

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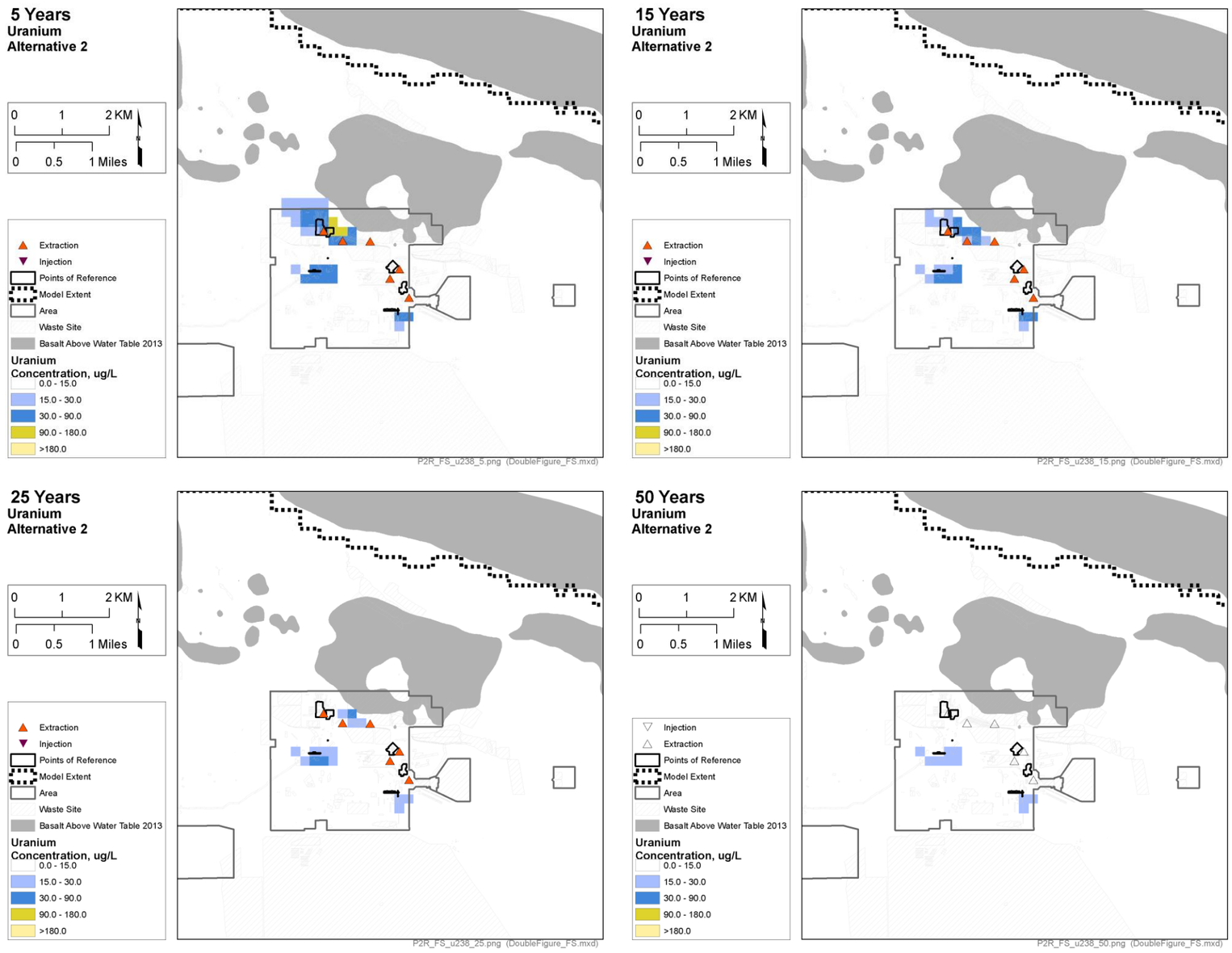
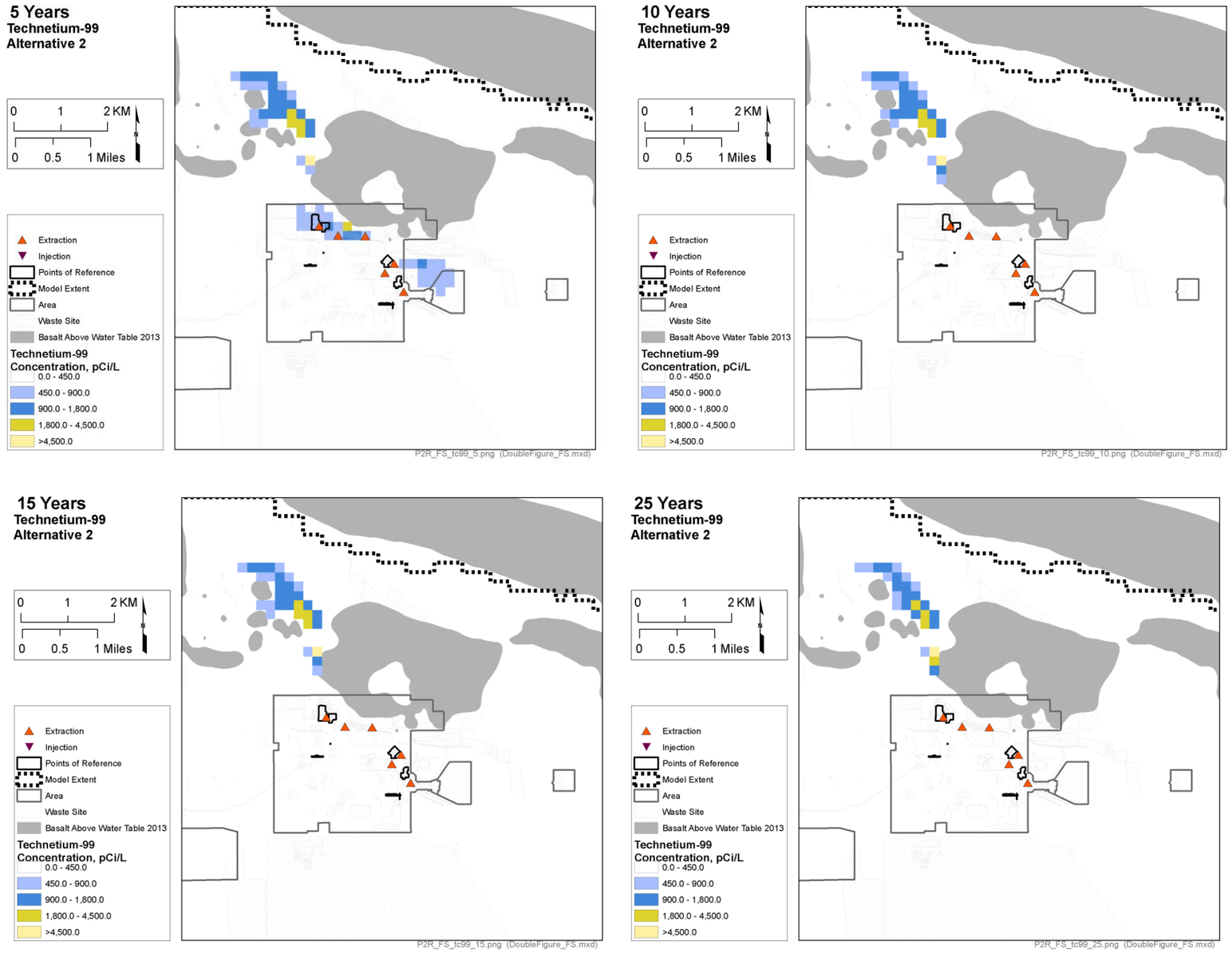


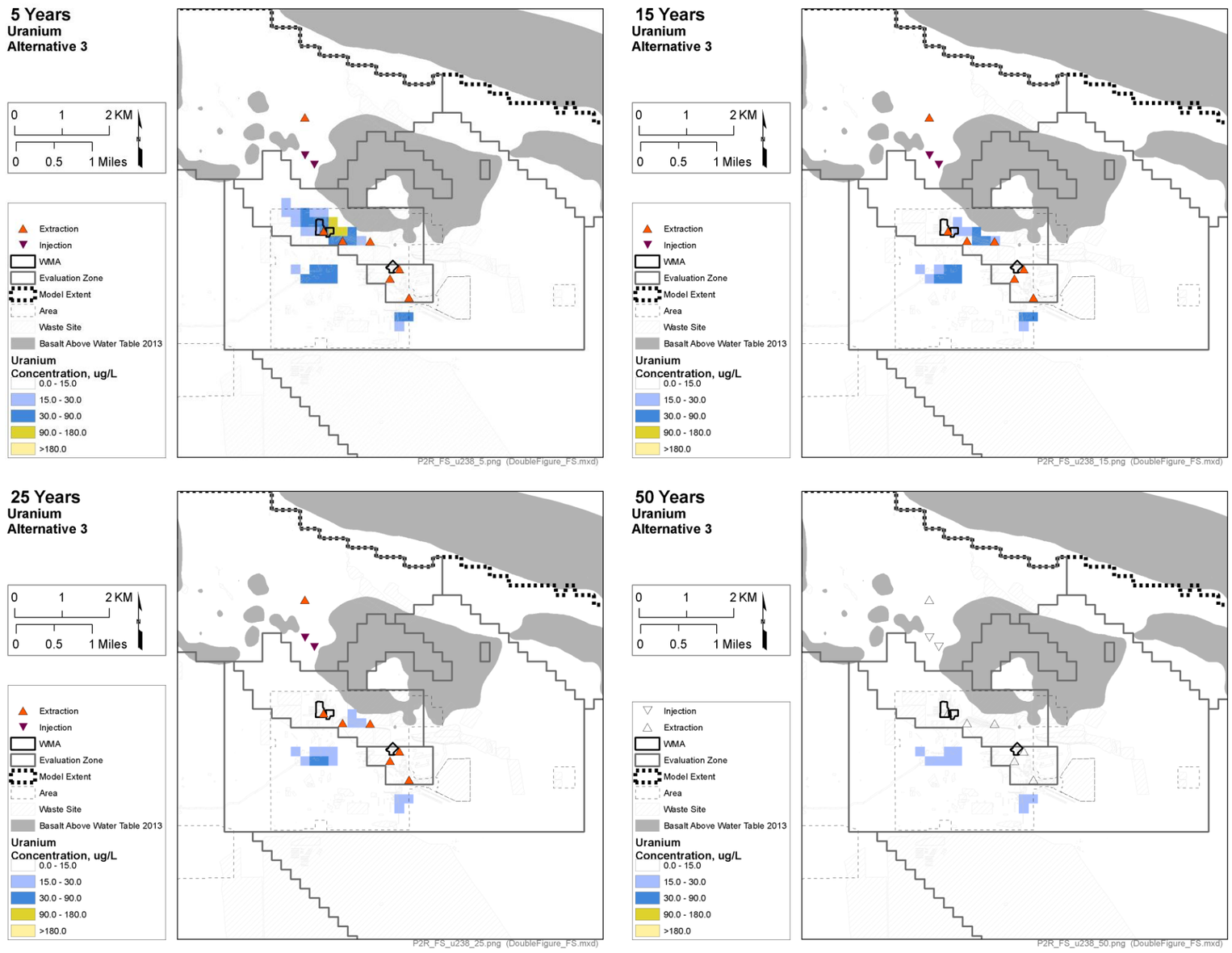
Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-7. Alternative 2 (B Complex, C Farm and A-AX Farms, 300 gal/min) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources



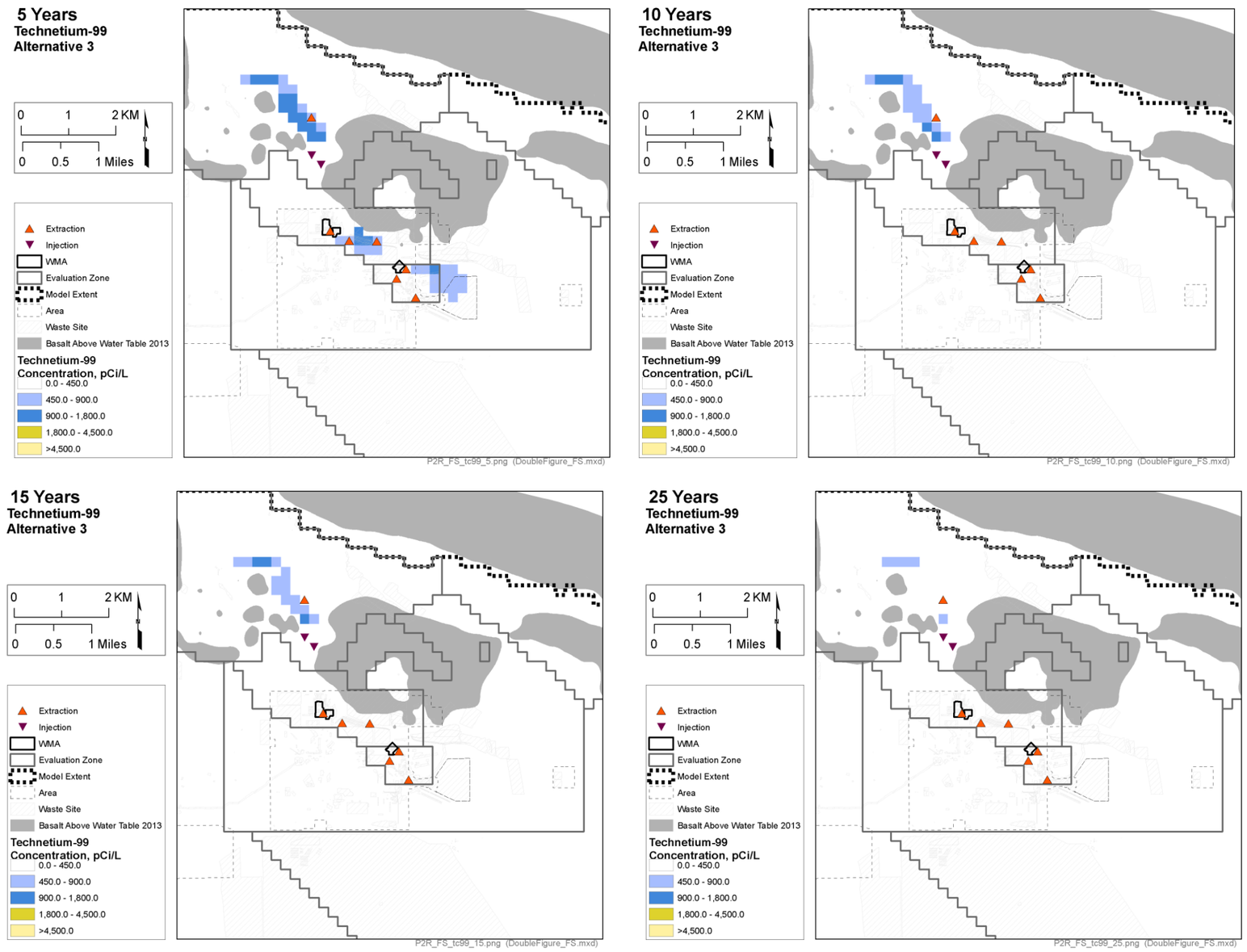
Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial* Alternatives (included in Appendix A of this feasibility study).

Figure 5-8. Alternative 2 (B Complex, C Farm and A-AX Farms, 300 gal/min) Technetium-99 Plume at Years 5, 10, 15, and 25 with No Continuing Sources



Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-9. Alternative 3 (B Complex, C Farm and A-AX Farms, Gable Gap, 400 gal/min) Uranium Plume at Years 5, 15, 25, and 50 with No Continuing Sources



Source: ECF-HANFORD-18-0023, *Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives* (included in Appendix A of this feasibility study).

Figure 5-10. Alternative 3 (B Complex, C Farm and A-AX Farms, Gable Gap, 400 gal/min) Technetium-99 Plume at Years 5, 10, 15, and 25 with No Continuing Sources

5.1.1.4 Simulations with a Continuing Source

The modeling results discussed above assume no continuing sources of uranium and technetium-99 to groundwater. Based on source-term information presented in ECF-HANFORD-13-0037, two areas within the 200 East Area have been identified where continuing sources, if not remediated, are likely to release contaminants from the vadose zone into the 200-BP-5 OU in the foreseeable future. These two sources include the B Complex (B-BX-BY Tank Farms and BY Cribs) (uranium and technetium-99) and the C Farm (technetium-99). Gable Gap does not have a continuing source. It should be noted that these vadose zone sources are not part of the 200-BP-5 or 200-PO-1 OUs. The mass/activity continuing source release rates recommended in ECF-HANFORD-13-0037 for uranium and technetium-99 were included in the modeling scenarios performed with a continuing source term.

The continuing source modeling results indicate that, without source remediation, contamination in groundwater beneath the B Complex and the C Farm and A-AX Farms area will remain at concentrations above the PRGs for >50 years. After existing groundwater contamination is remediated, groundwater plumes may re-form unless the sources are remediated or groundwater near the source areas is hydraulically contained. Figures 5-11 and 5-12 provide examples of the uranium and technetium-99 plumes, respectively, for year 50 for Alternative 2 (which included groundwater extraction and injection in Gable Gap, and simulated the highest total flow rate for the P&T systems) with continuing sources. These examples indicate that extraction wells operating in the 200-BP-5 OU for hydraulic containment of continuing sources may need to continue longer than the planned 25-year operating period for the 200 West P&T. However, estimates of future releases from sources to groundwater are uncertain. Thus, estimates of future plume conditions from ongoing sources are uncertain and should be regarded as only an indication of the potential for future groundwater contamination.

As described in Section 1.2, work is proceeding toward closure of WMA C (C Farm), and integrating this activity with the 200-BP-5 OU interim action will need to continue. The WMA C leak assessments performed for the closure activity indicate that estimates of technetium-99 inventory released to groundwater (as well as the current release rate) are in good agreement with values used in the modeling performed for this interim remedial action. The modeling will be updated in the future to support the RD/RAWP, as well as optimization of the remedy throughout its lifecycle, and refined release rates and inventories will be used. When operation of the P&T system has reduced the size of the technetium-99 plume, the focus of P&T will shift to hydraulic containment of the source to prevent plume redevelopment. This is expected to continue until WMA C is closed or until release rates decline to acceptable levels.

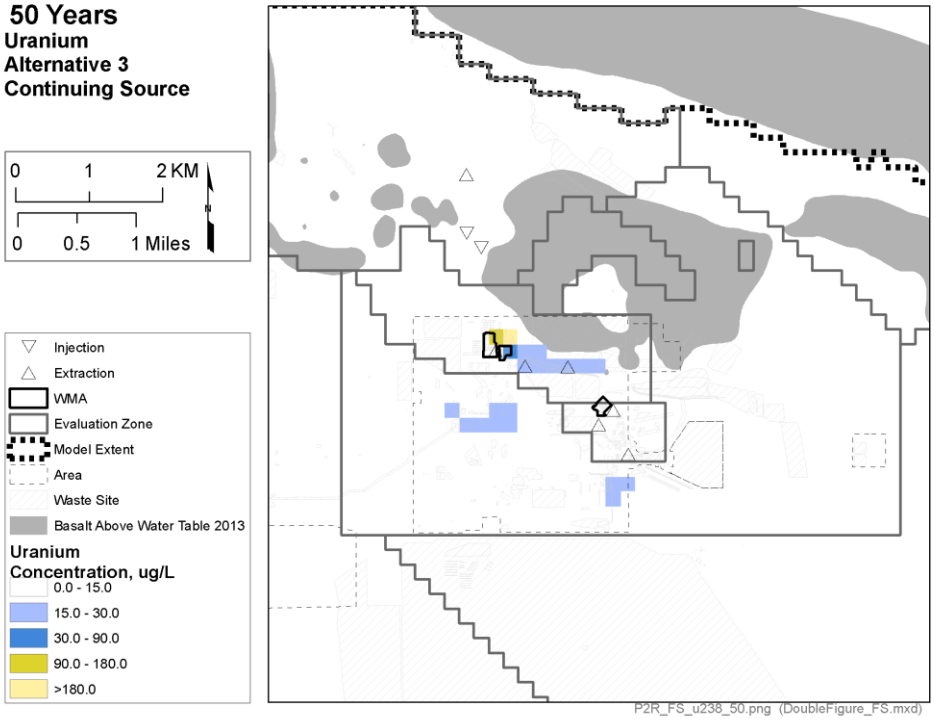


Figure 5-11. Uranium Plume at Year 50 for Alternative 2 (B Complex, C Farm and A-AX Farms, Gable Gap, 400 gal/min) with Continuing Sources

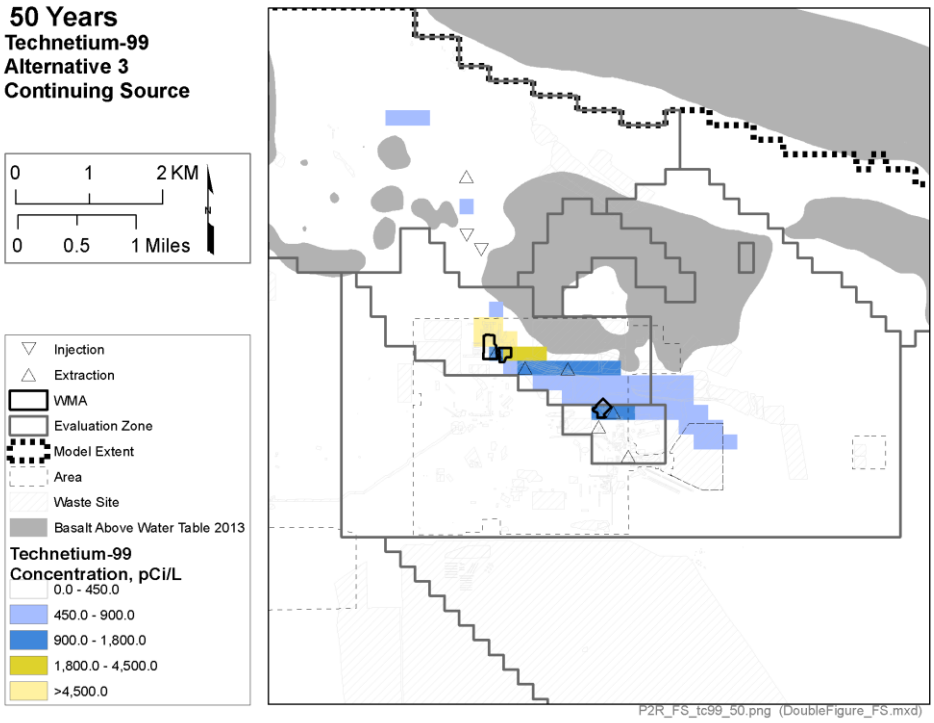


Figure 5-12. Technetium-99 Plume at Year 50 for Alternative 2 (B Complex, C Farm and A-AX Farms, Gable Gap, 400 gal/min) with Continuing Sources

5.2 Description of Remedial Alternatives

The remedial technologies retained from screening (discussed in Section 4.2) were used in combination with groundwater modeling to assemble the following three groundwater remedial alternatives for interim action at the 200-BP-5 and 200-PO-1 OUs:

- Alternative 1 – No Action
- Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms
- Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

In general, the P&T durations specified for Alternatives 2 and 3 are based on the predicted cleanup times, the 95 UCL concentrations, and the corresponding modeling scenarios (Table 5-2) rounded up to the nearest 5 years. The following sections present additional information on the components of each alternative.

5.2.1 Alternative 1 – No Action

The NCP (40 CFR 300.430(e)(6)) requires consideration of a No Action alternative. The No Action alternative serves as a baseline for evaluating other remedial alternatives and is generally retained throughout the FS process. “No action” means that no further remediation would be implemented to alter the existing groundwater conditions, although natural attenuation processes would still occur. For the No Action alternative, it is assumed that all site remedial activities and interim actions (e.g., P&T currently being performed as a NTCRA at the B Complex) would be discontinued. The Alternative 1 modeling results correspond with this alternative.

5.2.2 Alternative 2 – Pump and Treat at B Complex, and C Farm and A-AX Farms

Alternative 2 includes up to 25 years of P&T to capture and remove uranium and technetium-99 from groundwater beneath the B Complex, and up to 10 years of P&T to capture and remove technetium-99 from groundwater beneath the C Farm and the A-AX Farms. This alternative also includes ICs to prevent exposure to contaminated groundwater until PRGs are achieved, and monitoring to evaluate remedy performance.

5.2.2.1 Institutional Controls

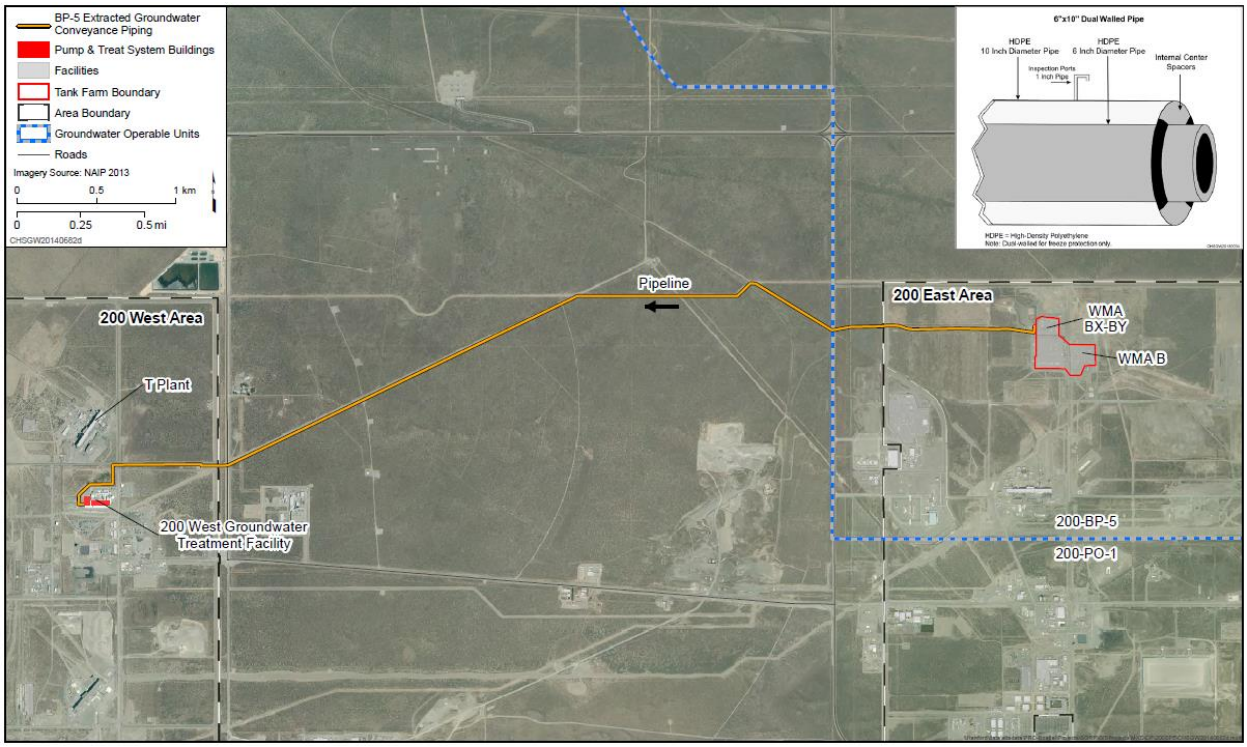
Alternative 2 (and Alternative 3) include ICs. Existing ICs and other measures that place controls on land use and groundwater use to prevent exposure are defined and further discussed in Section 4.2.1.2 and Table 4-3 of this FS. ICs are currently in place to protect workers and control site access, and ICs will be maintained during remedial actions until the PRGs are achieved.

Programs are in place to control access and specific uses of the Hanford Site that are protective of human health and the environment by limiting potential exposure to hazardous substances. Many of these multipurpose and programmatic controls were put in place under previous CERCLA RODs. The programmatic controls include site access; personnel badging; warning signs; maintaining a Sitewide ICs plan (DOE/RL-2001-41); implementing controls for excavating soil, and accessing and using groundwater; and implementing irrigation restrictions where necessary. While these controls transcend any specific CERCLA ROD or even the overall CERCLA cleanup, the Tri-Parties recognize the importance of maintaining these controls until unrestricted use conditions are achieved.

5.2.2.2 Non-Time-Critical Removal Action Transition to Interim Action

A NTCRA primarily targeting uranium, technetium-99, and nitrate through P&T of groundwater is currently underway in the B Complex area (DOE/RL-2016-41). The NTCRA P&T would be continued to capture and remove uranium and technetium-99 as a component of Alternative 2 (and Alternative 3) for the interim action.

The NTCRA P&T system extracts groundwater from the aquifer beneath the B Complex via two extraction wells (299-E33-360 and 299-E33-361). The extracted groundwater is combined with a relatively small amount of extracted perched water from the 200-DV-1 OU in a transfer tank, and then blended water is pumped via a cross-site aboveground pipeline to the existing 200 West P&T (Figure 5-13). Treated water generated by the NTCRA P&T system is reinjected in the 200 West Area.



Source: DOE/RL-2017-11, *Removal Action Work Plan for the 200-BP-5 Operable Unit Groundwater Extraction*.

Figure 5-13. Existing Conveyance Pipeline from the 200 East Area to the 200 West P&T

5.2.2.3 Groundwater Extraction and Conveyance

The P&T system for Alternative 2, based on modeling, consists of two existing (NTCRA) and one new extraction well in the B Complex area, and three new extraction wells in the C Farm and A-AX Farms area. The total extraction rates in the B Complex and C Farm and A-AX Farms area are estimated to be 757 and 379 L/min (200 and 100 gal/min), respectively (Table 5-1). The total Alternative 2 pumping rate is 1,136 L/min (300 gal/min).

Extracted groundwater is conveyed from the extraction wells to the existing 200 West P&T for treatment. The conveyance system consists of the existing facilities used for the B Complex NTCRA, plus new wells and transfer pumps, piping, and tankage for the additional groundwater flow generated by Alternative 2. Extracted groundwater from the B Complex is segregated from the C Farm and A-AX Farms groundwater (i.e., conveyed to the 200 West P&T in a separate pipeline) because the B Complex groundwater requires treatment for uranium, whereas the C Farm and A-AX Farms groundwater does not.

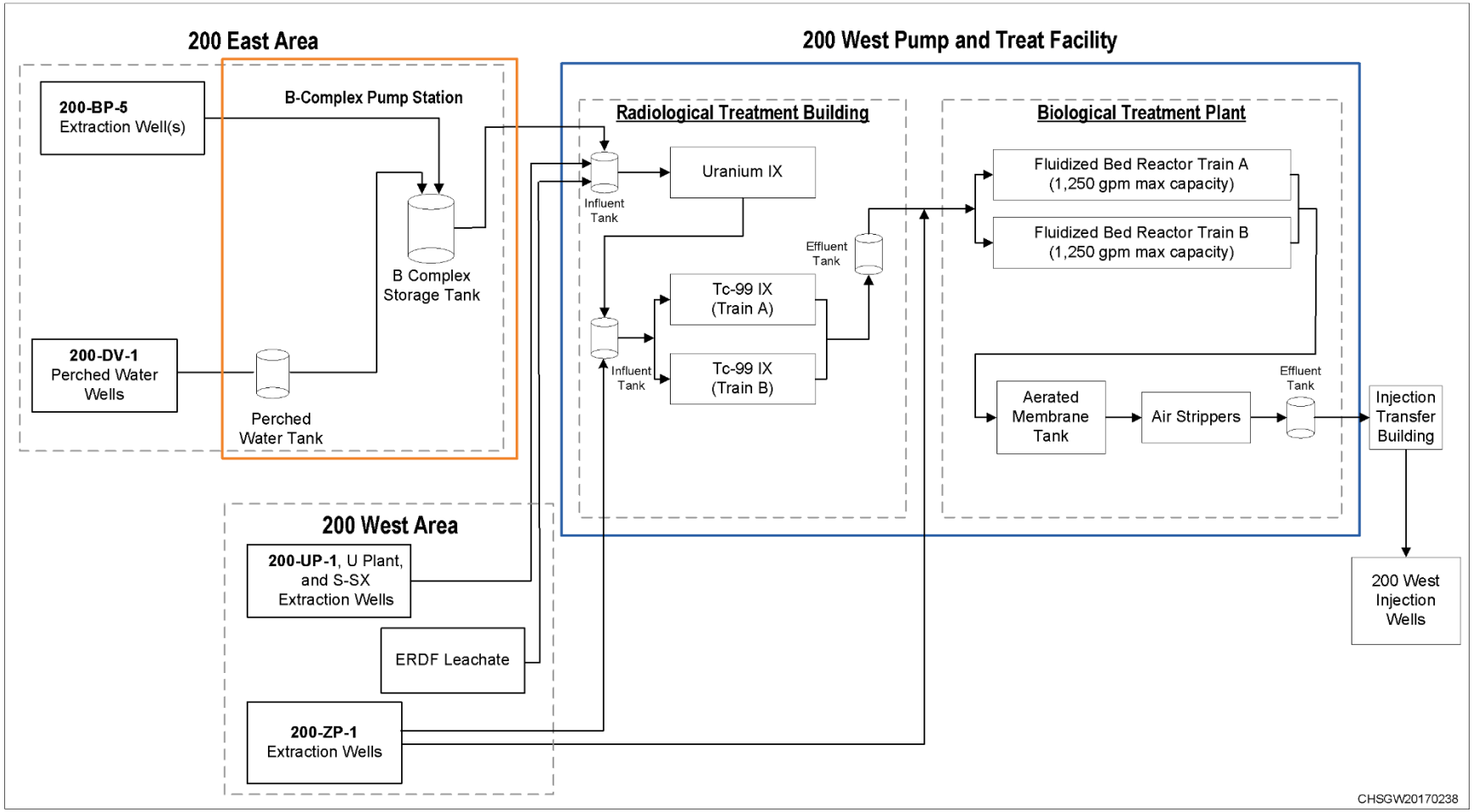
5.2.2.4 Groundwater Treatment

Ex situ treatment of groundwater is included in Alternative 2 (and Alternative 3) as a component of P&T. Groundwater extracted in Alternative 2 is conveyed to and treated by the existing 200 West P&T. The 200 West P&T is designed to treat 200-ZP-1 OU COCs (carbon tetrachloride, total and hexavalent chromium, nitrate, trichloroethene, uranium, and technetium-99) (DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*), which include the target COCs for the 200-BP-5 and 200-PO-1 OUs interim action.

The 200 West P&T is located south of the T Plant area (Figure 5-13) and includes two main elements: (1) a radiological treatment system consisting of separate IX processes for removing uranium and technetium-99; and (2) a nonradiological (biological) treatment system consisting of biochemical and physical treatment processes for removing organic contaminants, nitrate, hexavalent chromium, and solids, as well as sludge management processes (Figure 5-14; Table 5-3). The biochemical processes consist of anoxic and aerobic biotreatment in fluidized bed reactor (FBR) and aerated membrane tank units (in series). Physical treatment processes include membrane filtration (as part of the aerated membrane tank system) and air stripping, as well as sludge dewatering.

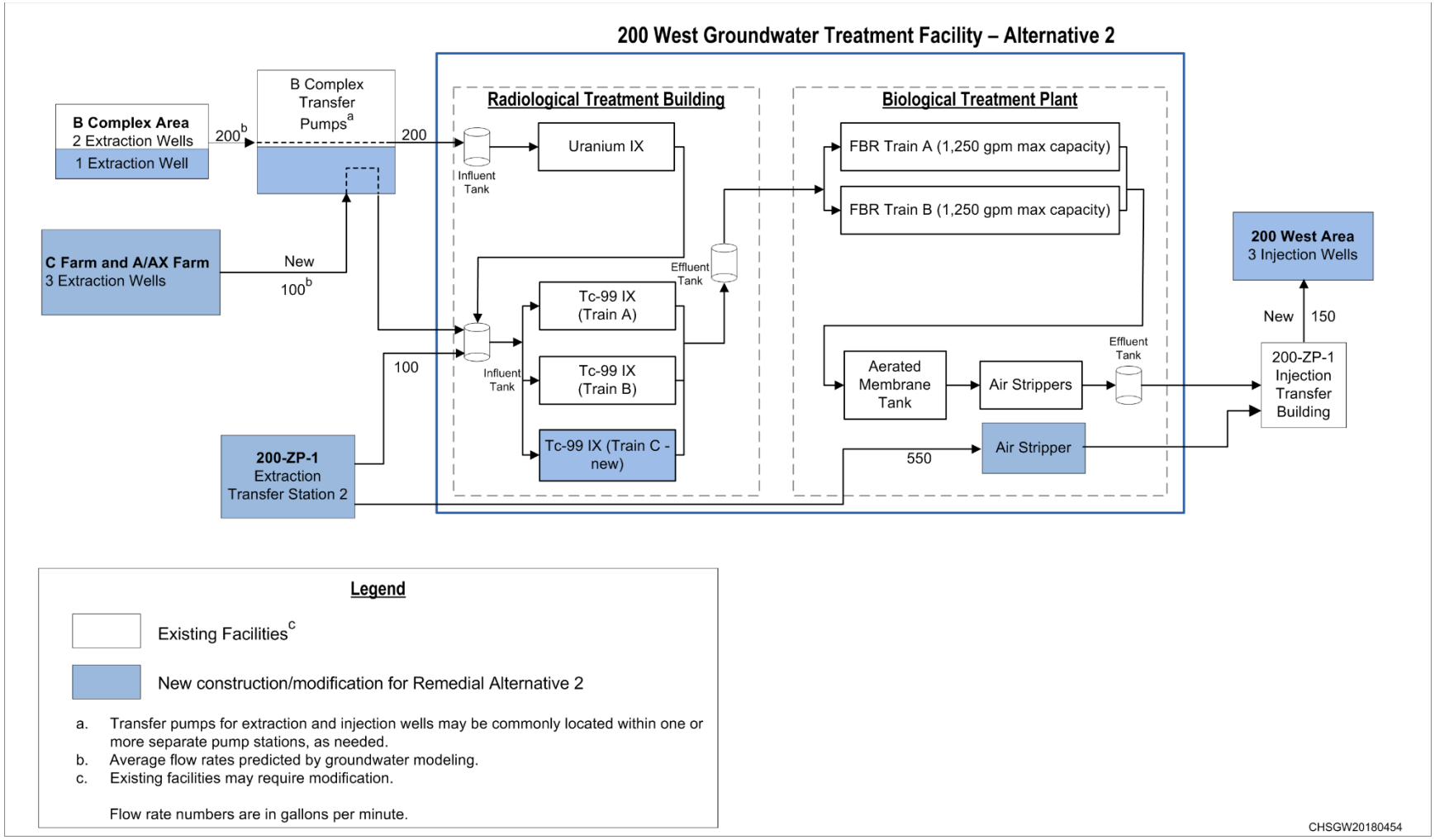
Extracted groundwater from the B Complex will contain uranium and technetium-99 in concentrations exceeding their PRGs; therefore, the groundwater will require treatment by both the uranium and technetium-99 IX processes at the 200 West P&T. In contrast, extracted groundwater from the C Farm and A-AX Farms area will contain elevated technetium-99 but will not contain uranium in concentrations exceeding the PRG. Therefore, the C Farm and A-AX Farms groundwater will not require treatment by the uranium IX system and can bypass the uranium IX process and be piped directly to the technetium-99 IX system (Figure 5-15). This flow routing will require separate pipelines and transfer pumps to keep the B Complex groundwater segregated from the C Farm and A-AX Farms groundwater. Following treatment for removal of uranium and technetium-99, all 200 East Area water will be treated in accordance with the 200 West P&T O&M plan (DOE/RL-2009-124).

Treatment of the additional water generated under this alternative (568 L/min [150 gal/min] above the current flow rate generated by the B Complex NTCRA) would require expansion of the radiological treatment system at the 200 West P&T by adding a new (third) technetium-99 IX train. Also, to accommodate the additional flow generated by this alternative in the biological (nonradiological) treatment portion of the 200 West P&T (for co-contaminant treatment), a new air stripper system would be added to allow 200-ZP-1 OU groundwater to be bypassed around the biological treatment processes for stripping of volatile organic compounds.



Note: Modified from DOE/RL-2017-11, *Removal Action Work Plan for the 200-BP-5 Operable Unit Groundwater Extraction*.

Figure 5-14. Block Flow Diagram of the Existing 200 West P&T



Note: Influent flows from other operable units are not shown.

Figure 5-15. Block Flow Diagram of the 200 West P&T with Alternative 2 Flows

Table 5-3. 200 West P&T Processes for 200-BP-5 and 200-PO-1 OU Target COCs and Co-Contaminants

Unit Process	Process Benefit	Targeted Parameter
Ion exchange	Removal of technetium-99 and uranium	Technetium-99 Uranium Ferrocyanide
Anoxic/anaerobic biodegradation	Biologically mediated reduction of target parameters	Nitrate Cyanide (total and free)
Air stripping	Removal of volatile organic compounds	Free cyanide

Reference: DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan*.

5.2.2.5 Groundwater Injection

Onsite discharge of treated water via injection into the saturated zone through vertical wells is included in Alternative 2 (and Alternative 3) as a component of P&T. The groundwater injection system will consist of existing and new wells, transfer pumps, and conveyance piping. In addition to discharging treated water, injection may be used to balance groundwater withdrawals to maintain a neutral water balance in the aquifer and/or to accelerate capture and removal of contaminant mass to decrease cleanup times. Alternative 2 includes new groundwater injection wells in the 200 West Area.

Under Alternative 2, three new vertical injection wells for reinjecting treated water in the 200 West Area would be required for the additional 570 L/min (150 gal/min) of groundwater flow from P&T. This additional flow is the portion of the total extracted flow (1,140 L/min [300 gal/min]) in excess of the 570 L/min (150 gal/min) currently being injected in the 200 West Area under the B Complex NTCRA P&T operation. The existing 200 West P&T treated water reinjection transfer station has sufficient surplus capacity to accommodate this additional flow.

5.2.2.6 Operations and Maintenance

The O&M for the P&T system is included in Alternative 2 (and Alternative 3). O&M activities include operation, inspection, and maintenance of wells, pumps, pipelines, and treatment facilities; optimization of extraction/injection well pumping; and periodic replacement of equipment and IX media.

5.2.2.7 Remedy Performance Monitoring

Performance monitoring is included in Alternative 2 (and Alternative 3) to evaluate the effectiveness of P&T to attain the PRGs for uranium and technetium-99 in the remediation target areas, and to achieve the interim action objectives and the RAO. Co-contaminant concentrations would also be monitored to support future remedy decisions. Detailed information on the performance monitoring program will be developed as part of the remedial design process.

Existing groundwater monitoring wells installed with the objective of defining the nature and extent of contamination may not be sufficient to evaluate interim action performance. For FS remedial alternative development purposes, it is assumed that four new monitoring wells would be installed under Alternative 2 (two each in the B Complex and the C Farm and A-AX Farms area).

Table 5-4 summarizes the key elements and assumptions for Alternative 2 that were used for cost estimating.

Table 5-4. Alternative 2 Components and Assumptions

Item	Location (Area)	Number of Wells/Pump Stations	Well Identification	Pumping Rate	
				L/min	gal/min
Extraction and Injection Wells					
Existing extraction wells	B Complex	2	299-E33-360 299-E33-361	189 284	50 75
New extraction wells	B Complex	1	BC_E_1	284	75
	C/A-AX Farms	3	WC_E_1 WC_E_2 WC_E_3	126 126 126	33.3 33.3 33.3
New injection wells	200 West	3	TBD TBD TBD	284 284 284	50 50 50
Extraction and Injection Water Pump Stations[a]					
Existing B Complex extraction water pump station	B Complex	1	Convey B Complex extraction water to 200 West P&T[b]	757	200
New C Farm extraction water pump station	C Farm	1	Convey C/A-AX Farms extraction water to 200 West P&T[c]	379	100
Extracted Groundwater Treatment at the 200 West P&T					
Item	**Description**				
P&T facility modifications	A new (third) technetium-99 IX train, and a new (third) air stripper are required.				
Operations and Maintenance					
Operations and maintenance duration	B Complex: 25 years C Farm and A-AX Farms: 10 years Gable Gap: not applicable				

a. The 200 West P&T treated water reinjection transfer station has sufficient capacity to accommodate the additional flow created by Alternative 2.

b. The existing B Complex pump station and cross-site pipeline can accommodate the additional 189 L/min (50 gal/min) flow rate generated by this Alternative 2 (above the 568 L/min [150 gal/min] currently conveyed by the non-time-critical removal action P&T system).

c. It is assumed that the existing, installed, spare cross-site pipeline will be used to convey the C Farm and A-AX Farms groundwater to the 200 West P&T.

P&T = pump and treat

TBD = to be determined

5.2.3 Alternative 3 – Pump and Treat at B Complex, C Farm and A-AX Farms, and Gable Gap

Alternative 3 includes up to 25 years of P&T to capture and remove uranium and technetium-99 from groundwater beneath the B Complex, and up to 10 years of P&T to capture and remove technetium-99 from groundwater beneath the C Farm and A-AX Farms and the Gable Gap remediation target areas. This alternative also includes ICs to prevent exposure to contaminated groundwater until PRGs are achieved, as well as monitoring to evaluate remedy performance.

5.2.3.1 Institutional Controls

The ICs for Alternative 3 are essentially the same as for Alternative 2, except Alternative 3 has a larger remediation footprint where ICs would need to be implemented.

5.2.3.2 Non-Time-Critical Removal Action Transition to Interim Action

The transition of the B Complex NTCRA P&T system to interim action under Alternative 3 is the same as for Alternative 2.

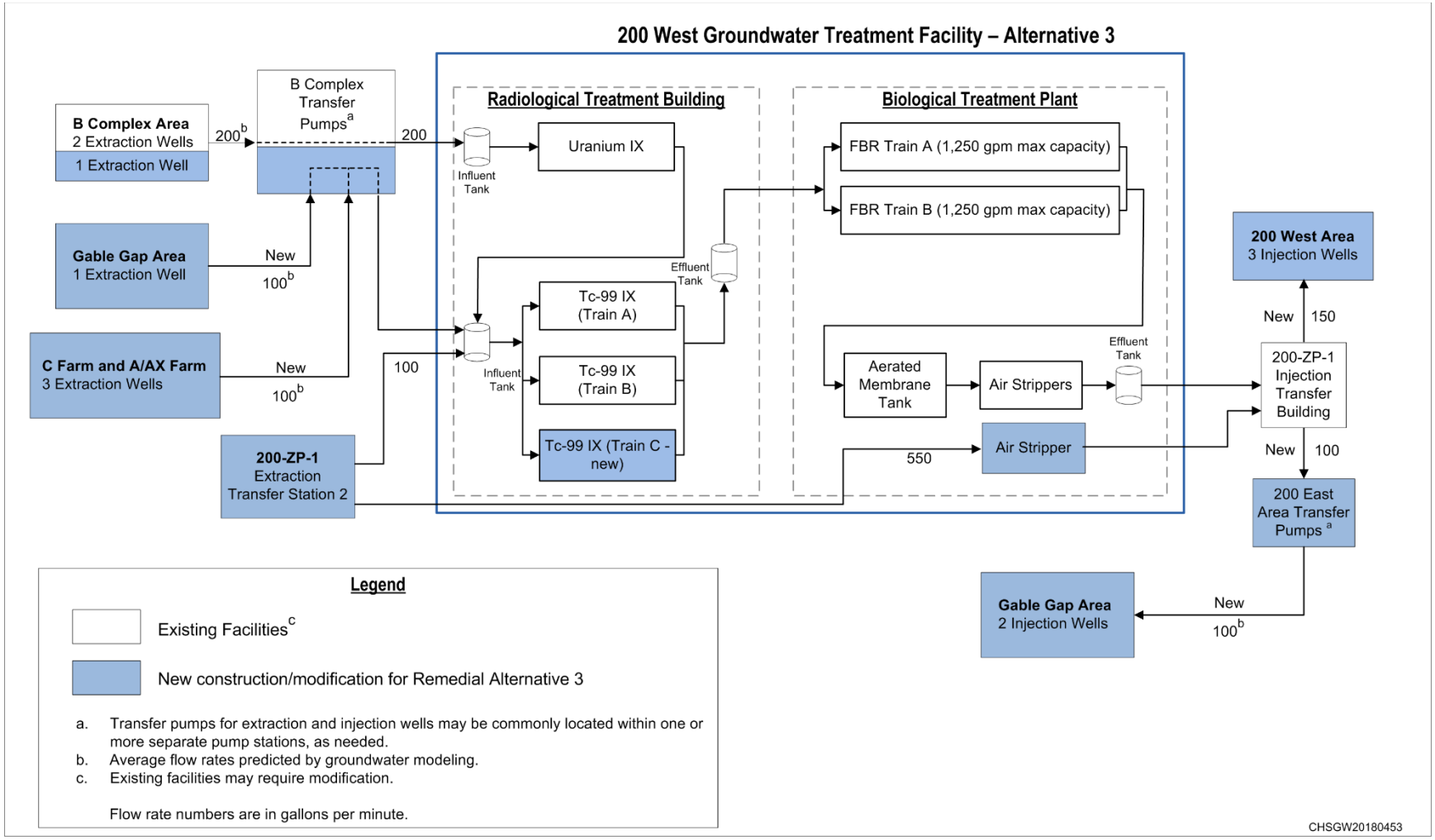
5.2.3.3 Groundwater Extraction and Conveyance

The P&T system for Alternative 3 (based on modeling) consists of two existing and one new extraction well in the B Complex area, three new extraction wells in the C Farm and A-AX Farms area, and one new extraction well in the Gable Gap area. The total extraction rates in the B Complex, C Farm and A-AX Farms, and Gable Gap are 757 L/min (200 gal/min), 379 L/min (100 gal/min), and 379 L/min (100 gal/min), respectively (Table 5-1). The total extraction pumping rate for Alternative 3 is 1,514 L/min (400 gal/min).

Extracted groundwater is conveyed to the existing 200 West P&T for treatment. The conveyance system consists of the existing facilities used for the B Complex NTCRA, plus new transfer pumps, piping, and tankage for the additional groundwater flow generated by Alternative 3. Extracted groundwater from the B Complex is kept segregated from the C Farm and A-AX Farms and Gable Gap groundwater (i.e., conveyed to the 200 West P&T in a separate pipeline) because the B Complex groundwater requires treatment for uranium, whereas the C Farm and A-AX Farms and Gable Gap groundwater does not. A new pipeline is also needed to convey extracted groundwater from Gable Gap to the B Complex transfer station.

5.2.3.4 Groundwater Treatment

As with Alternative 2, groundwater extracted under Alternative 3 would be treated at the existing 200 West P&T. As with Alternative 2, treatment of the additional water generated under Alternative 3 (946 L/min [250 gal/min]) would require expansion of the 200 West P&T by adding a new (third) technetium-99 IX train and a new (third) air stripper system (to allow 200-ZP-1 OU groundwater to be bypassed around the biological treatment processes for stripping of volatile organic compounds, and free up capacity in those systems to accommodate the Alternative 3 flow) (Figure 5-16).



Note: Influent flows from other operable units are not shown.

Figure 5-16. Block Flow Diagram of the 200 West P&T with Alternative 3 Flows

5.2.3.5 Groundwater Injection

Under Alternative 3, treated effluent would be injected in the 200 West Area (similar to Alternative 2) and a portion of the treated water would be injected into the Gable Gap area to accelerate technetium-99 remediation.[8] A new transfer station and pipeline would be used to return 379 L/min (100 gal/min) of treated effluent to Gable Gap for injection into two new vertical injection wells. Injection in the 200 West Area would use a combination of the existing injection system and three new vertical injection wells constructed to accommodate the balance of the Alternative 3 flow rate.

5.2.3.6 Operations and Maintenance

The O&M for the P&T system under Alternative 3 is very similar to that for Alternative 2, except Alternative 3 has a higher total flow rate and extraction and injection in Gable Gap, as well as additional wells, pipelines, and pumping requirements.

5.2.3.7 Remedy Performance Monitoring

Performance monitoring under Alternative 3 is similar to that for Alternative 2, except for the larger total remediation area requiring monitoring (including the Gable Gap area, which is not addressed by Alternative 2) and a greater number of monitoring wells. Detailed information on the performance monitoring program will be developed as part of the remedial design process. For FS remedial alternative development purposes, it is assumed that eight new monitoring wells would be installed under Alternative 3: two each in the B Complex and in the C Farm and A-AX Farms, and four in Gable Gap. Table 5-5 summarizes the key elements and assumptions for Alternative 3 that were used in cost estimating.

Table 5-5. Alternative 3 Components and Assumptions

Item	Location (Area)	Number of Well/Pump Stations	Well Identification	Pumping Rate	
				L/min	gal/min
Extraction and Injection Wells					
Existing extraction wells	B Complex	2	299-E33-360 299-E33-361	189 284	50 75
New extraction wells	B Complex	1	BC_E_1	284	75
	C/A-AX Farms	3	WC_E_1 WC_E_2 WC_E_3	126 126 126	33.3 33.3 33.3
	Gable Gap	1	GG_E_1	379	100
New injection wells	200 West	3	TBD TBD TBD	284 284 284	50 50 50
	Gable Gap	2	GG_I_1 GG_I_2	189 189	50 50

[8] An alternative source of clean water (e.g., river water) might be available for use for injection in Gable Gap under Alternative 3 (to avoid the long conveyance run) and will be evaluated further during the development of the RD/RAWP, if that alternative is selected.

Table 5-5. Alternative 3 Components and Assumptions

Item	Location (Area)	Number of Well/Pump Stations	Well Identification	Pumping Rate	
				L/min	gal/min
Extraction and Injection Water Pump Stations[a]					
Existing extraction water pump station	B Complex	1	Convey B Complex extracted groundwater to 200 West P&T[b]	757	200
New B Complex extraction water pump station	B Complex	1	Convey C/A-AX Farms and Gable Gap extracted groundwater to 200 West P&T[c]	757	200
New 200 East Area pump station	200 West P&T	1	Convey treated effluent to new Gable Gap IWs	379	100
Extracted Groundwater Treatment at the 200 West P&T					
Item	**Note**				
P&T facility modifications	A new (third) technetium-99 ion-exchange train and a new (third) air stripper are required.				
Operations and Maintenance					
Operations and maintenance duration	B Complex: 25 years C Farm and A-AX Farms: 10 years Gable Gap: 10 years				

a. The 200 West treated water reinjection transfer station has sufficient capacity to accommodate the additional flow (not reinjected in the 200 East Area) created by Alternative 3.

b. The existing B Complex pump station and pipeline could accommodate the additional 189 L/min (50 gal/min) generated by Alternative 3 (above the 568 L/min [150 gal/min] currently conveyed by the non-time-critical removal action P&T system).

c. It is assumed that the existing, installed, spare cross-site pipeline will be used to convey the C Farm and A-AX Farms and Gable Gap groundwater to the 200 West P&T.

P&T = pump and treat

5.3 Screening of Remedial Alternatives

As discussed in OSWER Directive 9355.3-01FS3, *The Feasibility Study: Development And Screening Of Remedial Action Alternatives*, each of the remedial alternatives developed in Section 5.2 of this FS were screened based on the CERCLA criteria of effectiveness, implementability, and cost. Effectiveness considers the ability of a remedial alternative to achieve the interim action objectives and RAOs; implementability considers the technical and administrative feasibility of implementing the alternative; and costs consider capital, annual O&M, and periodic O&M costs. The purpose of the alternative screening step is to reduce the number of alternatives carried forward for detailed and comparative analysis, if warranted. However, because only three alternatives were developed for the interim action considered in this FS, reducing the number of alternatives was not necessarily warranted.

5.3.1 Effectiveness

The groundwater modeling results provide an indication of the effectiveness for each alternative to achieve the interim action objectives in terms of cleanup times required for uranium and technetium-99 concentrations to decrease and remain below the PRGs. Alternative screening against the effectiveness

criterion is based on predicted cleanup times for the existing dissolved-phase plumes (i.e., without considering effects of a continuing source of contaminants from the vadose zone to groundwater). Figure 5-17 summarizes the predicted cleanup times for uranium and technetium-99 in the remediation target areas, assuming no continuing contaminant source. Observations regarding the effectiveness of Alternatives 2 and 3 are as follows:

- Alternatives 2 and 3 reduce the predicted cleanup time for uranium in the B Complex area substantially compared to the No Action alternative (Alternative 1). Groundwater extraction in Gable Gap under Alternative 3 results in shorter predicted cleanup times for uranium in the B Complex area than Alternative 2. Although the predicted cleanup time for uranium in the B Complex under Alternative 2 is slightly longer than 25 years (28 years based on 95 UCL concentrations) (Table 5-2), it is expected that this timeframe could be shortened to within 25 years by optimizing extraction well placement (during remedial design) and optimizing extraction well pumping.
- Alternatives 2 and 3 reduce the predicted cleanup time for technetium-99 in the B Complex area substantially compared to the No Action alternative (Alternative 1). Alternative 3 results in slightly a shorter cleanup time for technetium-99 in the B Complex than Alternative 2.
- Predicted cleanup times for technetium-99 in the C Farm and A-AX Farms area are very similar for Alternatives 1 through 3. Thus, modeling indicates that P&T under Alternatives 2 and 3 provides little or no improvement in cleanup time compared to No Action (Alternative 1). However, Alternatives 2 and 3 would provide substantial removal of technetium-99 mass from the groundwater aquifer.
- Alternative 3 substantially reduces the projected cleanup time for technetium-99 in the Gable Gap area compared to both Alternatives 1 and 2, as expected, since neither Alternative 1 or 2 addresses this area.
- Both Alternatives 2 and 3 achieve the RAO in that ICs prevent exposure to groundwater contaminants until compliance with PRGs/DWSs are achieved.

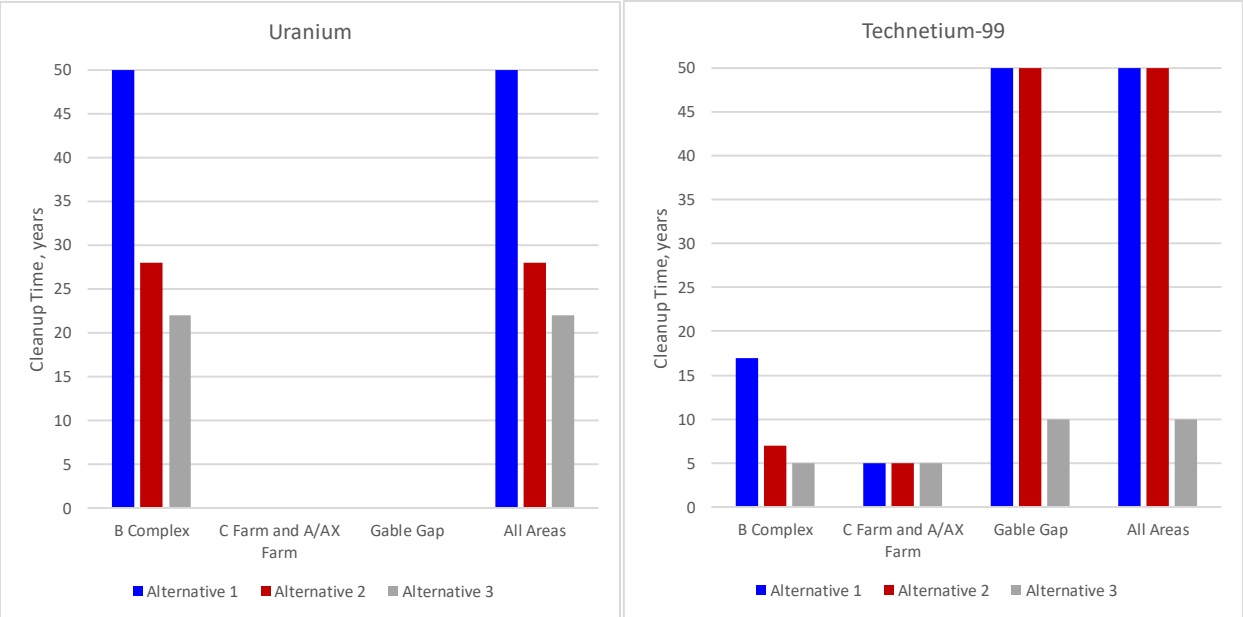
Neither Alternative 2 or 3 warrant being screening out based on effectiveness, and the No Action alternative is retained per CERCLA requirement.

5.3.2 Implementability

Alternatives 2 and 3 include groundwater P&T, which is well demonstrated and widely used at the Hanford Site for mobile contaminants, including the 200 West and 200 East Areas, with an existing groundwater treatment system (200 West P&T) that is currently operating. Groundwater alternatives using P&T technologies do not pose any significant technical or administrative challenges based on the hydrogeologic conditions and target COCs present in the 200-BP-5 and 200-PO-1 OUs.

Alternatives 2 and 3 would both require expansion of the 200 West P&T to add a new (third) technetium-99 IX train and a new (third) air stripper system (both well-demonstrated technologies used at the Hanford Site) to accommodate the additional water generated by those alternatives. The new air stripper would allow groundwater from the 200-ZP-1 OU to be bypassed around the biological treatment processes for stripping of volatile organic compounds, thereby creating capacity for biological treatment of 200-BP-5/200-PO-1 OU groundwater. Alternative 3 requires more new pipelines and transfer (pump) stations than Alternative 2.

No significant issues were identified that warrant screening out Alternative 2 or Alternative 3 based on the implementability criterion.



Note: Cleanup time bars shown as "50" indicate >50 years. Alternative 2 does not address the Gable Gap area.

Figure 5-17. Predicted Cleanup Times for Target COCs Based on 95 UCL Concentrations (No Continuing Source)

5.3.3 Cost

A feasibility-level cost estimate was developed for each alternative (Appendix B), and Table 5-6 summarizes the resulting estimates. The estimated total present value costs are approximately $199 million for Alternative 2 and $245 million for Alternative 3 (roughly 23% higher). Alternative 1 (no action) has no cost.

Considering there are only three alternatives for this FS, none of the alternatives warrant being screening out based on cost.

Table 5-6. Comparison of Remedial Alternative Cost Estimates

Cost Description	Alternative 1 – No Action	Alternative 2 – P&T at B Complex and C Farm and A-AX Farms	Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap
Capital cost	$0	$24,000,000	$37,800,000
Total annual O&M cost	$0	$183,000,000	$216,000,000
Periodic O&M cost	$0	$7,000,000	$8,100,000
Total nondiscounted cost	$0	$214,000,000	$261,000,000
Total present value cost	$0	$199,000,000	$245,000,000

Table 5-6. Comparison of Remedial Alternative Cost Estimates

Cost Description	Alternative 1 – No Action	Alternative 2 – P&T at B Complex and C Farm and A-AX Farms	Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap
Expected Accuracy Range: −30% to +50%			
−30%	$0	$139,000,000	$172,000,000
+50%	$0	$299,000,000	$368,000,000

Notes:

The estimates include the cost of expanding the 200 West P&T to accommodate the additional flows generated by Alternative 2 (568 L/min [150 gal/min]) or Alternative 3 (946 L/min [250 gal/min]). Modifications include changes to extraction treatment buildings, adding a third IX train in the radiological building, and adding a third air stripper in the biological treatment building. Interim remedy design requirements will be addressed in the remedial design/remedial action work plan.

Changes in the cost elements may occur as a result of new information and data collected during preparation of the remedial design/remedial action work plan or interim remedy design.

Present value of costs in future years discounted using standard rates from OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs."

Accuracy range selected is within the Class 5 feasibility estimate accuracy range identified in AACE International, 2011, *Cost Estimate Classification System, TCM Framework: 7.3 – Cost Estimating and Budgeting*.

O&M = operations and maintenance

P&T = pump and treat

5.3.4 Remedial Alternative Screening Summary

Based on the screening of Alternatives 2 and 3 against the CERCLA criteria of effectiveness, implementability, and cost, both alternatives are retained and will be carried forward for detailed analysis in Chapter 6 of this FS.

6 Detailed and Comparative Analysis of Alternatives

This chapter presents the detailed and comparative analysis of remedial action alternatives retained from the screening discussed in Section 5.3 of this FS. The retained alternatives are evaluated in this chapter against seven of the nine CERCLA criteria described in the NCP (40 CFR 300.430(e)(9)) to support identifying a preferred alternative in the PP. The last two criteria, which are identified as modifying criteria, are formally assessed during the public participation process that precedes remedy selection and, therefore, are not addressed in this FS for interim action.

6.1 Description of CERCLA Evaluation Criteria

The nine CERCLA evaluation criteria and their subfactors (Figure 6-1), upon which the detailed and comparative analyses of alternatives are based, guide the evaluation process by assessing the ability of each alternative to address the statutory, technical, and policy considerations necessary for selecting an interim action remedial alternative for the uranium and technetium-99 plumes in the 200-BP-5 and 200-PO-1 OUs.

The nine CERCLA criteria are grouped into threshold, balancing, and modifying categories based on their function in the remedy selection process. The NCP (40 CFR 300.430(f)) states that the two threshold criteria (protection of human health and the environment, and compliance with ARARs) must be met by a remedial alternative in order to be selected, unless a waiver can be granted under CERCLA Section 121(d)(4).

The five balancing criteria represent the technical considerations upon which the detailed analysis is largely based. The five balancing criteria include long-term effectiveness and permanence, reduction of TMV through treatment, short-term effectiveness, implementability, and cost. The preferred alternative is typically protective of human health and the environment, ARAR-compliant, and ranked highest relative to the balancing criteria.

The final two criteria (state acceptance and community acceptance) are modifying criteria, which are formally assessed following issuance of the RI and FS reports, during preparation of the PP (state acceptance), and following review of public and Tribal Nations comments on the PP (community acceptance). Since the state is the lead regulatory agency, state acceptance will be inherent. Based on public and Tribal Nations comments, the Tri-Parties may modify some aspects of the preferred alternative or decide that another alternative is more appropriate.

Table 6-1 further defines the evaluation criteria.

6.2 Individual Analysis of Alternatives

This section presents the detailed evaluation of alternatives for remediating the 200-BP-5 and 200-PO-1 OU groundwater target COC plumes (Figure 1-2). The following alternatives, retained from the screening presented in Section 5.3, were carried forward for detailed evaluation:

- Alternative 1 – No Action
- Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms
- Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

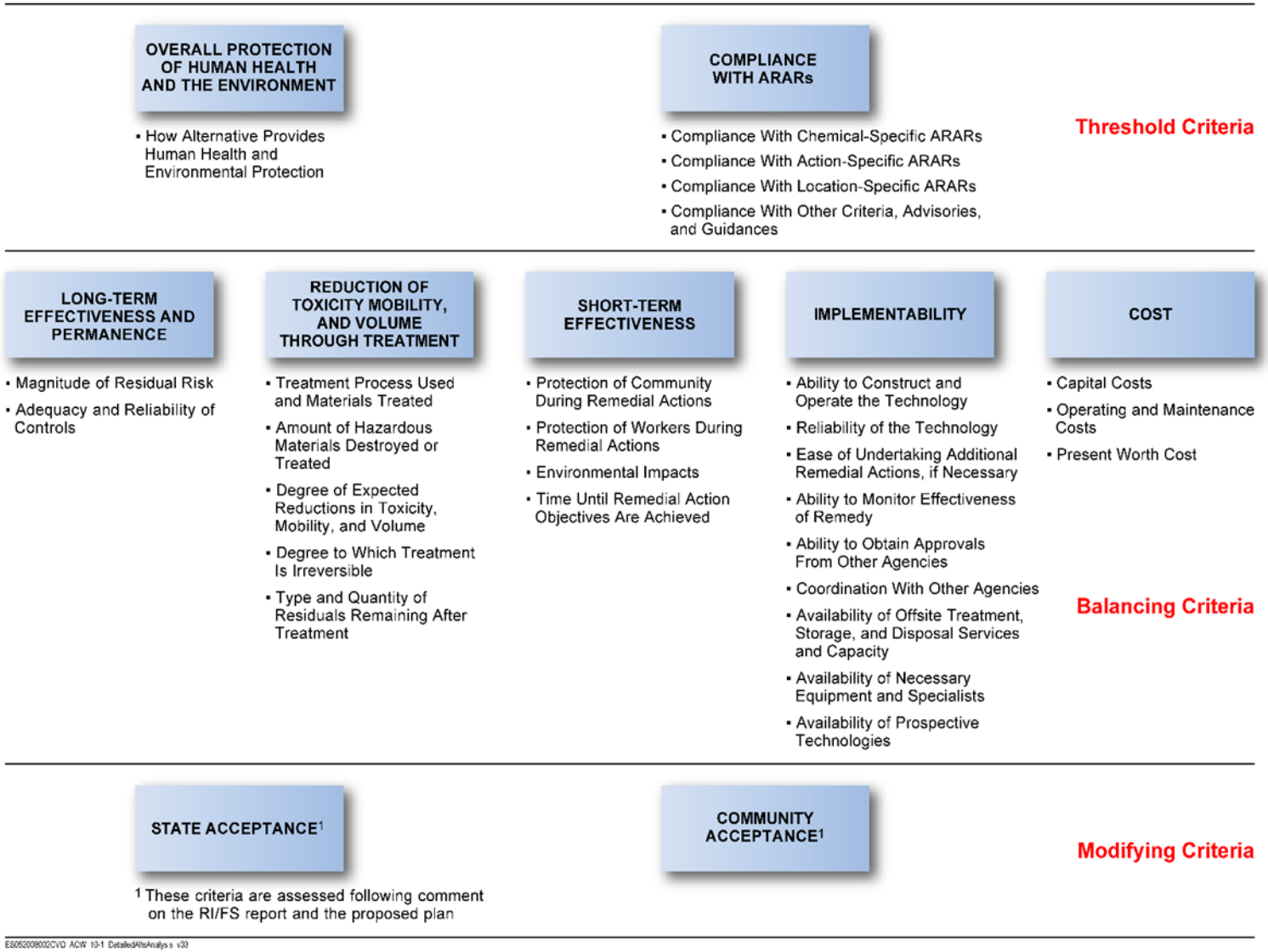


Figure 6-1. CERCLA Remedial Action Alternative Evaluation Criteria

Table 6-1. CERCLA Remedial Action Alternative Evaluation Criteria Description

Threshold Criteria	
Overall protection of human health and the environment	Alternatives are assessed to determine whether they can adequately protect human health and the environment, in both the short and long term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals consistent with 40 CFR 300.430(e)(2)(i), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy." Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The assessment against this criterion describes how the alternative, as a whole, achieves and maintains protection of human health and the environment.
Compliance with ARARs	Alternatives are assessed to determine whether they attain ARARs under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers identified in 40 CFR 300.430(f)(1)(ii)(C). This assessment also addresses other information from advisories, criteria, and guidance that the lead and support agencies have agreed is to be considered.
Balancing Criteria	
Long-term effectiveness and permanence*	Alternatives are assessed for the long-term effectiveness and permanence they afford, along with the degree of certainty that the alternative will prove successful. Factors to be considered, as appropriate, include the following: • Magnitude of residual risk from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. Characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their TMV and propensity to bioaccumulate. • Adequacy and reliability of controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste. This factor particularly addresses uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement. The definition of long-term effectiveness and permanence differs between interim and final remedial actions. This interim action is projected to occur for 25 years, although that duration could be extended in some areas due to continuing sources of contaminants to groundwater. For the purposes of this feasibility study, the duration of this evaluation criterion can be considered to be 50 years or until a final remedial action in implemented.

Table 6-1. CERCLA Remedial Action Alternative Evaluation Criteria Description

Balancing Criteria (continued)	
Reduction of TMV through treatment*	Alternatives are evaluated to assess the degree to which they use recycling or treatment to reduce TMV, including how treatment is used to address the principal threats posed by the site. Factors to be considered, as appropriate, include the following: • Treatment or recycling processes the alternatives use and materials that the alternatives will treat. • Amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled. • Degree of expected reduction in TMV of the waste due to treatment or recycling and the specification of which reductions are occurring. • Degree to which the treatment is irreversible. • Type and quantity of residuals that will remain following treatment, considering the persistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents. • Degree to which treatment reduces the inherent hazards posed by principal threats at the site.
Short-term effectiveness*	Alternatives are evaluated to assess short-term impacts considering the following: • Short-term risks that might be posed to the community during implementation of an alternative. • Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures. • Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation. • Time until protection is achieved. For groundwater, the remedial action timeframe for uranium and technetium-99 is based on the estimated time for the 95th percentile upper confidence limit concentrations to decline below their respective preliminary remediation goals. For remedial action timeframes <50 years in duration, the timeframe is rounded up to the next highest 5-year interval.
Implementability	Alternatives are evaluated to assess the ease or difficulty of implementation considering the following, as appropriate: • Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor remedy effectiveness. • Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required to obtain any necessary approvals and permits from other agencies (for offsite actions). • Availability of services and materials, including the availability of adequate offsite treatment, storage capacity, and disposal capacity and services; availability of necessary equipment, specialists, and provisions to ensure any necessary additional resources; availability of services and materials; and availability of prospective technologies.

Table 6-1. CERCLA Remedial Action Alternative Evaluation Criteria Description

Balancing Criteria (continued)	
Cost	Alternatives are evaluated with respect to capital cost, annual operations and maintenance cost, periodic operations and maintenance cost, and total life cycle cost (present value cost). Present value costs were estimated using a 1.4% discount factor per OMB Circular No. A-94, 2015, "Guidelines and Discount Rates for Benefit Cost Analysis of Federal Programs." Cost estimates were prepared in accordance with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, as well as DOE G 430.1-1, *Cost Estimating Guide*. The cost estimates are for comparison purposes and are prepared to meet the −30 to +50% range of accuracy recommended in EPA/540/G-89/004, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. All remedial action alternative cost estimates were rounded to nearest $1 million.
Modifying Criteria (Not Evaluated in the Feasibility Study)	
State acceptance	This assessment reflects the state (or support regulatory agency's) apparent preferences among or concerns about alternatives.
Community acceptance	This assessment reflects the community's apparent preferences among or concerns about alternatives.

*The ranking of three of the balancing criteria (long-term effectiveness, reduction of TMV, and short-term effectiveness) depends, in part, on the projected cleanup times for the target contaminants of concern. For the detailed and comparative analysis of alternatives, the cleanup times used for ranking are those based on the existing, dissolved-phase plumes, without consideration of a continuing source of contaminants to groundwater from the vadose zone.

ARAR = applicable or relevant and appropriate requirement

TMV = toxicity, mobility, or volume

The detailed evaluation of alternatives provided in the following sections is presented in a tabular form and the results are summarized narratively. The tabular format provides a pass (yes) or fail (no) determination for the two threshold criteria and a rating factor for four of the five balancing criteria, with estimated costs presented for the fifth balancing criteria. The rating factors are designed to facilitate the comparative evaluation of alternatives presented in Section 6.3 and the identification of a preferred alternative in the PP. The following rating factors are used to assess the performance of each alternative against the CERCLA balancing criteria:

- Performs superior against the balancing criterion with no disadvantages or uncertainties
- Performs well against the balancing criterion with minor disadvantages or uncertainties
- Performs fair against the balancing criterion with some disadvantages or uncertainties
- Performs poor against the balancing criterion with more disadvantages or uncertainties

The detailed analysis of alternatives for the threshold criteria of overall protection of human health and the environment draws upon the results of balancing criteria evaluation. Therefore, there are similarities between the information presented in the threshold criteria evaluation and the information presented in the balancing criteria evaluation for each of the alternatives.

6.2.1 Alternative 1 – No Action

The NCP (40 CFR 300.430(e)(6)) requires that a No Action alternative be included in the FS to serve as a baseline for comparison to other remedial action alternatives.

As described in Section 5.2.1, Alternative 1 does not include active measures. Operation of the NTCRA P&T system in the B Complex and maintenance of land-use and groundwater-use restrictions (i.e., ICs) would be discontinued. With no active remediation, natural attenuation processes would continue to reduce target COC concentrations in the groundwater plumes targeted for interim action.

Table 6-2 summarizes the evaluation of Alternative 1 against the CERCLA criteria.

6.2.1.1 Threshold Criteria Evaluation

The No Action alternative is not protective of human health because there would be no ICs in place to prevent exposure, and concentrations of uranium and technetium-99 (as well as some co-contaminants not addressed by this interim action) exceed their respective PRGs. Alternative 1 is not protective of the environment because existing uranium and technetium-99 plumes would expand into less contaminated and uncontaminated portions of the aquifer.

Alternative 1 would not achieve compliance with chemical-specific ARARs for uranium in the B Complex (Figure 6-2), nor for technetium-99 in Gable Gap (Figure 6-3) within 50 years based on 95 UCL concentrations. Since this is longer than the specified project life of 25 years, Alternative 1 is considered to not comply with the ARARs threshold criterion.

Since no actions are implemented, compliance with location- and action-specific ARARs would not be triggered.

6.2.1.2 Balancing Criteria Evaluation

Because the No Action alternative does not meet the threshold criteria for protection of human health and the environment, nor does it comply with chemical-specific ARARs, it cannot be selected under CERCLA. Therefore, Alternative 1 was not evaluated against the CERCLA balancing criteria.

Table 6-2. Detailed Evaluation for Alternative 1 – No Action

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
Threshold Criteria			
Overall protection of human health and the environment	No	• Human health is not protected because groundwater-use institutional controls would be discontinued where concentrations of uranium and technetium-99 (as well as some co-contaminants not addressed by this interim action) exceed their respective PRGs. • Environment (e.g., aquifer) is not protected because uranium and technetium-99 plumes will expand into less contaminated and uncontaminated portions of the aquifer.	
Compliance with ARARs	No	• Uranium and technetium-99 concentrations in B Complex groundwater are projected to remain above their PRGs for >50 years and approximately 17 years, respectively, based on 95 UCL concentrations, assuming no continuing source. • Technetium-99 concentrations in C Farm and A-AX Farms groundwater are projected to remain above the PRG for approximately 5 years, based on 95 UCL concentrations, assuming no continuing source.	• Technetium-99 concentrations in Gable Gap groundwater are projected to remain above the PRG for >50 years, based on 95 UCL concentrations (no continuing source exists in the Gable Gap area). Modeling performed in conjunction with the remedial investigation indicates that technetium-99 concentrations in Gable Gap will remain above the PRG for hundreds of years without remedial action.
		• Since no action is implemented, action- and location-specific ARARs would not be triggered.	
Balancing Criteria			
Long-term effectiveness and permanence	Not evaluated	This alternative does not satisfy the threshold criteria and cannot be selected. Therefore, an evaluation against the balancing criteria was not performed.	
Reduction of toxicity, mobility, or volume through treatment			
Short-term effectiveness			
Implementability			

Table 6-2. Detailed Evaluation for Alternative 1 – No Action

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
Estimated cost (base year 2018):			
• Capital cost		$0	
• Annual O&M cost		$0	
• Periodic O&M cost		$0	
• Total nondiscounted cost		$0	
• Total present value cost		$0	
Modifying Criteria			
Community acceptance	Not evaluated	To be evaluated during public comment period held following issuance of the Proposed Plan.	

95 UCL = 95th percentile upper confidence limit
ARAR = applicable or relevant and appropriate requirement
O&M = operations and maintenance
PRG = preliminary remediation goal

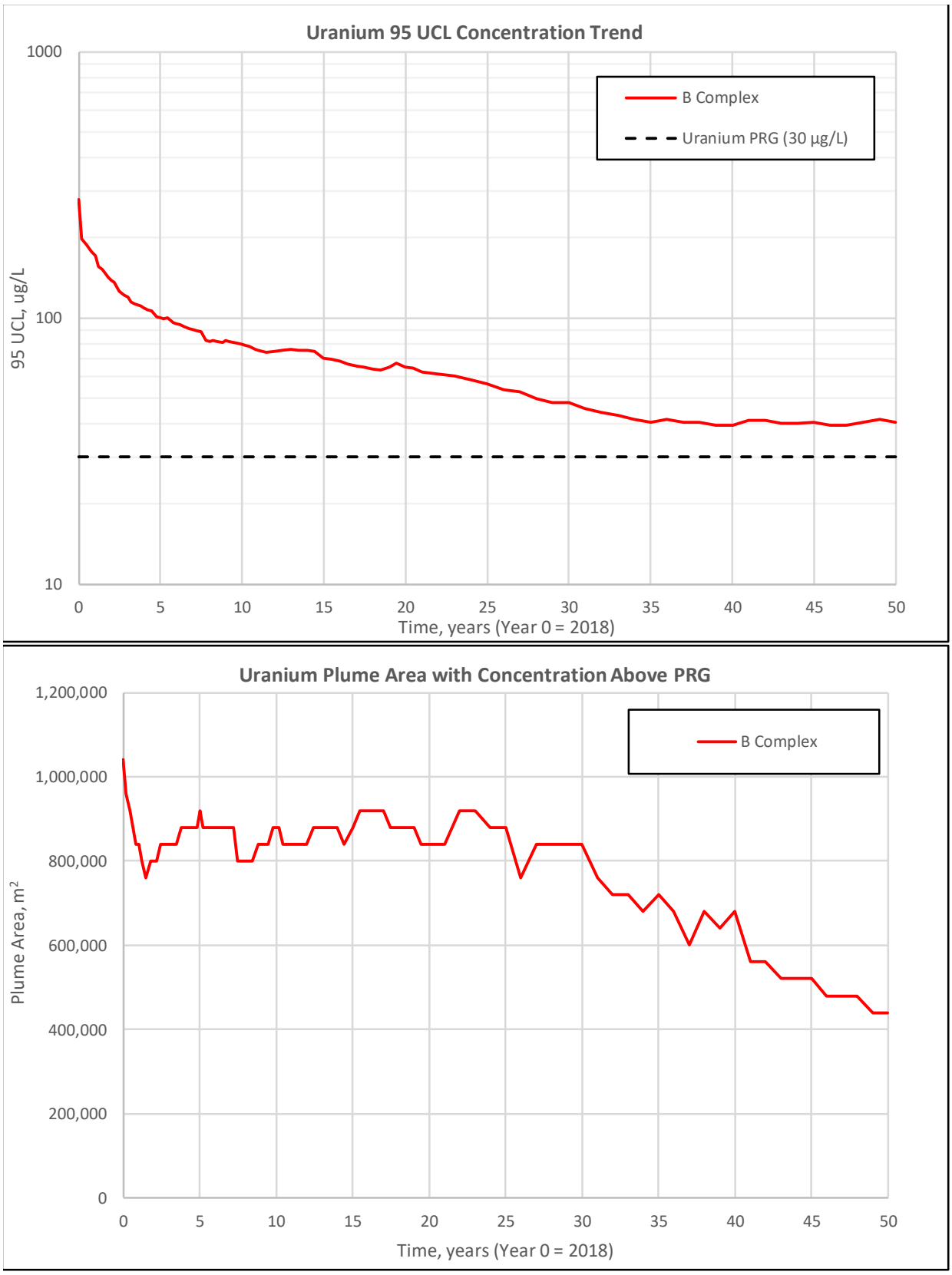


Figure 6-2. Alternative 1 – Predicted Uranium 95 UCL Concentrations and Plume Areas

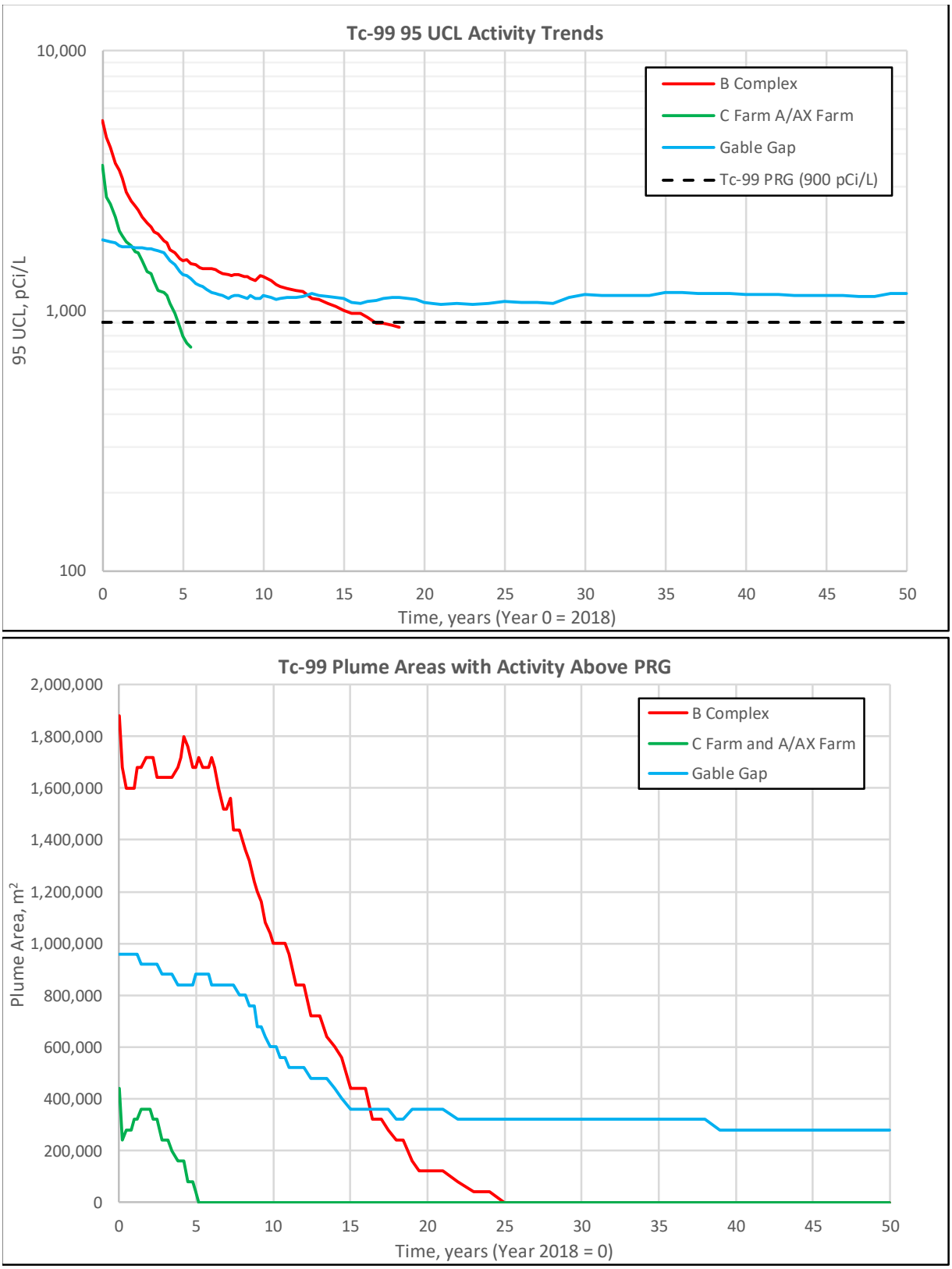


Figure 6-3. Alternative 1 – Predicted Technetium-99 95 UCL Activities and Plume Areas

6.2.2 Alternative 2 – Pump and Treat at B Complex, and C Farm and A-AX Farms

Alternative 2 consists of the following major components:

- Groundwater P&T for up to 25 years in the B Complex area to capture and remove uranium and technetium-99
- Groundwater P&T for up to 10 years in the C Farm and A-AX Farms area to capture and remove technetium-99
- Treatment of extracted groundwater at the existing 200 West P&T, with reinjection of treated effluent in the 200 West Area
- Implementation and maintenance of land-use and groundwater-use restriction ICs until PRGs are achieved

Table 6-3 summarizes the evaluation of Alternative 2 against the CERCLA criteria.

6.2.2.1 Threshold Criteria Evaluation

Alternative 2 protects human health and the environment by implementing and maintaining land-use and groundwater-use ICs to prevent exposure until groundwater PRGs are achieved. Alternative 2 protects the environment by controlling uranium and technetium-99 plume migration in groundwater beneath the B Complex and C Farm and A-AX Farms area, thus preventing expansion into less contaminated or uncontaminated portions of the aquifer, and by reducing concentrations and the overall size of the contaminant plumes.

Alternative 2 is expected to reduce uranium and technetium-99 concentrations in the target plumes to below PRGs for compliance with chemical-specific ARARs within the specified 25-year project life (with optimization), assuming no continuing source (Figures 6-4 and 6-5). However, in the B Complex area, this will require optimizing extraction well locations during remedial design and optimizing extraction flow rates during operation, because the cleanup time for uranium in B Complex groundwater predicted by Alternative 2 is slightly longer (28 years based on 95 UCL concentrations).

Compliance with location-specific and action-specific ARARs would be achieved through remedial design and implementation of the remedial action in accordance with the RD/RAWP.

6.2.2.2 Balancing Criteria Evaluation

Alternative 2 performs well with respect to the long-term effectiveness and permanence criterion, with minor disadvantages or uncertainties. Residual risk from the target COCs (uranium and technetium-99) in the target remediation areas (current groundwater plumes below the B Complex and C Farm and A-AX Farms) is expected to be largely eliminated within approximately 25 years for uranium (with some uncertainty, as discussed in Section 6.2.2.1) and within 7 years for technetium-99. These predicted cleanup times are based on the assumption of no continuing source. Without source control, residual risk from uranium and technetium-99 in groundwater below the B Complex and C Farm and A-AX Farms area could persist for >50 years; however, this interim action targets only the existing dissolved-phase contaminant plumes.

It is uncertain whether concentrations of co-contaminants not addressed by this interim action will be reduced below their respective PRGs by the interim action, and these co-contaminants could pose residual risk beyond the 25-year project life.

Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms

Criterion	Rating	Detailed Analysis	
		B Complex	C Farm and A-AX Farms
Threshold Criteria			
Overall protection of human health and the environment	Yes	• Land-use and groundwater-use restriction ICs would be implemented and maintained to protect current and future human health until groundwater PRGs are achieved through P&T. • The environment (e.g., aquifer) is protected by capturing and recovering uranium and technetium-99, thereby preventing plume expansion into less contaminated and uncontaminated portions of the aquifer, and reducing the overall plume area with concentrations above PRGs.	
Compliance with ARARs	Yes	• Uranium and technetium-99 concentrations in the B Complex groundwater are projected to be below the PRGs within 28 and 7 years, respectively, based on 95 UCL concentrations (assuming no continuing source). • The uranium PRG could possibly be achieved within the project life of 25 years by optimizing well placement and pumping rates.	Technetium-99 concentrations in C Farm and A-AX Farms groundwater are projected to decrease below the PRG within 5 years based on 95 UCL concentrations (assuming no continuing source).
		The alternative would be designed and implemented in accordance with a remedial design/remedial action work plan to comply with action-specific and location-specific ARARs.	
Balancing Criteria			
Long-term effectiveness and permanence:	★★★☆		
• Magnitude of residual risk		Uranium and technetium-99 concentrations in groundwater in the target plumes are expected to be reduced to below PRGs, which represent concentrations that are protective of human health and the environment, within the 25-year P&T timeframe (assuming no continuing source). There is some uncertainty regarding uranium because modeling predicts a cleanup timeframe of 28 years based on 95 UCL concentration.	Uranium and technetium-99 concentrations in groundwater in the target plumes are projected to be reduced to below PRGs, which represent concentrations that are protective of human health and the environment, within the 10-year P&T timeframe (assuming no continuing source).
		It is uncertain if concentrations of all co-contaminants will be below the respective PRGs, and additional treatment could be required under the final remedy.	

Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms

Criterion	Rating	Detailed Analysis	
		B Complex	C Farm and A-AX Farms
• Adequacy and reliability of controls		Under this alternative, land-use and groundwater-use restriction ICs would be maintained for up to 25 years (and possibly longer) until PRGs for all contaminants are achieved. ICs have been successfully implemented at the Hanford Site and are expected to be reliable for the foreseeable future.	
Reduction of TMV through treatment:	★★★☆		
• Treatment process used and materials treated		Groundwater P&T (groundwater extraction, treatment at the 200 West P&T, and reinjection of treated effluent). Treatment involves uranium and technetium-99 removal from groundwater using IX and biochemical treatment of co-contaminants (primarily nitrate and cyanide).	
• Amount of hazardous material destroyed or treated		Estimated plume areas of contaminated groundwater remediated: • Uranium = 26 ha (64 ac) • Technetium-99 = 89 ha (219 ac)	Estimated plume area of contaminated groundwater remediated: • Technetium-99 = 21 ha (51 ac)
• Degree of expected reduction in TMV		Estimated volumes of contaminated groundwater remediated: • Uranium = 208,000 m^3 • Technetium-99 = 712,000 m^3	Estimated volume of contaminated groundwater remediated: • Technetium-99 = 630,000 m^3
• Degree to which treatment is irreversible		Contaminants are physically removed from the aquifer with extracted groundwater and are removed from the groundwater before treated effluent is reinjected. Treatment of extracted groundwater at the 200 West P&T involves transferring uranium and technetium-99 (and cyanide) from groundwater onto the IX resin materials, whereas nitrate and cyanide (co-contaminants) are biodegraded.	
• Type and quantity of residuals remaining after treatment		Residuals associated with uranium and technetium-99 posing a threat to human health and the environment would not remain in the groundwater at the end of the remedial action. Treatment residuals, including spent IX resin and biochemical sludge, would be stabilized and disposed at ERDF.	

Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms

Criterion	Rating	Detailed Analysis	
		B Complex	C Farm and A-AX Farms
Short-term effectiveness:	★★★☆		
• Time until PRGs are achieved (baseline year is 2018)		Based on 95 UCL concentrations and assuming no continuing source: • Uranium: 28 years (25 years with optimization) • Technetium-99: 7 years	Based on 95 UCL concentrations and assuming no continuing source: • Technetium-99: 5 years
• Protection of community during remedial actions		Due to the remote location of the target remediation areas and depth of groundwater, there would be no impacts to the general community during the remedial action.	
• Protection of workers during remedial actions		Hanford Site workers follow a rigorous health and safety plan and use personal protective equipment to reduce the potential for exposure. Periodic groundwater monitoring activities would pose minimal hazard to workers.	
• Environmental impacts		Minimal environmental effects are expected. The only actions that involve waste handling or transfer are new well construction, extracted groundwater conveyance through pipelines, and management of treatment residuals. All of these activities are routinely performed at the Hanford Site, and engineering controls are well established for preventing contaminant release during the remedial action.	
Implementability:	★★★☆		
• Ability to construct and operate the technology		Groundwater P&T and ICs are mature technologies widely used at the Hanford Site. Groundwater monitoring (sampling and laboratory analysis) and data evaluation procedures are well established for the Hanford Site. The 200 West P&T would need to be modified to add an additional (third) technetium-99 IX train and an additional (third) air stripper to accommodate the extra flow.	
• Reliability of the technology		Groundwater P&T for the target contaminants of concern and co-contaminants, as well as ICs, are very reliable and have been demonstrated as effective at the Hanford Site. P&T systems at the Hanford Site have up-times >90%.	
• Ease of undertaking additional remedial actions, if necessary		Implementation of this alternative would not deter additional remedial actions, if necessary. P&T technology is readily optimized, and system modification through flow rate adjustments, installation of new wells, or shutdown of active wells are readily performed. Performance monitoring can also be expanded to install new wells or to sample other existing wells, if deemed necessary.	

Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms

Criterion	Rating	Detailed Analysis	
		B Complex	C Farm and A-AX Farms
• Ability to monitor effectiveness of remedy		Groundwater monitoring (sampling and analysis) to confirm P&T performance for uranium and technetium-99 is readily performed. Groundwater monitoring for co-contaminants to support future decisions is also standard practice. The Hanford Site has a well-established program to monitor IC effectiveness sitewide.	
• Ability to obtain approvals from other agencies		Approvals from other agencies are not expected to hinder implementability.	
• Coordination with other agencies		Coordination with other agencies or stakeholders is not expected to hinder implementability.	
• Availability of offsite treatment storage, and disposal services and capacity		Disposal of treatment and well construction residuals, and well sampling purge water, would be managed in accordance with current practices. Spent IX resin would be packaged and disposed onsite at ERDF.	
• Availability of necessary equipment and specialists		Equipment and manpower are readily available using existing Hanford Site resources, suppliers, and subcontractors.	
• Availability of prospective technologies		Groundwater P&T and ICs are mature technologies that are readily available.	
Estimated cost (base year 2018):			
• Capital cost		$24,300,000	
• Annual O&M cost		$183,000,000	
• Periodic O&M cost		$6,500,000	
• Total nondiscounted cost		$214,000,000	
• Total present value cost		$199,000,000	

Table 6-3. Detailed Evaluation for Alternative 2 – P&T at B Complex, and C Farm and A-AX Farms

Criterion	Rating	Detailed Analysis	
		B Complex	C Farm and A-AX Farms
Modifying Criteria			
Community acceptance	Not evaluated	To be evaluated during the public comment period held following issuance of the Proposed Plan.	

Note:

★★★★ = Performs superior against the CERCLA balancing criterion with no disadvantages or uncertainties.

★★★☆ = Performs well against the CERCLA balancing criterion with minor disadvantages or uncertainties.

★★☆☆ = Performs fair against the CERCLA balancing criterion with some disadvantages or uncertainties.

★☆☆☆ = Performs poor against the CERCLA balancing criterion with more disadvantages or uncertainty.

95 UCL = 95th percentile upper confidence limit
ARAR = applicable or relevant and appropriate requirement
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
ERDF = Environmental Restoration Disposal Facility
IC = institutional control
IX = ion exchange
O&M = operations and maintenance
P&T = pump and treat
PRG = preliminary remediation goal
TMV = toxicity, mobility, or volume

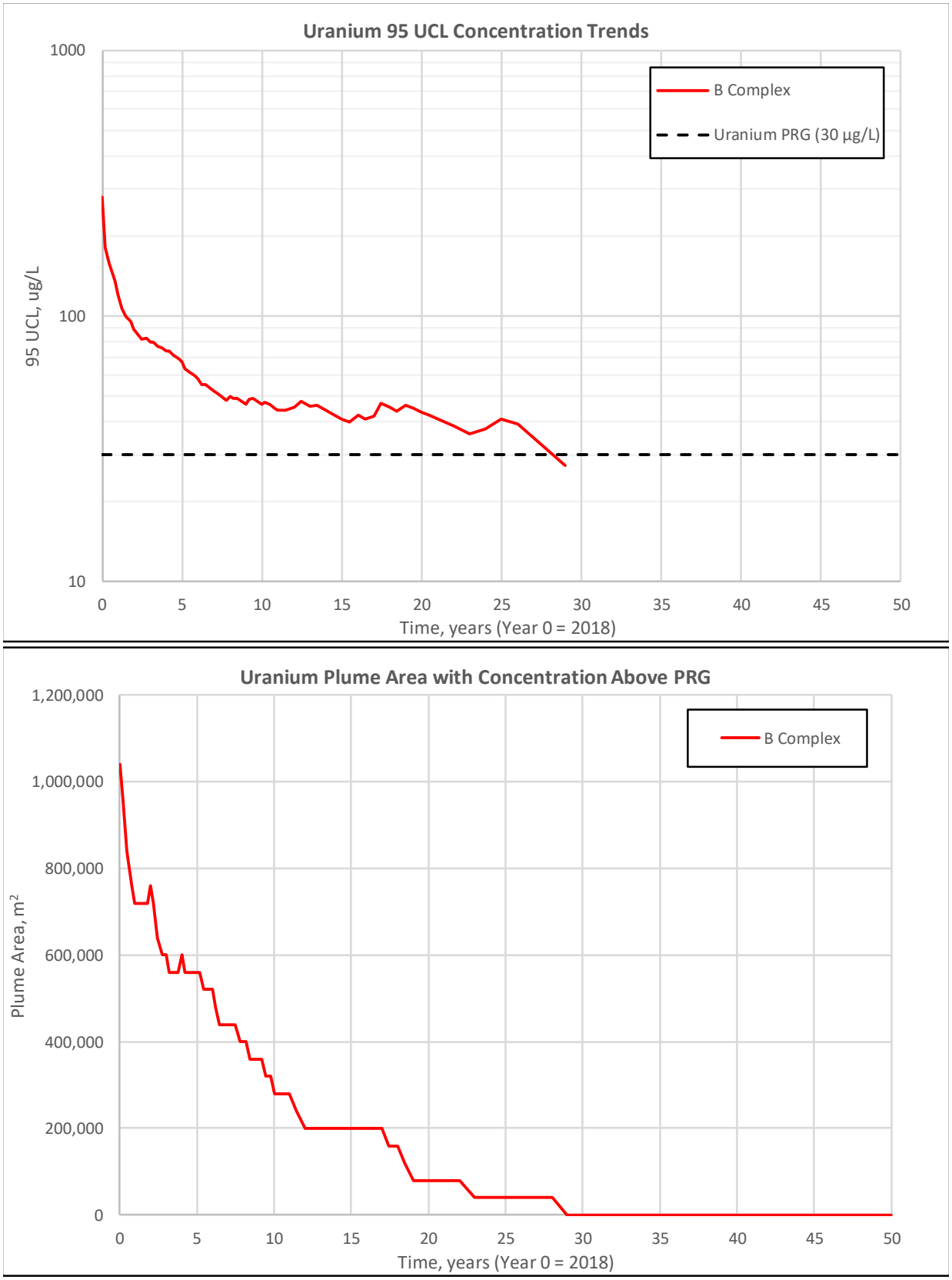


Figure 6-4. Alternative 2 – Predicted Uranium 95 UCL Concentrations and Plume Areas

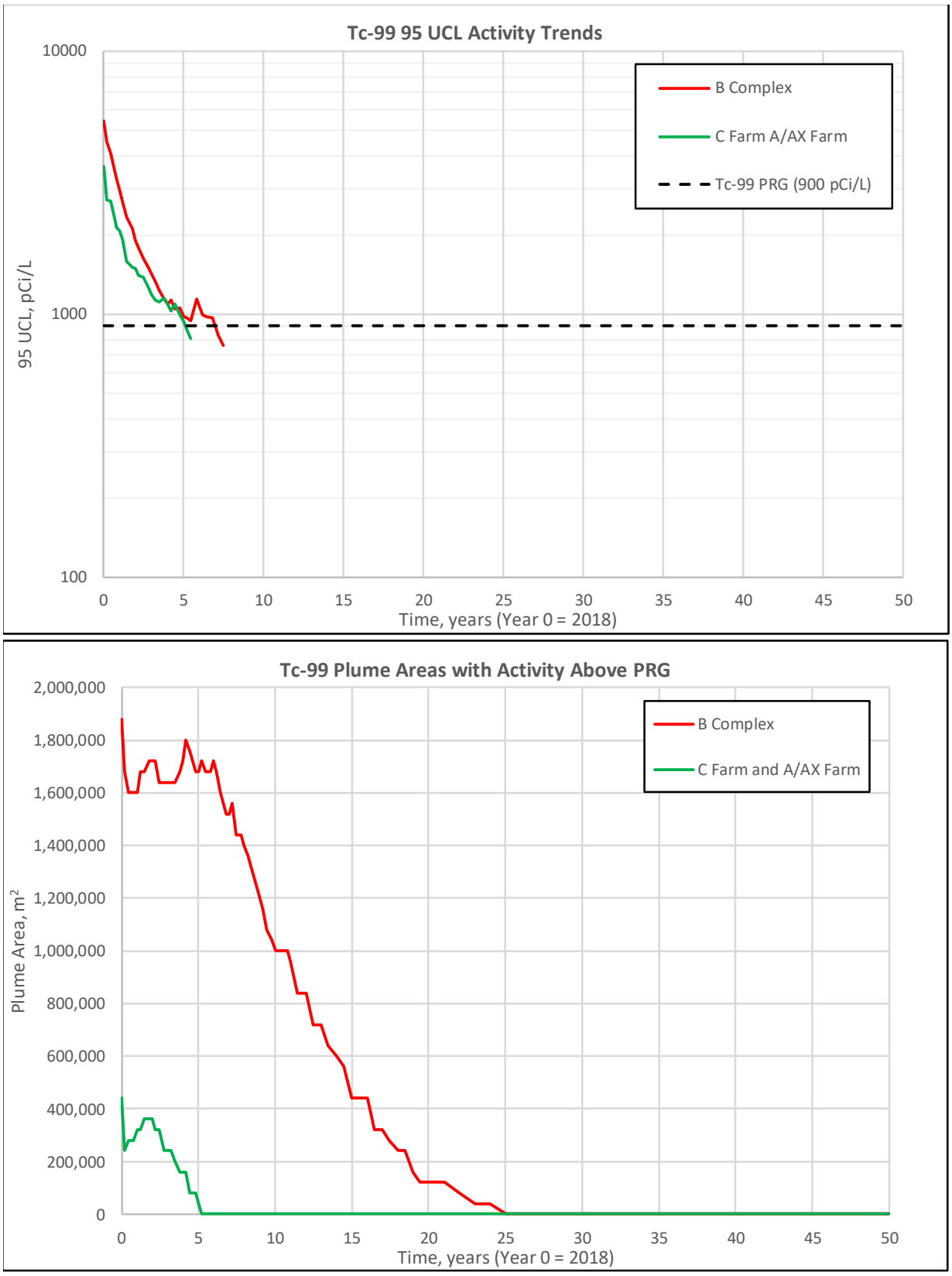


Figure 6-5. Alternative 2 – Predicted Technetium-99 95 UCL Activities and Plume Areas

Alternative 2 performs well with respect to the reduction of TMV through treatment criterion, with minor disadvantages or uncertainties. The estimated plume areas and groundwater volumes remediated shown in Table 6-3 are based on the assumption of no continuing source. Contaminants are physically removed from the aquifer with extracted groundwater, which is then treated at the existing 200 West P&T, where uranium and technetium-99 (and cyanide) are transferred from the groundwater onto solid IX resin material. The co-contaminants nitrate and cyanide are treated using biodegradation. Spent IX resin used for uranium and technetium-99 treatment is disposed at the ERDF. While IX treatment and spent resin disposal at ERDF do not represent contaminant destruction, the TMV of uranium and technetium-99 in groundwater is reduced.

Alternative 2 performs well with respect to the short-term effectiveness criterion, with minor disadvantages or uncertainties. The predicted timeframes to achieve PRGs are 28 years for uranium in B Complex groundwater, and 7 and 5 years for technetium-99 in the B Complex and C Farm and A-AX Farms groundwater, respectively (based on 95 UCL concentrations, assuming no continuing source). The community, workers, and environment would be well protected during construction and implementation of the interim action.

Alternative 2 performs well with respect to the implementability criterion, with minor disadvantages or uncertainties. This alternative uses technologies (groundwater P&T and ICs) that are mature, well demonstrated, and widely used at the Hanford Site. However, a new (third) technetium-99 IX train and a new (third) air stripping system would need to be constructed at the 200 West P&T to accommodate the water generated by this alternative. The 25- and 10-year P&T timeframes are within the 200 West P&T design life. No technical or administrative impediments to implementing this alternative are anticipated.

The total present value cost of Alternative 2 is estimated at $199 million. Most of the cost (roughly 89%) is associated with O&M of the B Complex and C Farm and A-AX Farms P&T systems for 25 and 10 years, respectively. Table 6-3 provides additional cost information.

6.2.3 Alternative 3 – Pump and Treat at B Complex, C Farm and A-AX Farms, and Gable Gap

Alternative 3 consists of the following major components:

- The same components for the B Complex and the C Farm and A-AX Farms area as described for Alternative 2.
- Groundwater P&T for capturing and removing technetium-99 for up to 10 years in the Gable Gap area, with reinjection of 379 L/min (100 gal/min) of treated effluent in the Gable Gap area.
- Implementation and maintenance of land-use and groundwater-use ICs until PRGs are achieved.

Table 6-4 summarizes the evaluation of Alternative 3 against the CERCLA criteria.

Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
Threshold Criteria			
Overall protection of human health and the environment	Yes	• Land-use and groundwater-use restriction ICs would be implemented and maintained to protect human health until groundwater PRGs are achieved through P&T. • Environment (e.g., aquifer) is protected by capturing and recovering uranium and technetium-99, thereby preventing plume expansion into less contaminated and uncontaminated portions of the aquifer, and by reducing the overall plume area with concentrations above PRGs.	
Compliance with ARARs	Yes	• Uranium and technetium-99 concentrations in the B Complex groundwater are projected to be below the PRGs within 22 years and 5 years, respectively, based on 95 UCL concentrations (assuming no continuing source). Thus, groundwater extraction in the Gable Gap area under Alternative 3 results in reduced cleanup times in B Complex compared to Alternative 2. • Technetium-99 concentrations in C Farm and A-A Tank Farms groundwater are projected to be below the PRG within 5 years, based on 95 UCL concentrations (assuming no continuing source). These predicted cleanup times are virtually the same as for Alternative 2.	Technetium-99 concentrations in Gable Gap groundwater are projected to be below the PRGs within 10 years, based on 95 UCL concentrations (no continuing source exists in the Gable Gap area).
		The alternative would be designed and implemented in accordance with a remedial design/remedial action work plan to comply with action-specific and location-specific ARARs.	
Balancing Criteria			
Long-term effectiveness and permanence:	★★★★		
• Magnitude of residual risk		Uranium and technetium-99 concentrations in groundwater in the target plumes are projected to be reduced to below PRGs, which represent concentrations that are protective of human health and the environment, within the 25-year (for the B Complex) or 10-year (for C Farm and A-AX Farms, and Gable Gap) P&T timeframe. However, this prediction is based on the assumption of no continuing source.	

Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	**Gable Gap**
		It is uncertain if concentrations of all co-contaminants will be below PRGs, and additional treatment could be required under the final remedy.	
• Adequacy and reliability of controls		Under this alternative, land-use and groundwater-use restriction ICs would be maintained for up to 25 years (and possibly longer) until the PRGs for all contaminants are achieved. ICs have been successfully implemented at the Hanford Site and are expected to be reliable for the foreseeable future.	
Reduction of TMV through treatment:	★★★★		
• Treatment process used and materials treated		Groundwater P&T (groundwater extraction, treatment at the 200 West P&T, and reinjection of treated effluent). Treatment involves uranium and technetium-99 removal from groundwater via IX, and biochemical treatment of co-contaminants (primarily nitrate and cyanide).	
• Extraction amount of hazardous material destroyed or treated		Estimated plume area of contaminated groundwater remediated (same as for Alternative 2): • Uranium in B Complex = 26 ha (64 ac) • Technetium-99 in B Complex = 89 ha (219 ac) • Technetium-99 in C Farm and A-AX Farms = 21 ha (51 ac)	Estimated plume area of contaminated groundwater remediated: • Technetium-99 in Gable Gap = 61 ha (151 ac)
• Degree of expected reduction in TMV		Estimated volume of contaminated groundwater remediated (same as for Alternative 2): • Uranium in B Complex = 208,000 m^3 • Technetium-99 in B Complex = 712,000 m^3 • Technetium-99 in C Farm and A-AX Farms = 630,000 m^3	Estimated volume of contaminated groundwater remediated: • Technetium-99 in Gable Gap = 488,000 m^3
• Degree to which treatment is irreversible		Contaminants are physically removed from the aquifer with extracted groundwater and removed from the groundwater before the treated effluent is reinjected. Treatment of extracted groundwater at the 200 West P&T involves transferring uranium and technetium-99 (and cyanide) from the groundwater onto the IX resin materials, whereas nitrate and cyanide (co-contaminants) are biodegraded.	
• Type and quantity of residuals remaining after treatment		None of the residuals associated with uranium and technetium-99 posing a threat to human health and the environment would remain in the groundwater at the end of the remedial action. Treatment residuals, including spent IX resin and biochemical sludge, would be stabilized and disposed at ERDF.	

Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
Short-term effectiveness:	★★★☆		
• Time until PRGs are achieved		Based on 95 UCL concentrations and assuming no continuing source: • Uranium in B Complex: 22 years • Technetium-99 in B Complex: 5 years • Technetium-99 in C Farm and A-AX Farms: 5 years	Based on 95 UCL concentrations and assuming no continuing source: • Technetium-99 in Gable Gap: 10 years
• Protection of community during remedial actions		Due to the remote location of the target remediation areas and depth of groundwater, there would be no impacts to the general community during the remedial action.	
• Protection of workers during remedial actions		Hanford Site workers follow a rigorous health and safety plan and use personal protective equipment to reduce the potential for exposure. Periodic groundwater monitoring activities would pose minimal hazard to workers.	
• Environmental impacts		Minimal environmental effects are expected. The only actions that involve waste handling or transfer are new well construction, extracted groundwater conveyance through pipelines, and management of treatment residuals. All these activities are routinely performed at the Hanford Site, and engineering controls are well established for preventing contaminant release during the remedial action.	
Implementability:	★★☆☆		
• Ability to construct and operate the technology		Groundwater P&T and ICs are mature technologies widely used at the Hanford Site. Likewise, groundwater monitoring (sampling and laboratory analysis) and data evaluation procedures are well established for the Hanford Site. The 200 West P&T would need to be modified to add an additional (third) technetium-99 IX train and an additional (third) air stripper to accommodate the extra flow. In addition, Alternative 3 would require additional pipelines and pump stations.	
• Reliability of the technology		Groundwater P&T for the target contaminants of concern and co-contaminants, as well as ICs, are very reliable and have been demonstrated as effective at the Hanford Site. P&T systems at the Hanford Site have run-times/availability >90%.	
• Ease of undertaking additional remedial actions, if necessary		P&T technology is readily optimized, and system modification through flow rate adjustments, installation of new wells, or shutdown of active wells are readily performed. Performance monitoring can also be expanded to install new wells or to sample other existing wells, if deemed necessary.	

Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
• Ability to monitor effectiveness of remedy		Groundwater monitoring (sampling and analysis) to confirm P&T performance for uranium and technetium-99 is readily performed. Groundwater monitoring for co-contaminants to support future decisions is also standard practice. The Hanford Site has a well-established program to monitor IC effectiveness sitewide.	
• Ability to obtain approvals from other agencies		Approvals from other agencies are not expected to hinder implementability.	
• Coordination with other agencies		Coordination with other agencies or stakeholders not expected to hinder implementability.	
• Availability of offsite treatment storage, and disposal services and capacity		Disposal of treatment residuals, well construction residuals, and well sampling purge water would be managed in accordance with current practices. Spent IX resin would be packaged and disposed of onsite at ERDF.	
• Availability of necessary equipment and specialists		Equipment and manpower are readily available using existing Hanford Site resources, suppliers, and subcontractors.	
• Availability of prospective technologies		Groundwater P&T and ICs are mature technologies that are readily available.	
Estimated cost (base year 2018):			
• Capital cost		$37,800,000	
• Annual O&M cost		$216,000,000	
• Periodic O&M cost		$8,100,000	
• Total non-discounted cost		$261,000,000	
• Total present value cost		$245,000,000	

Table 6-4. Detailed Evaluation for Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap

Criterion	Rating	Detailed Analysis	
		B Complex and C Farm and A-AX Farms	Gable Gap
Modifying Criteria			
Community acceptance	Not evaluated	Will be evaluated during the public comment period held following issuance of the Proposed Plan.	

Note:

★★★★ = Performs superior against the CERCLA balancing criterion with no disadvantages or uncertainties.

★★★☆ = Performs well against the CERCLA balancing criterion with minor disadvantages or uncertainties.

★★☆☆ = Performs fair against the CERCLA balancing criterion with some disadvantages or uncertainties.

★☆☆☆ = Performs poor against the CERCLA balancing criterion with more disadvantages or uncertainty.

95 UCL = 95th percentile upper confidence limit
ARAR = applicable or relevant and appropriate requirement
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
ERDF = Environmental Restoration Disposal Facility
IC = institutional control
IX = ion exchange
O&M = operations and maintenance
P&T = pump and treat
PRG = preliminary remediation goal
TMV = toxicity, mobility, or volume

6.2.3.1 Threshold Criteria Evaluation Summary

Alternative 3 protects human health and the environment in the B Complex and C Farm and A-AX Farms area, as described for Alternative 2. In the Gable Gap area, human health is protected by maintaining land-use and groundwater-use ICs to prevent exposure until PRGs are achieved. Alternative 3 protects the environment by controlling technetium-99 plume migration in groundwater beneath the Gable Gap area, thus preventing expansion into less contaminated or uncontaminated portions of the aquifer, and by reducing concentrations and the overall size of the contaminant plume.

Alternative 3 complies with chemical-specific ARARs in the B Complex and C Farm and A-AX Farms area, as described for Alternative 2 (Figures 6-6 and 6-7). Alternative 3 complies with chemical-specific ARARs in the Gable Gap area by decreasing technetium-99 concentrations in the target plume below the PRG within 10 years based on 95 UCL concentrations.

Compliance with location- and action-specific ARARs would be achieved through remedial design and implementation of the remedial action in accordance with the RD/RAWP.

6.2.3.2 Balancing Criteria Evaluation

In general, Alternatives 2 and 3 perform similarly against the balancing criteria, with a few exceptions. Alternative 3 addresses technetium-99 contamination in the Gable Gap area, whereas Alternative 2 does not. This results in Alternative 3 scoring slightly higher for the long-term effectiveness and permanence and reduction of TMV through treatment criteria. P&T activities in the B Complex and C Farm and A-AX Farms areas are identical for Alternative 3 and Alternative 2; consequently, remedial performance between the two alternatives in these areas is similar, except that P&T in Gable Gap under Alternative 3 is predicted to improve (shorten) the cleanup timeframe for uranium (and, to a lesser degree, technetium-99) in the B Complex compared to Alternative 2. This reduced cleanup time under Alternative 3 is counterbalanced by a higher potential for impacts to the community, workers, and the environment due to its greater remediation area, construction, and equipment operation. For this reason, Alternatives 2 and 3 were scored equally for the short-term effectiveness criterion. Both alternatives use proven technologies that are widely used at the Hanford Site (P&T, ICs), but the additional infrastructure (wells, piping, transfer stations) and O&M requirements associated with Alternative 3 result in a slightly lower rating with respect to the implementability criterion, as well as higher cost, compared to Alternative 2. Uncertainties associated with predicted cleanup times being based on the no-continuing-source assumption and with residual concentrations of co-contaminants not specifically addressed by the interim action are also very similar for Alternatives 2 and 3.

Alternative 3 performs very well with respect to the long-term effectiveness and permanence criterion, with minimal disadvantages or uncertainties. Residual risk from the target COCs (uranium and technetium-99) in the target remediation areas below the B Complex and C Farm and A-AX Farms area is expected to be eliminated within 22 years for uranium and within 5 years for technetium-99. Residual risk from technetium-99 in the Gable Gap plume is expected to be eliminated within 10 years. These predicted cleanup timeframes are based on the assumption of no continuing source and without source control. Residual risk from uranium and technetium-99 in groundwater below the B Complex and the C Farm and A-AX Farms area could persist for >50 years. However, this interim action targets only the existing dissolved-phase contaminant plumes.

It is uncertain whether concentrations of co-contaminants not addressed by this interim action will be reduced to below their respective PRGs by the interim action, and the co-contaminants could pose residual risk beyond the 25-year project life.

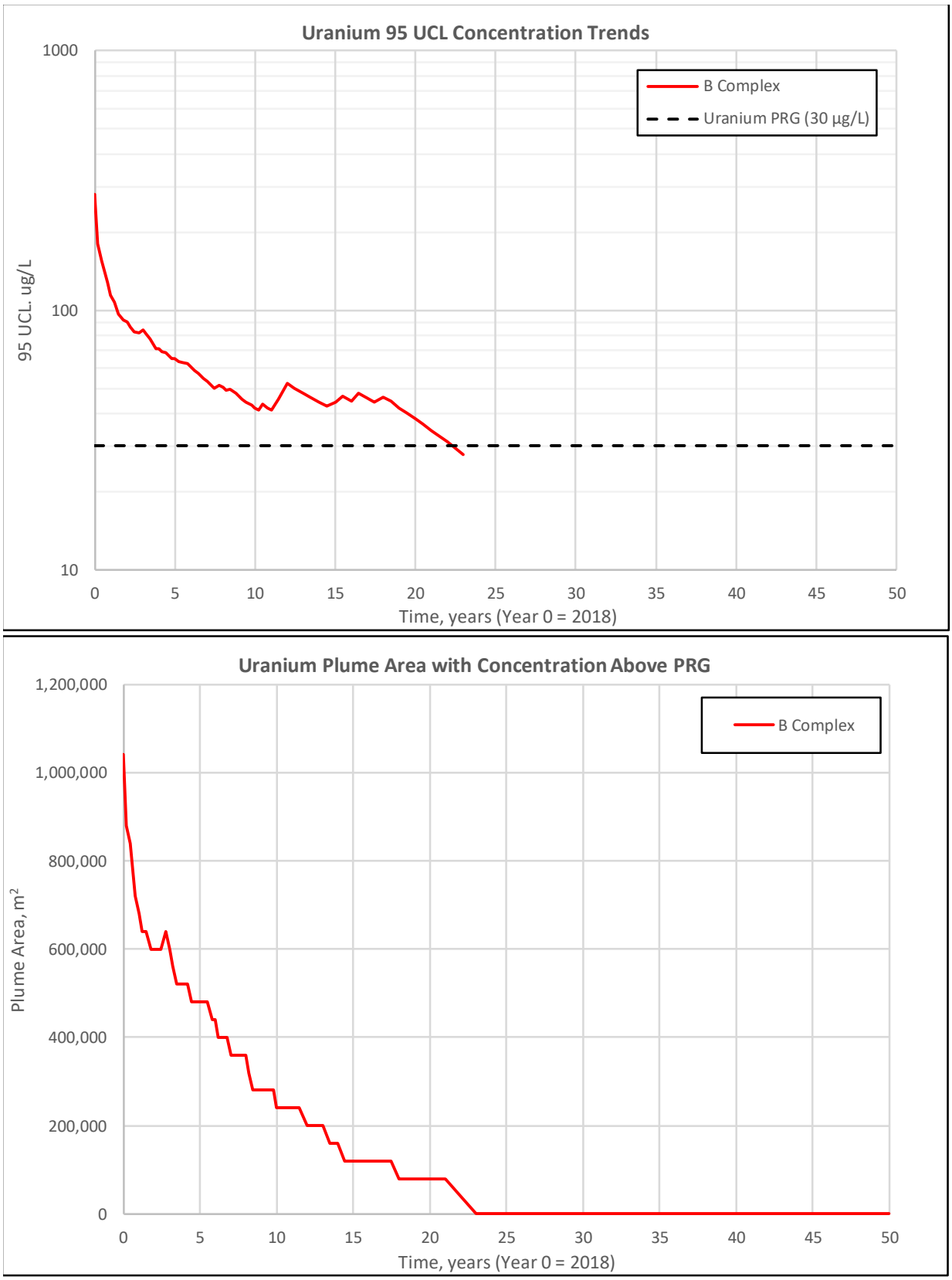


Figure 6-6. Alternative 3 – Predicted Uranium 95 UCL Concentrations and Plume Areas

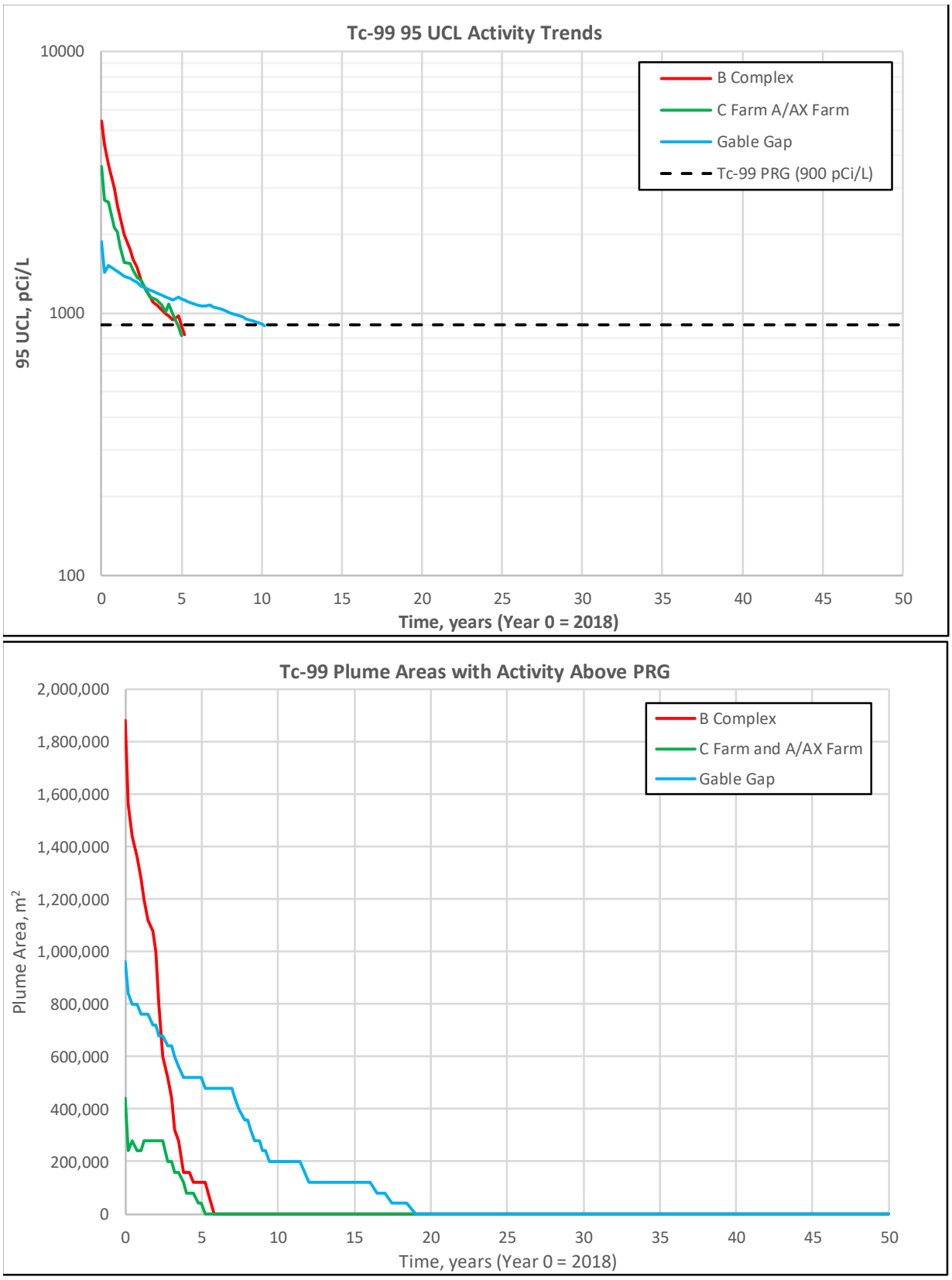


Figure 6-7. Alternative 3 – Predicted Technetium-99 95 UCL Activities and Plume Areas

Alternative 3 performs very well with respect to reducing TMV through treatment criterion, with minimal disadvantages or uncertainties. Alternative 3 provides greater TMV reduction in terms of plume area and volume of contaminated groundwater remediated (compared to Alternative 2) by addressing the Gable Gap technetium-99 plume. The estimated plume areas and groundwater volumes remediated (Table 6-4) are based on the no-continuing-source assumption. Contaminants are physically removed from the aquifer through groundwater P&T. Extracted groundwater is treated at the existing 200 West P&T, where uranium and technetium-99 (and cyanide) are transferred from the groundwater onto solid IX resin material. Co-contaminants nitrate and cyanide are treated using biodegradation. Spent IX resin is disposed at the ERDF. While IX treatment and ERDF disposal do not represent destruction, uranium and technetium-99 toxicity and mobility in groundwater are reduced.

Alternative 3 performs well with respect to the short-term effectiveness criterion, with minor disadvantages or uncertainties. P&T in Gable Gap shortens the predicted cleanup times for uranium and, to a lesser degree, technetium-99 in B Complex groundwater. However, Alternative 3 has a greater potential for impacts to the community, workers, and the environment than Alternative 2 due to its larger remedial footprint, as well as the associated greater amount of construction, operating equipment, and water volume conveyed and treated.

Alternative 3 performs fair with respect to the implementability criterion, with some disadvantages or uncertainties. This alternative uses technologies (groundwater P&T and ICs) that are mature, well demonstrated, and widely used at the Hanford Site. However, a new (third) technetium-99 IX train and a new (third) air stripper system would need to be constructed at the 200 West P&T to accommodate the water generated by this alternative. Alternative 3 also requires more new pipelines and transfer (pump) stations than Alternative 2. Other than these issues, no major technical or administrative impediments to implementing this alternative are anticipated.

The total present value cost of Alternative 3 is estimated at $245 million. Most of the cost (roughly 86%) is associated with O&M. Table 6-4 provides additional cost information.

6.3 Comparative Evaluation of Alternatives

This section compares the advantages and disadvantages of the alternatives to identify key tradeoffs that should be noted to support identification of a preferred alternative. The comparative evaluation is summarized in Table 6-5 and discussed in the following sections.

6.3.1 Overall Protection of Human Health and the Environment

Alternatives 2 and 3 protect human health and the environment through groundwater P&T and maintenance of ICs to prevent exposure until P&T achieves compliance with PRGs and by preventing expansion of contamination into less contaminated or uncontaminated portions of the aquifer. Alternative 1 does not protect human health and the environment.

Table 6-5. Comparative Evaluation of Alternatives

Criterion	Alternative 1 – No Action	Alternative 2 – P&T at B Complex and C Farm and A-AX Farms	Alternative 3 – P&T at B Complex, C Farm and A-AX Farms, and Gable Gap
Threshold Criteria			
Protects human health and the environment	No	Yes	Yes
Complies with applicable or relevant and appropriate requirements	No	Yes	Yes
Balancing Criteria			
Long-term effectiveness and permanence	Not evaluated	★★★☆	★★★★
Reduction of toxicity, mobility, or volume through treatment	Not evaluated	★★★☆	★★★★
Short-term effectiveness	Not evaluated	★★★☆	★★★☆
Implementability	Not evaluated	★★★☆	★★☆☆
Cost			
Total present value cost	$0	$199,000,000	$245,000,000
Total present value cost range:			
−30%	$0	$139,000,000	$172,000,000
+50%	$0	$299,000,000	$368,000,000
Modifying Criteria			
Community acceptance	To be evaluated following issuance of the Proposed Plan.		

Note:

★★★★ = Performs superior against the CERCLA balancing criterion with no disadvantages or uncertainties.

★★★☆ = Performs well against the CERCLA balancing criterion with minor disadvantages or uncertainties.

★★☆☆ = Performs fair against the CERCLA balancing criterion with some disadvantages or uncertainties.

★☆☆☆ = Performs poor against the CERCLA balancing criterion with more disadvantages or uncertainty.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

P&T = pump and treat

6.3.2 Compliance with Applicable or Relevant and Appropriate Requirements

Alternatives 2 and 3 are expected to achieve compliance with chemical-specific ARARs for the target COCs (uranium and technetium-99) in the targeted remediation area plumes within the 25-year project life, assuming no continuing source (Figures 6-8 through 6-11). Uncertainties include the need for source control to achieve the predicted cleanup times based on the no-continuing-source assumption, as well as the residual concentrations/activities of co-contaminants not specifically addressed by the interim action. An additional uncertainty associated with Alternative 2 is that current fate and transport modeling predicts a cleanup time for uranium in the B Complex that is slightly longer than the 25-year project life (28 years). However, it is expected that concentrations below the uranium PRG could be achieved by optimizing extraction well placement and extraction flow rates.

Alternative 1 includes no remedial action, so action- and location-specific ARARs are not triggered. Alternatives 2 and 3 would be designed and implemented in accordance with an RD/RAWP to comply with action- and location-specific ARARs.

Treated groundwater will comply with the requirements of the 200-ZP-1 OU ROD (EPA et al., 2008, *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site Benton County, Washington*) by meeting the treated effluent criteria ARARs for the 200 West P&T.

6.3.3 Long-Term Effectiveness and Permanence

Alternative 3 provides further reduction in residual risk by remediating technetium-99 in the Gable Gap plume, whereas Alternative 2 does not address Gable Gap groundwater. Otherwise, the Alternatives 2 and 3 perform similarly against the long-term effectiveness and permanence criterion.

6.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 3 results in more TMV reduction in terms of plume area and contaminated groundwater volume remediated (Tables 6-3 and 6-4) because it addresses technetium-99 in the Gable Gap plume whereas Alternative 2 does not. The same technologies are used by both alternatives (groundwater P&T and ICs). Consequently, the Alternatives 2 and 3 perform similarly against the other sub-criteria under the reduction of TMV through treatment criterion.

6.3.5 Short-Term Effectiveness

Alternatives 2 and 3 perform similarly with respect to the short-term effectiveness criterion. Alternative 3 is predicted to result in a slightly shorter time to achieve the uranium PRG in B Complex (22 years) than Alternative 2 (28 years), although it is expected that the cleanup timeframe for Alternative 2 can be shortened through optimization. However, Alternative 3 involves a larger remediation footprint, leading to somewhat greater potential for impacts to the community, workers, and the environment due to the greater amount of construction, operating equipment, and water volume conveyed and treated.

6.3.6 Implementability

Both Alternatives 2 and 3 use mature technologies that are well proven, readily available, and widely used at the Hanford Site. While both Alternatives 2 and 3 require similar modifications of the 200 West P&T, Alternative 2 is rated slightly higher for implementability because Alternative 3 requires more new pipelines and transfer stations than Alternative 2.

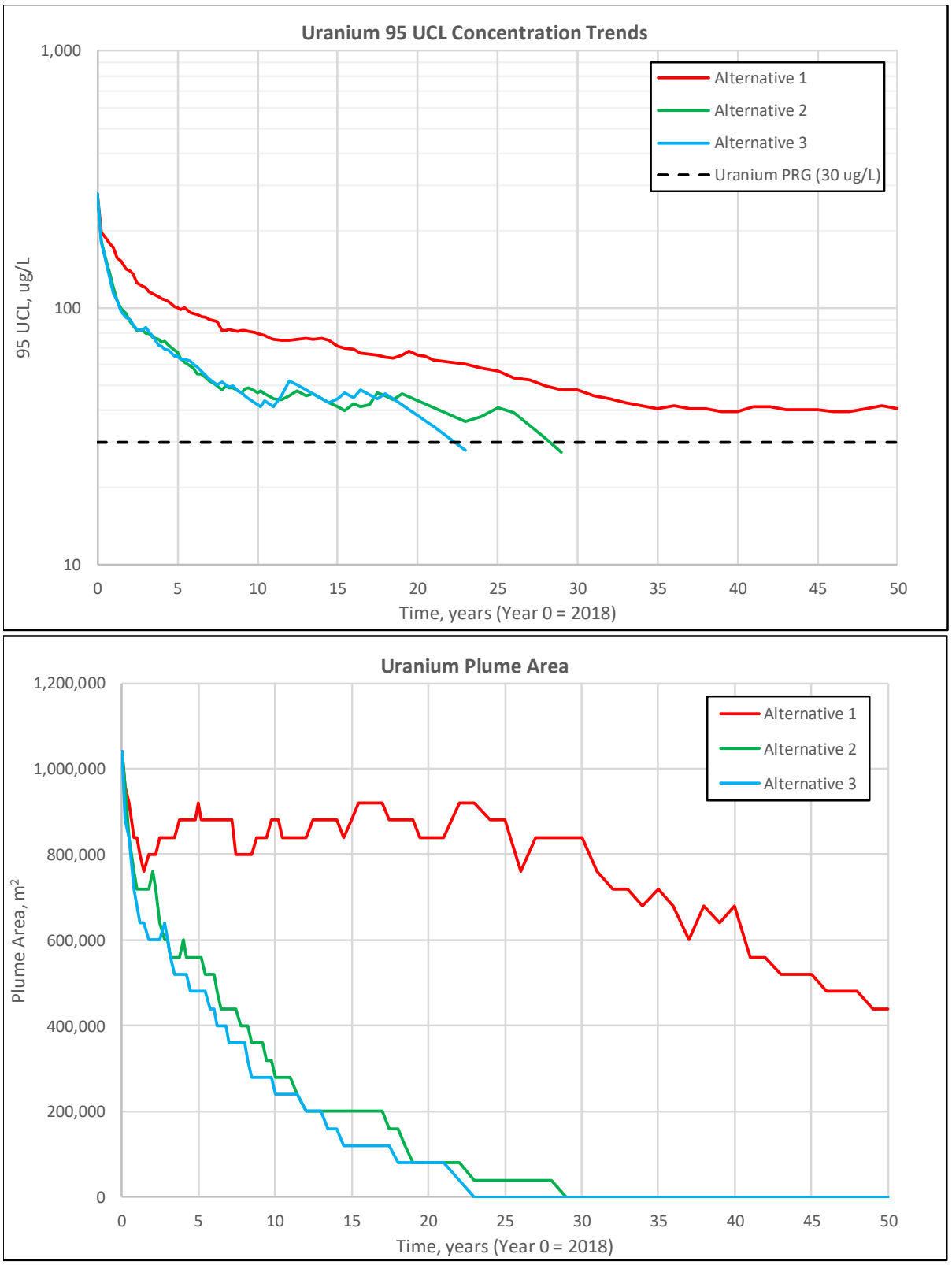


Figure 6-8. Alternatives Comparison – Predicted Uranium 95 UCL Concentrations and Plume Areas in B Complex

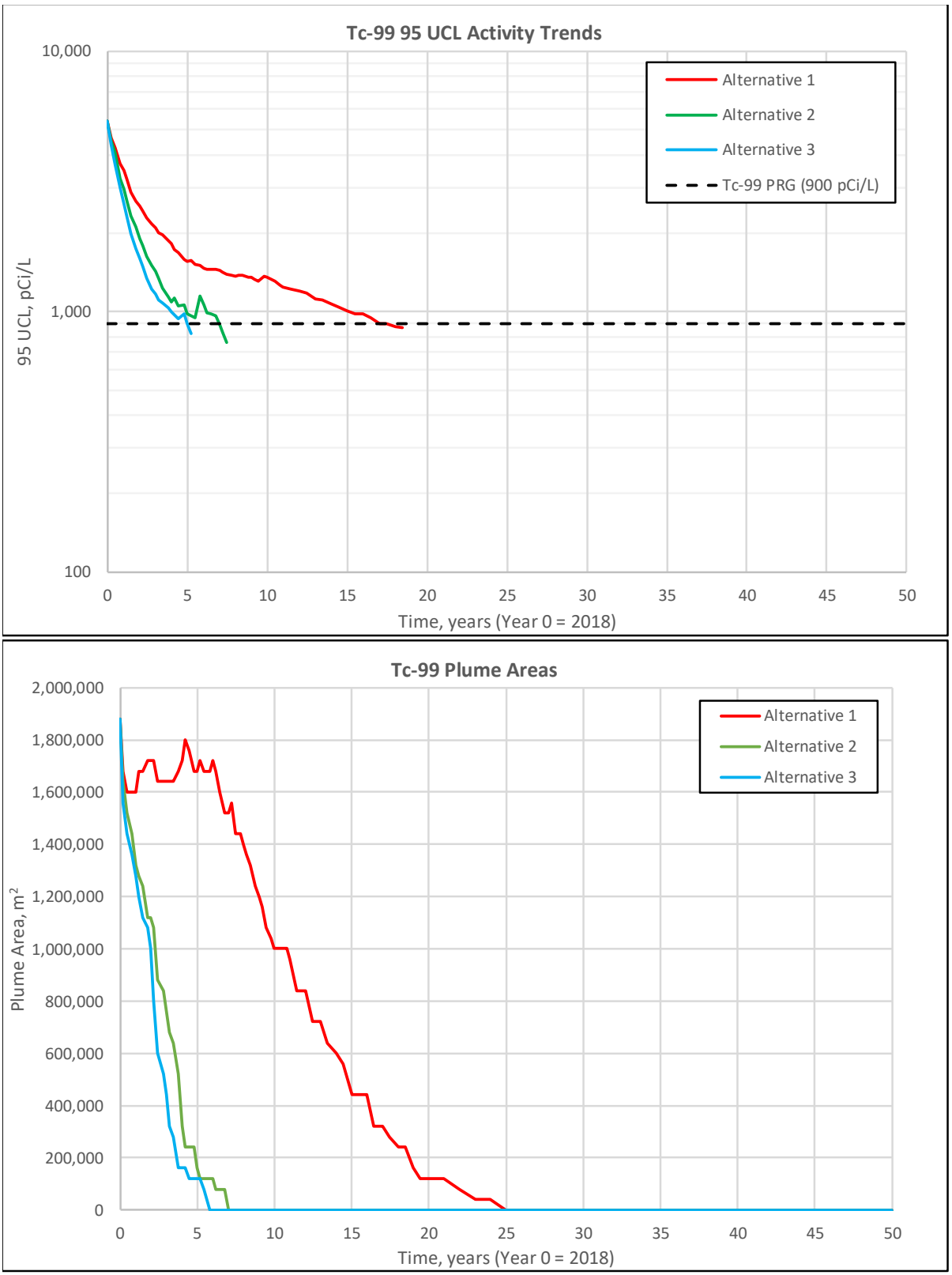


Figure 6-9. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in B Complex

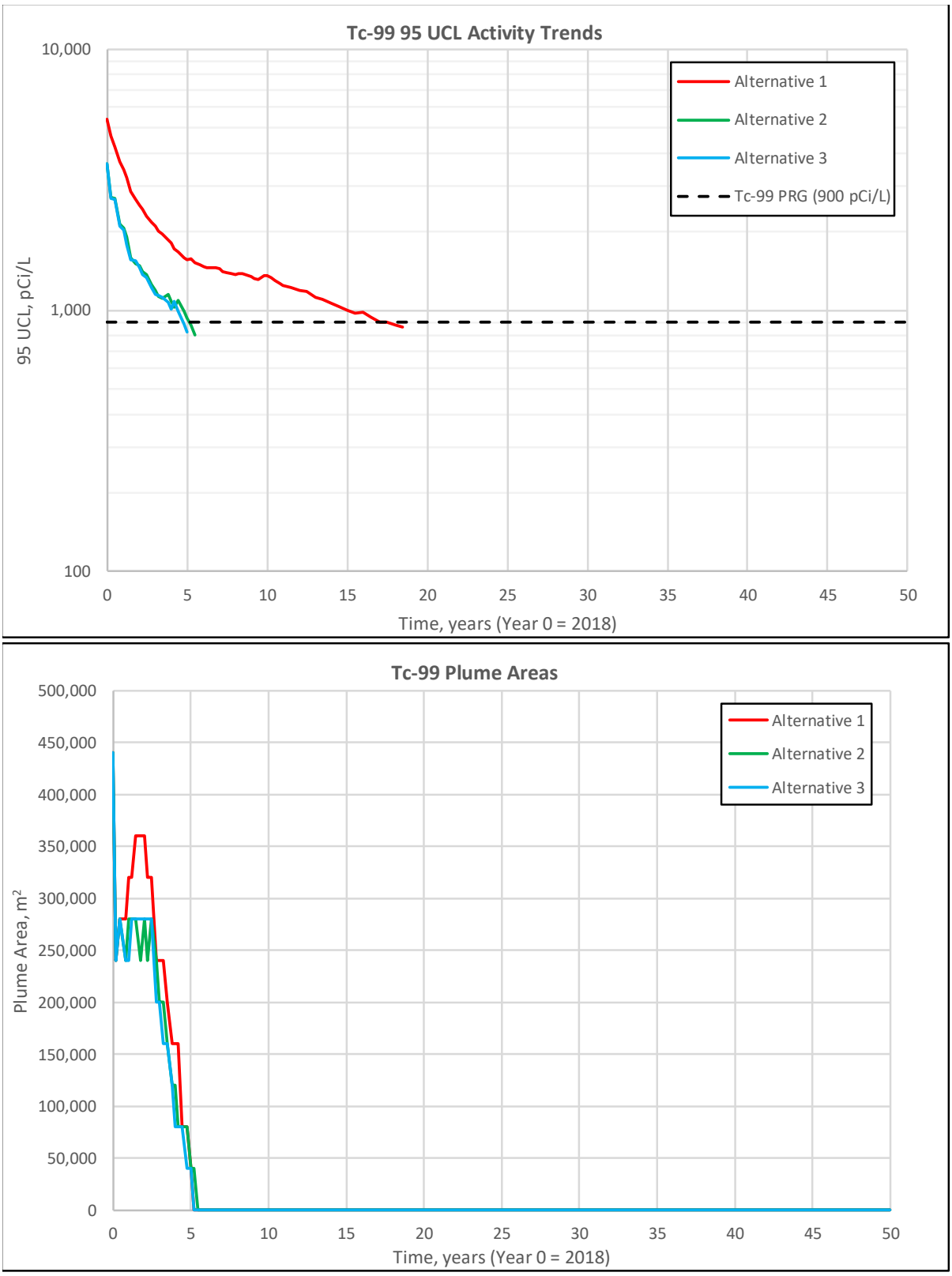


Figure 6-10. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in C Farm and A-AX Farms

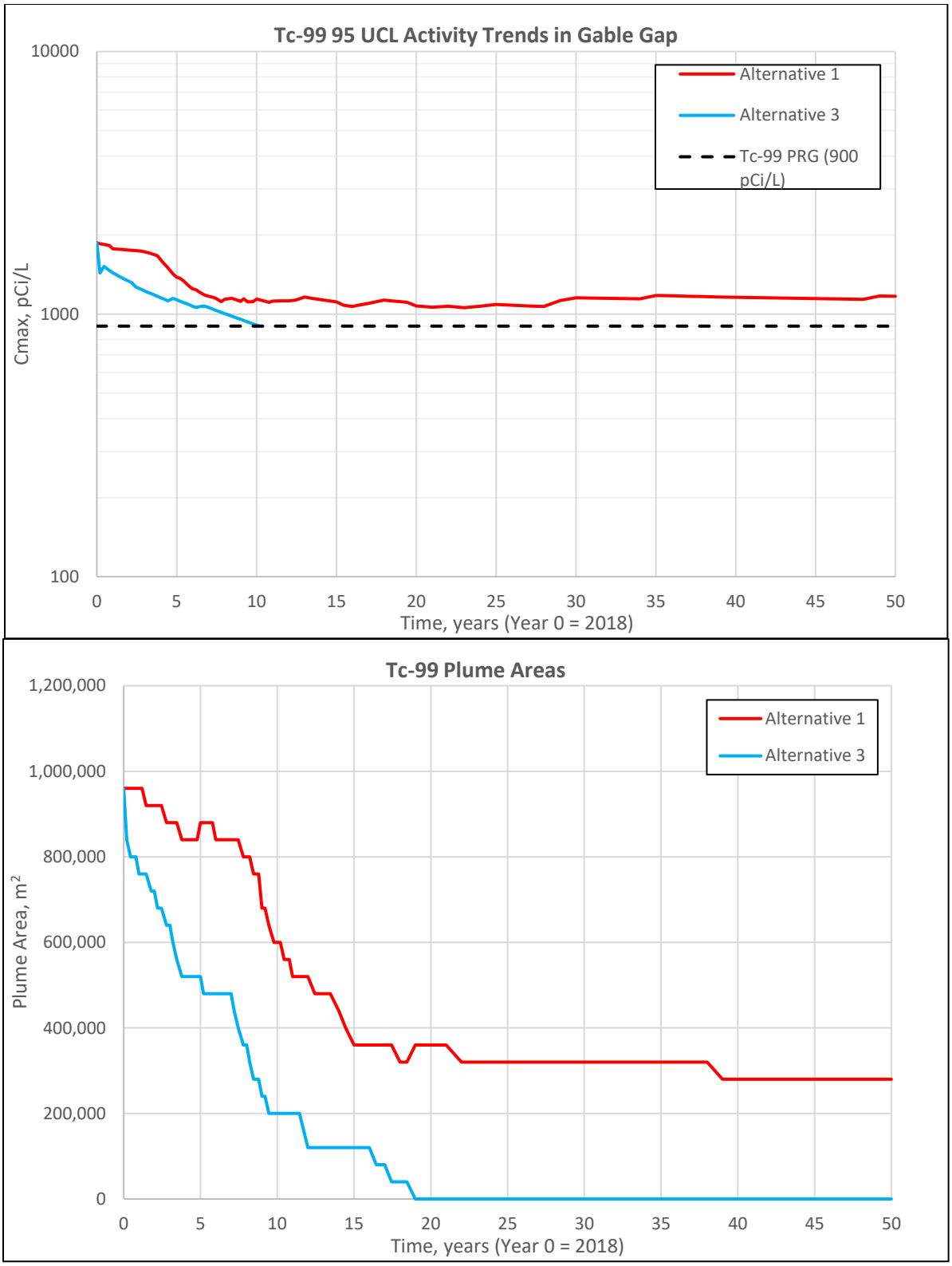


Figure 6-11. Alternatives Comparison – Predicted Technetium-99 95 UCL Activities and Plume Areas in Gable Gap

6.3.7 Cost

The estimated total present value cost of Alternative 2 ($199 million) is $46 million less than the estimated total present value cost of Alternative 3 ($245 million). Thus, on a total net value cost basis, the estimated cost of Alternative 3 is approximately 23% higher than the cost of Alternative 2.

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Appendix A

ECF-HANFORD-18-0023, Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives

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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

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Environmental Calculation File

Evaluation of Contaminant Transport for the 200-BP-5 and 200-PO-1 Operable Units Feasibility Study Evaluation of Remedial Alternatives

Contents

1 Purpose **1**

2 Background **1**

3 Methodology **2**

3.1 P&T Scenario Analysis Goals 3

3.2 Ranking Metrics 3

3.2.1 Model Regions 3

3.2.2 Summary Statistics 4

3.3 Developing Individual Simulations 5

3.3.1 Identify Well Location and Rate 5

3.3.2 Modify Simulation Inputs and Executing Simulations 6

3.3.3 Post Processing Results 6

3.4 Remedial Evaluation Case 7

4 Assumptions and Inputs **8**

4.1 Extraction and Injection Wells 8

4.2 Initial Conditions 12

4.2.1 Contaminant Concentration 12

5 Software Applications **13**

5.1 Approved Software 13

5.1.1 MODFLOW-2000-MST 13

5.1.2 MT3DMS-MST 14

5.1.3 MODFLOW & Related Codes Support Software 15

5.2 Software Installation and Checkout 15

5.3 Statement of Valid Software Application 16

6 Calculation **16**

6.1 Assessing Plume Migration for Existing Plumes 16

6.1.1 Plan View Contours 16

6.1.2 Statistical Summary Chart 17

7 Results **18**

8 References **21**

Attachments

A. **Software and Installation Checkout Form** 23

B. **Simulation results from Selected P&T Scenarios** 26

Figures

Figure 3.1 – Locations of model domain sub regions used to evaluate simulation results. 4
Figure 3.2 – Location of wells used as part of the scenario analysis in support of the 200-East FS 6
Figure 4.1 – Simulated nitrate concentration over time illustrating the tendency of contamination to stagnate in low transmissivity areas of the model (highlighted in red). 10
Figure 4.2 – Estimated transmissivity map for 200-East based on the simulated transmissivity field in the P2R model. 11
Figure 6.1 – Plan view contours of the nitrate plume at simulation time 20 years based on average concentration initial conditions. 17
Figure 6.2 – Statistical summary of simulated concentration within subregions of the model domain for the cyanide plume for average concentration initial conditions. 18

Tables

Table 2-1. P2R Model Well Locations 2
Table 3.1 – Location and rates of injection and extraction wells for all simulation sets developed for the evaluation scenarios to support the 200-East FS. 8
Table 4.2 - Vadose Zone COPC Continuing Sources 12
Table 7.1 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Complex Area. 19
Table 7.2 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Waste Management Area C. 20
Table 7.3 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Plant Area (including the Greater 200 East Area). 20
Table 7.4 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Gable Gap Area. 21

Terms

BCM	B-Complex
COC	contaminant of concern
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DST	distal
ECF	environmental calculation file
F&T	fate-and-transport
FS	feasibility study
G2E	Greater 200 East
GGP	Gable Gap
P&T	pump-and-treat
P2R	Plateau to River (model)
REC	remediation evaluation case
RI	remedial investigation
TEDF	Treated Effluent Disposal Facility
WMC	waste management complex

1 Purpose

The calculation described in this environmental calculation file (ECF) is part of the combined Feasibility Study (FS) of groundwater remedial alternatives for the 200-BP-5 and 200-PO-1 Operable Units (collectively referred to herein as 200 East). The purpose of the FS is to provide a comparison of potential remedial actions for cleanup of groundwater in 200 East area of the U.S. Department of Energy's (DOE's) Hanford Site. The remedial actions evaluated in the FS are limited to pump and treat (P&T) alternatives. The method of evaluation is fate and transport (F&T) modeling. The outcome of the FS will be to determine if P&T is a viable remedial alternative and to provide a description of a feasible range of extraction and injection well configurations (including well locations and rates) that can be used as the basis for the design of such a system.

The objective of this modeling calculation is to provide a description of current and expected future groundwater contaminant concentrations with and without the effects of various P&T scenarios developed as part of the RI/FS process. The model was used to calculate the fate and transport of eight contaminants of potential concern (COPCs). These include:

- For the 200-PO-1 FS: cyanide, tritium, strontium-90, iodine-129, technetium-99, nitrate, and uranium
- For the 200-BP-5 FS: tritium, strontium-90, iodine-129, technetium-99, nitrate, chromium, cyanide, and uranium

The P&T scenarios developed for assessing an effective cleanup strategy focused on technetium-99, uranium, and nitrate as the key drivers of risk. Given that multiple factors may impact COPC fate and transport, sensitivities of the calculation to initial contaminant distribution, potential for continuing vadose zone sources of COPCs, and the potential influence of future liquid discharge at the Treated Effluent Disposal Facility (TEDF) were modeled for the range of P&T configurations.

2 Background

The F&T model used to perform simulations supporting the 200-East RI/FS is the Plateau-to-River (P2R) Model. This is the same model applied for evaluation of baseline future groundwater conditions in the Remedial Investigation (RI) reports for the 200-BP-5 and 200-PO-1 Operable Units (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*, and DOE/RL-2009-85, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit*, respectively). The P2R Model is documented in CP-57037, *Model Package Report: Plateau to River Groundwater Transport Model (Version 7.1)*, and in ECF-HANFORD-13-0031, *Fate and Transport Modeling for Baseline Conditions for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*. Detailed information concerning the model construction, calibration, and application for baseline conditions are found in those reports.

The scenarios presented in this ECF are based on simulations using the P2RGWM reported in ECF-HANFORD-13-0031. It must be noted that some wells in the 200 West area were not located correctly in those model files. The following table lists those wells and shows their updated location information.

Table 2-1. P2R Model Well Locations

Well Name	ECF-HANFORD-13-0031[a] Simulated Locations		Updated Locations	
	Row	Column	Row	Column
IW-3-I	40	Column	41	33
IW-2-Cr	41	19	53	30
IW-2-I	41	20	43	33
IW-1-I	43	33	45	33
EW-2-Cr	43	15	48	40
IW-1-Cr	45	33	49	28
EW-1-Cr	45	15	50	35
EW-1-Tc	45	16	43	15
EW-2-Tc	48	33	45	15
EW-3-Tc	49	40	45	16
EW-2-U	50	28	41	20
EW-1-U	53	35	40	19

a. ECF-HANFORD-13-0031, *Fate and Transport Modeling for Baseline Conditions for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Unit*.

To maintain configuration management and consistency with this ECF, those well locations are not updated in this ECF. These wells are well outside the area of interest for the alternatives evaluations presented in this ECF, and the updated locations do not impact the relative performance of these alternatives. It is recognized that future evaluations in support of the 200-BP-5 and 200-PO-1 RD/RA WP will utilize updated models, including updated initial conditions, pumping rates, and well locations.

3 Methodology

Developing a set of simulations to evaluate possible remedial strategies for 200-East included was completed in several steps. These include, 1) development of a set of goals to guide the evaluation process; 2) determining the metric used to rank the effectiveness of the scenarios at achieving the remedial goals; 3) completing individual simulations for comparing P&T scenarios; and 4) establishing the remedial evaluation case or the parameters and inputs that will reflect the expected behavior of the plume for comparison to the various P&T scenarios. Each of these steps is discussed in the following sections.

3.1 P&T Scenario Analysis Goals

A set of goals was developed in order to guide the development of the P&T analysis and comparison. These goals were established in order ensure that the simulated scenarios provided the information necessary to make a reasonable comparison. These included:

- Simulate at least a 50-year duration to match the total remedy duration identified as part of the FS process.
- Present a range of P&T scenarios that show a progression of aggressiveness toward reaching remedial goals
- Limit P&T duration to 25 years and vary the number and extraction/injection rate of wells to achieve cleanup within this time frame.

These guidelines were used to develop the individual MODFLOW/MT3D simulations used to compare the effectiveness of P&T scenarios.

3.2 Ranking Metrics

MT3D-MST results provide an estimate of concentration for each computational cell at each time for the entire model domain. In order to assimilate all of this information into a useful narrative it is often useful to develop summary statistics for the entire model and for separate regions of the model. These statistical measures can be used to compare between separate P&T scenarios. They can also be used as metrics for establishing the rank of effectiveness for the P&T scenarios at remediating portions of and/or the entire model. This section describes the methods used to calculate the metrics used to compare the various P&T scenarios.

3.2.1 Model Regions

At times it is useful to evaluate the model as a whole and/or based on sub regions of the model. This provides a method to compare the P&T scenarios effectiveness on the local scale and on the model scale. For the scenario analysis a set of sub regions was developed based on both the plume geometry and the location of infrastructure at 200-East in order to compare simulation results. Figure 3.1 shows the 6 sub regions developed for evaluating the model results. These include the B-complex, B-plant, WMA C, Gable Gap, Gable Mountain Pond, and Distal Plume sub regions. When summary statistics are calculated for the entire model all computational cells in the model domain are used for the calculation. When the statistics are calculated for the sub region, only those computational cells within the boundary of the sub region are used for the calculation.

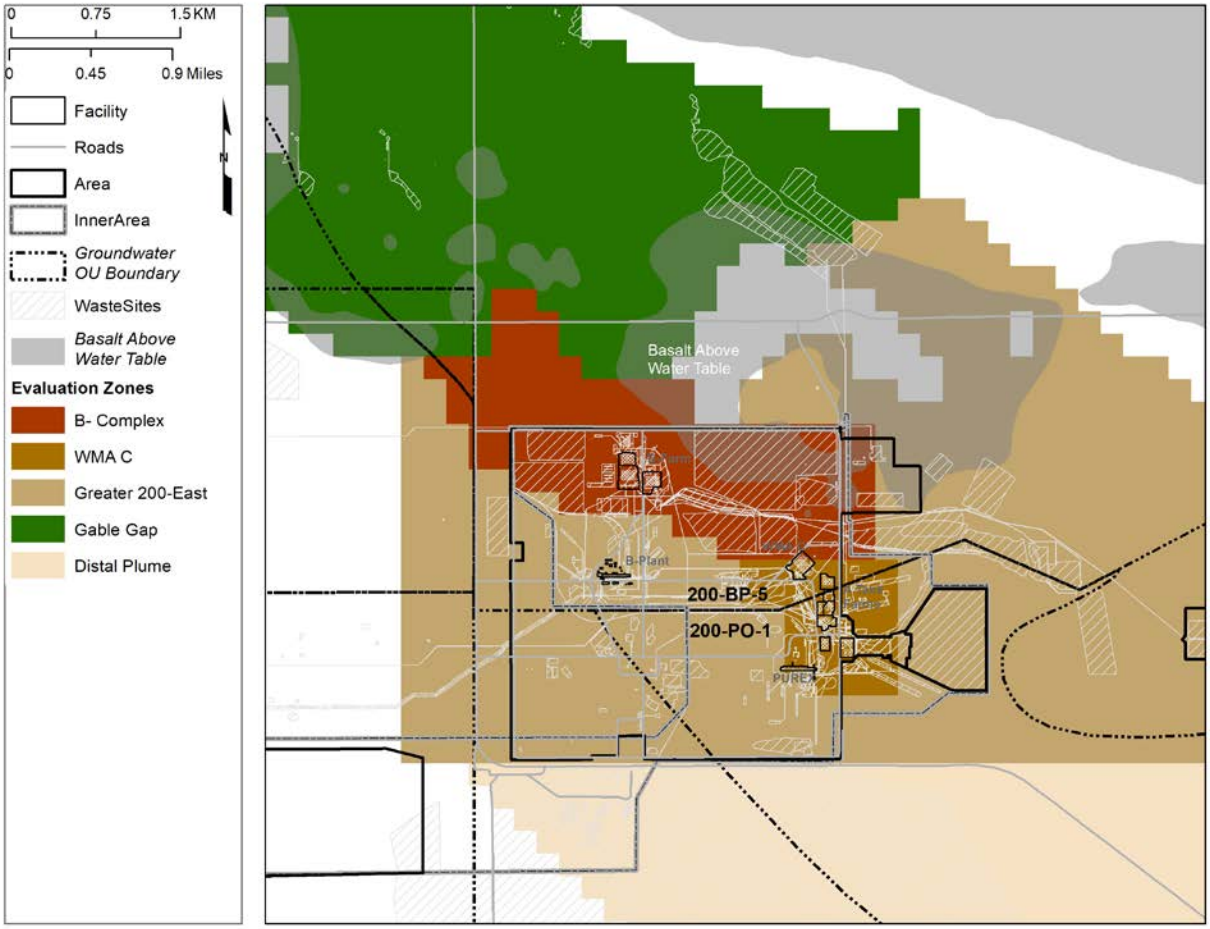

Figure 3.1 – Locations of model domain sub regions used to evaluate simulation results.

3.2.2 Summary Statistics

The primary statistics used to analyze the results of F&T modeling for the COCs were the peak, the 90th percentile, and the arithmetic mean concentration. The 90th percentile rank is calculated for the simulated results for comparison with regulatory standards to assess cleanup times. For all calculations of summary statistics, when the estimated concentration at any computational cell location falls below half of the cleanup level (DWS) the cell was not included in the calculation of the summary statistics. The calculation of each summary statistic is described further in the following sections.

3.2.2.1 Peak

The peak concentration refers to the highest magnitude concentration at any computational cell within its corresponding region.

3.2.2.2 90th Percentile

The 90th percentile calculation is carried out non-parametrically using a Weibull ranking scheme. The values for all cells are tabulated, sorted based on concentration value, and a rank is applied to the sorted data based on Equation 3.1. The concentration whose plotting position has the exact value of 0.9 is selected as the 90th percentile concentration. However, in most cases no concentration will have an exact

rank of 0.9. Therefore, in these cases, the two values with ranks closest to 0.90, above and below, are selected and the 90th percentile concentration is selected by linearly interpolating between these values using the rank as the weighting factor.

$$P = r/(n+1) \qquad \text{Equation 3.1}$$

where, P = Weibull plotting position
r = rank of data point
n = number of samples

3.2.2.3 Mean

The arithmetic mean is calculated by summing the estimated concentration value for each cell within the region and dividing by the number of cells within the region. Only those cells above half the cleanup level are considered a part of the calculation.

3.3 Developing Individual Simulations

Individual simulations were developed based on the guidelines above and through an iterative process of running simulations, reviewing the results, and developing new P&T scenarios based on the analysis goals and the information obtained from the previous simulations. A total of 3 P&T scenarios were developed as part of the analysis in addition to a no action scenario (4 modeling scenarios). These simulations are summarized in Table 3.1. The steps used in developing these simulations included the following steps:

- Identifying the location and rates of wells
- Modifying the model inputs and executing the simulation
- Post-processing and evaluating the results

Each of these steps is discussed in the following sections.

3.3.1 Identify Well Location and Rate

The locations of all wells used at some point in the scenario analysis are shown in Figure 3.2. These locations were initially selected based on previously constructed extraction wells (299-E33-268 and 299-E33-36) and on areas where plume concentrations were of the greatest magnitude. Once the initial simulations were completed the locations were adjusted based on the resulting F&T of the contaminant plumes over the duration of the simulation. The extraction/injection rates ranged from a total of 250/0 gallons per minute (gpm) to 425/100 gpm in the simulations. These were also adjusted in an iterative manner based on the simulation results. Table 3.1 illustrates how changes progressed through the iterative process. All wells were simulated as fully penetrating wells with the exception of wells targeting the B-Plant plume. These wells were simulated in order to focus remediation within the deeper portions of the unconfined aquifer.

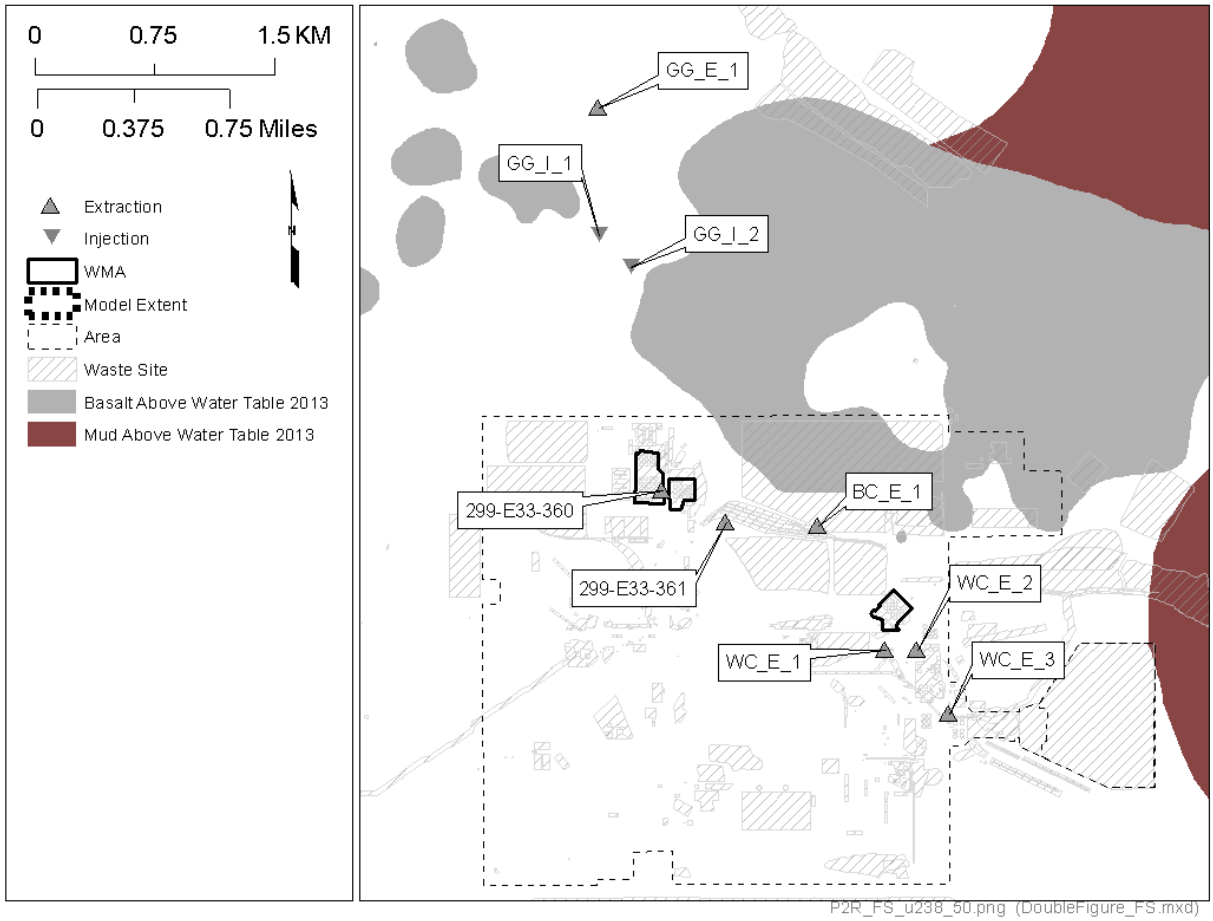

Figure 3.2 – Location of wells used as part of the scenario analysis in support of the 200-East FS.

3.3.2 Modify Simulation Inputs and Executing Simulations

The MODFLOW discretization and the multi-node well (MNW2) package for the P2R model were altered as part of the simulations involved in the P&T scenario analysis. The discretization package was altered to reflect a shortened time frame of evaluation. All simulations were carried out for a 50-year period. The MNW2 package was altered for each simulation to reflect the extraction/injection rates, duration, and locations listed in Table 3-1. The WEL package was unaltered from the P2R model.

The MODFLOW and MT3DMS software programs were used to simulate groundwater flow and contaminant transport, respectively. MODFLOW solves the groundwater flow equation to calculate hydraulic heads and groundwater flow velocities. MT3DMS uses the resultant groundwater flow velocities, along with transport properties of the aquifer and contaminants, to solve the groundwater advection-dispersion equation, yielding concentrations in time and space. These resultant concentration estimates were used to evaluate the future conditions of plumes based on the simulated P&T scenarios.

3.3.3 Post Processing Results

After completion of the MODFLOW/MT3D simulations the estimated concentrations were post-processed to provide summary statistics tables and charts and plume concentration contour maps for the

200-East area. These products were utilized to compare results between P&T scenarios and make adjustments for subsequent scenario simulations. Post-processing was completed using several applications designated as support software for the MODFLOW/MT3D. These include PEST, ArcGIS®[1], Tecplot®[2] and R software package were used to process these results. PEST utilities were used to provide the summary statistic estimates presented in 3.2.2, Tecplot and ArcGIS were used to prepare the plume concentration contour maps, and the R software package was used to tabulate the time to cleanup and create chart summary statistics over time.

3.4 Remedial Evaluation Case

The remedial evaluation case provides a baseline set of simulation results that can be used to compare subsequent simulations in order to assess P&T effectiveness. Key features of the remedial evaluation case for the 200-East FS include:

- Initial distribution of contaminant concentration is based on the averaging concentrations from the annual report plumes within the boundary of each computational cell.
- No continuing source is considered for any contaminant plumes.
- Discharge from TEDF is assumed to occur.

While this case provides a baseline for assessing the effectiveness of the P&T scenarios, the value of simulating other conditions than those listed above provides an assessment of the uncertainty in the numerical model. Therefore, other conditions than those provided above were simulated to address the uncertainty that exists in the assumptions used to rank the P&T scenarios. The model inputs affecting the remedial evaluation case are discussed in detail in Section 4 of this ECF.

[1] ArcGIS® is a registered trademark, or service mark, of ESRI in the United States, the European Community, or certain other jurisdictions.

[2] TecPlot is a registered trademark of Tecplot, Inc., Bellevue, Washington.

Table 3.1 – Location and rates of injection and extraction wells for all simulation sets developed for the evaluation scenarios to support the 200-East FS.

Well Name	X	Y	Scenario			
			1	2	3	4
C8923 (299-E33-360)	573772.1	137386.9	0	-75	-75	-75
C8924 (299-E33-361)	574069.3	137122.3	0	-75	-75	-75
BC_E_1	574900	137100	0	0	0	-75
WC_E_1	575100	136300	0	-33.3	-33.3	-33.3
WC_E_2	575300	136300	0	-33.3	-33.3	-33.3
WC_E_3	575500	135900	0	-33.3	-33.3	-33.3
GG_E_1	573300	139700	0	0	-100	-100
GG_I_1	573300	138900	0	0	50	50
GG_I_2	573500	138700	0	0	50	50
B Complex	Total EXT		0	-150	-150	-225
	Total INJ		0	0	0	0
WMA C	Total EXT		0	-100	-100	-100
	Total INJ		0	0	0	0
Gable Gap	Total EXT		0	0	-100	-100
	Total INJ		0	0	100	100
Total Extraction			0	-250	-350	-425
Total Injection			0	0	100	100

4 Assumptions and Inputs

All model properties, initial conditions and boundary conditions are drawn from the P2R Model. A full description of the P2R Model provided in CP-57037 (Appendix F), and its application to simulate contaminant F&T for the scenarios is detailed in ECF-HANFORD-13-0031. The inputs and assumptions presented in the previous reports documenting the P2R model are inherited by the use of the model for this application. Only those assumptions and inputs unique to this application of the P2R model will be presented in this ECF. In this section the development of the extraction well network, the initial contaminant plumes, and the continuing source terms used in the modeling will be discussed.

4.1 Extraction and Injection Wells

The extraction and injection wells associated with the P&T systems evaluated are modeled using the Modified Multi-Node Well Package (MNW2) available as part of MODFLOW. The locations of all wells evaluated as part of the analysis are shown in Figure 3.2. Pump-and-treat remediation schemes have been developed at the Hanford site to aid in the cleanup effort. The process of selecting well locations was discussed in Section 3.

As part of the RI simulation development, documented in ECF-HANFORD-13-0031, several features of the predicted fate and transport of the contaminant plumes were documented that affected the placement of the extraction/injection wells. These included the development of stagnation zones where contamination remained present for a longer than expected duration based on the behavior of the adjacent plume. Figure 4.1 shows the nitrate concentration at simulations times 0, 20, and 50 years. While much of the plume disperses from 0 to 20 years, near Gable Mountain Pond and B-plant portions of the plume remain until past the 50 years.

The locations in the model where the plumes persist correspond to the locations of low transmissivity within the aquifer. Figure 4.2 shows the transmissivity map developed based on the calibrated groundwater flow model. Each of the locations showing persistent contamination past 50 years is associated with a location within the model domain that is estimated to have a relatively lower transmissivity than the surrounding aquifer. Placement of the extraction/injection wells was conducted with consideration for the total transmissivity of the aquifer in order to minimize the stagnation zones that appeared within the simulated model domain. In some cases, placement of extraction wells decreased transmissivity causing stagnation in locations where it had they had not previously occurred. Also, in some instances injection wells were placed in locations to increase the transmissivity in order to promote movement out of stagnation zones towards extraction wells. Developing the final set of scenarios was based on an iterative process of executing simulations and interpreting simulation results.

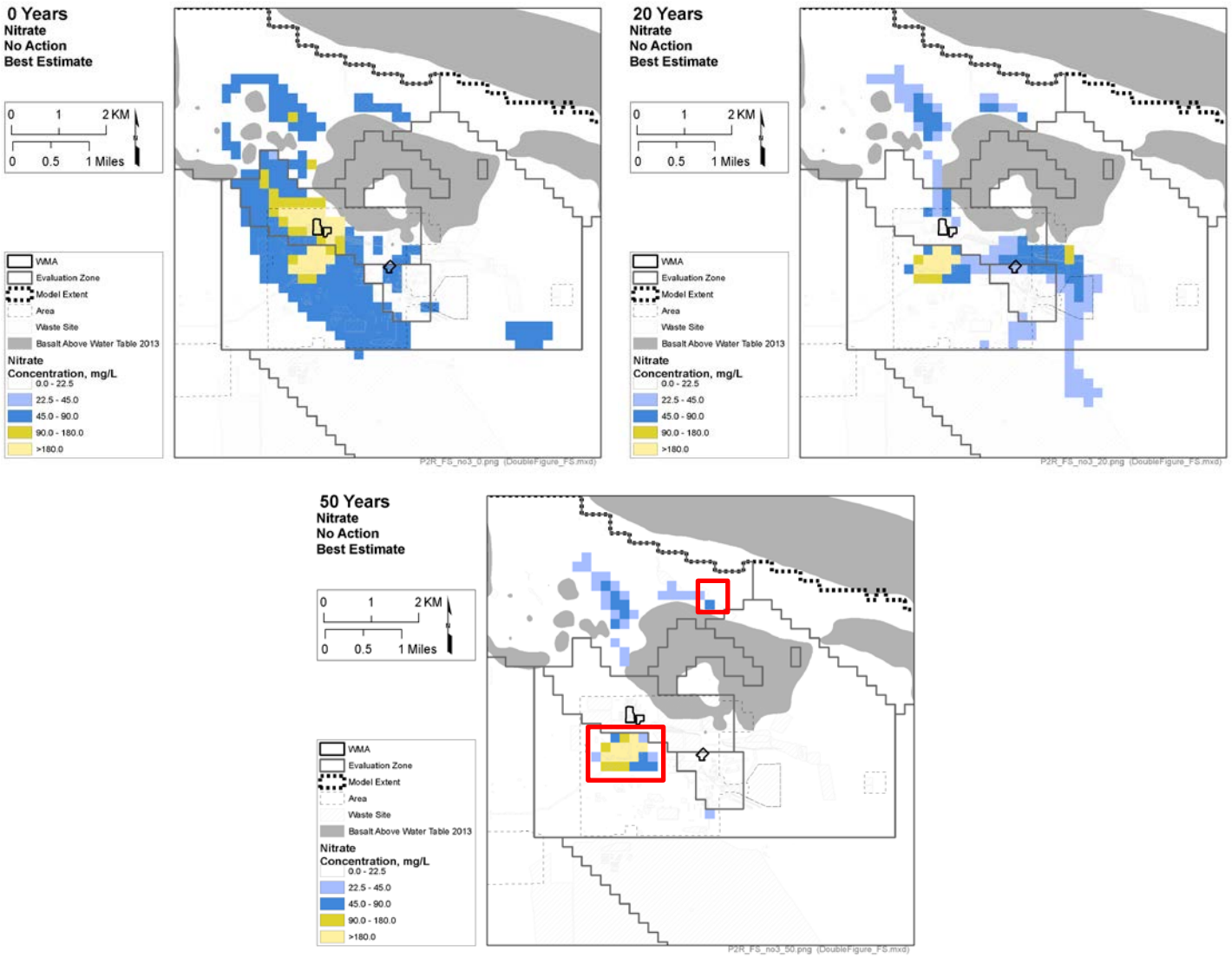

Figure 4.1 – Simulated nitrate concentration over time illustrating the tendency of contamination to stagnate in low transmissivity areas of the model (highlighted in red).

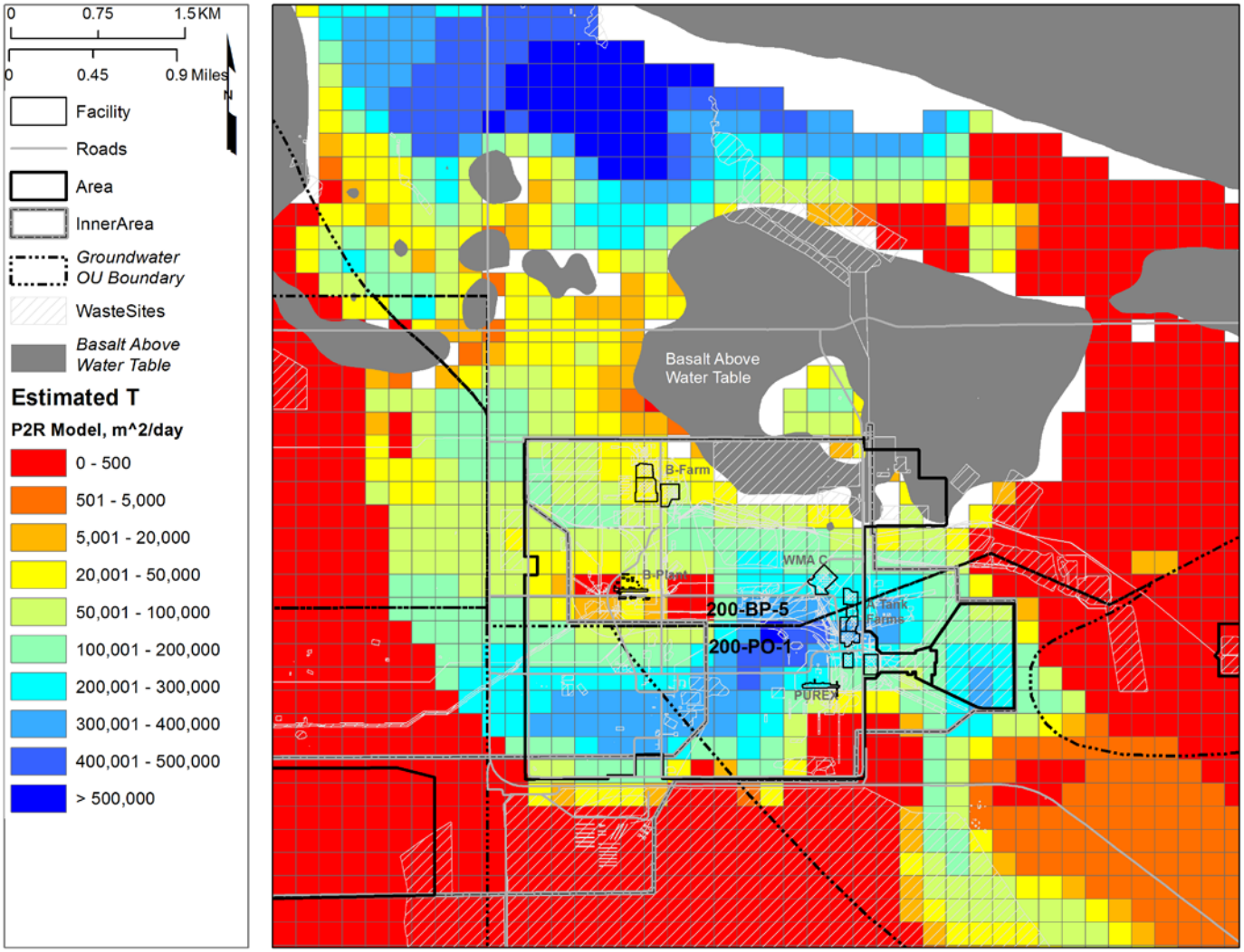

Figure 4.2 – Estimated transmissivity map for 200-East based on the simulated transmissivity field in the P2R model.

4.2 Initial Conditions

4.2.1 Contaminant Concentration

The initial groundwater contaminant distributions of the eight COPCs identified in Section 1 were based on ECF-HANFORD-13-0030, *Initial Groundwater Plume Development to Support Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*. The approach documented there is summarized in the following sections.

Contaminant plumes were created to represent average and maximum concentration initial conditions. Figure 4-3 shows a visual representation of how this was determined. The original estimate (presented in the 2013 annual Hanford Site groundwater monitoring report; DOE/RL-2014-32) was produced using a 10 m × 10 m raster estimate of concentrations in the unconfined aquifer. The initial estimate was upscaled to the P2R Model grid based on the on the arithmetic average concentration within each 200 m × 200 m cell for the average initial concentration conditions.

Based on information presented in ECF-HANFORD-13-0037, two areas have been identified within the 200 East Area where continuing sources of contaminant release from the vadose zone into the 200-BP-5 OU are likely to persist over the foreseeable future: WMA C (C Tank Farm area) and the B-Complex (B-BX-BY Tank Farms and BY cribs area). Note that the vadose zone sources described in this section are not associated with TEDF nor are they part of the 200-BP-5 OU. The primary contaminants of concern that are likely to provide continuing source from the vadose zone are technetium-99, uranium, and nitrate. The recommended mass and activity from the ECF are presented in Table 4.2. These values were included in the Continuing Source simulations using the source/sink mixing package of MT3DMS.

Table 4.2 - Vadose Zone COPC Continuing Sources

Area	Contaminant	Units	Rate	Duration (years)
WMAC	Technetium-99	Ci/yr	0.1	60
BYCRIB	Technetium-99	Ci/yr	0.22	90
BYCRIB	Nitrate	kg/yr	8,212.5	90
BBXB7	Technetium-99	Ci/yr	0.008	300
BBXB7	Uranium	kg/yr	3.8	300

Source: ECF-HANFORD-13-0037, *Development of Source Terms for Inclusion in Fate and Transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Units*.

5 Software Applications

MODFLOW-2000-MST, MT3D-MST, Excel®[3], PEST, ArcGIS®, and Groundwater Vistas™[4] software programs were used for this calculation. These are CH2M Hill Plateau Remediation Company (CHPRC) approved software, managed and used in compliance with the requirements of controlled software management procedure that implements the requirements of DOE O 414.1d, *Quality Assurance*. MODFLOW-2000-MST and MT3D-MST are approved calculation software and Excel®, PEST, ArcGIS, and Groundwater Vistas are approved support software (CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*).

MODFLOW-2000-MST, MT3D-MST, and PEST were executed on the Tellus Linux®[5] Cluster. The details regarding the cluster are presented below. A copy of the *Software Installation and Checkout Form* for the MODFLOW-2000 and MT3D-MST installation used for this calculation is provided in Attachment A to this ECF.

The Tellus Linux cluster that is owned by CHPRC and operated by Mission Support Alliance. The Tellus cluster consists of 16 Dell®[6] PowerEdge® M610 blade servers. Each with 2x Intel®[7] Xeon® X5670 CPU's (6 cores/CPU, 2.93 GHz), 96GB of RAM, and 10Gbps Ethernet cards. The management node is a Dell®[8] PowerEdge® M710 blade server with 2x Intel® Xeon® X5550 CPU's (4 cores/CPU, 2.7 GHz, 96 GB of RAM. As given by the command "uname –a", the operating system details are:

```
Linux tellusmgmt.rl.gov 2.6.18-308.4.1.el5 #1 SMP Tue Apr 17
17:08:00 EDT 2012 x86_64 x86_64 x86_64 GNU/Linux
```

Microsoft Excel®[9] is site-licensed software used as "flat file" spreadsheets that are wholly incorporated into this calculation and verified during the technical review of this report and is therefore rated as exempt software. Excel® spreadsheets were used to tabulate average monthly and long-term hydraulic head and river stage data for model input, and chart modeling results produced by MODFLOW-2000 and MT3DMS-MST.

5.1 Approved Software

MODFLOW-2000-MST and MT3D-MST are approved calculation software (CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*). PEST, ArcGIS, TecPlot, and Groundwater Vistas are approved support software per CHPRC-00258.

5.1.1 MODFLOW-2000-MST

- Software Title: MODFLOW-2000-MST

[3] Excel is a registered trademark of Microsoft Corporation, Redmond, Washington.
[4] Groundwater Vistas™ is a trademark of Environmental Simulations, Inc.
[5] Linux is a registered trademark of Linux Torvalds.
[6] Dell and PowerEdge are trademarks of Dell, Inc., Round Rock, Texas.
[7] Intel and Xeon are registered trademarks of Intel Corporation.
[8] Dell and PowerEdge are registered trademarks of Dell Corporation.
[9] Excel is a registered trademark of Microsoft Corporation in the United States and other countries.

- Software Version: CHPRC Build 6 (executable “mf2k-mst-chprc06dp.x”), double precision compilation
- Hanford Information System Inventory (HISI) Identification Number: 2517 (Safety Software, Level C)
- Authorized Workstation type and property number: Linux® Cluster, HLAN Property Tag (Front End Node) WD56054
- Authorized User: J. Fullerton
- Software Vendor Documents:
    - Harbaugh et al. (2000), *MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process*
    - SSPA (2012a), *Documentation for: MODFLOW-2000-SSPA Build 006 Modifications and options added to MODFLOW-2000*
- CHPRC Software Control Documents:
    - CHPRC-00257, *MODFLOW and Related Codes Functional Requirements Document*
    - CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*
    - CHPRC-00259, *MODFLOW and Related Codes Software Test Plan*
    - CHPRC-00260, *MODFLOW and Related Codes Requirements Traceability Matrix: CHPRC Build 6*
    - CHPRC-00261, *MODFLOW and Related Codes Acceptance Test Report: CHPRC Build 6*

5.1.2 MT3DMS-MST

- Software Title: MT3DMS-MST
- Software Version: CHPRC Build 6 (executable name “mt3d-mst-chprc06dp.x”), double precision compilation
- HISI Identification Number: 2518 [Support Software; CHPRC-00258]
- Authorized Workstation type and property number: Linux® Cluster, HLAN Property Tag (Front End Node) WD56054
- Authorized User: J. Fullerton
- Software Vendor Documents:
    - Zheng and Wang (1999), *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*

  - SSPA (2012b), *Documentation for: MT3DMS-SSPA Build 006 Modifications and options added to MT3DMS*

- CHPRC Software Control Documents:
  - CHPRC-00257, *MODFLOW and Related Codes Functional Requirements Document*
  - CHPRC-00258, *MODFLOW and Related Codes Software Management Plan*
  - CHPRC-00259, *MODFLOW and Related Codes Software Test Plan*
  - CHPRC-00260, *MODFLOW and Related Codes Requirements Traceability Matrix: CHPRC Build 6*
  - CHPRC-00261, *MODFLOW and Related Codes Acceptance Test Report: CHPRC Build 6*

5.1.3 MODFLOW & Related Codes Support Software

CHPRC-00257 distinguishes calculational software from supporting software because these two groups of software are classified and graded differently. The basis for the difference is that calculational software, including MODFLOW-2000-MST and MT3DMS-MST, calculate results that will be used to support decision-making and as such, constitute safety software graded to level C. In contrast, supporting software includes graphical interfaces, visualization, and input preparation support but not calculation of results that directly support decision-making, and are therefore not rated as safety software. The support software items identified in CHPRC-00258 and used in this calculation were:

- **Groundwater Vistas:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used graphical tools for model input/output review. Groundwater Vistas™ was used in pre-processing some input files.
- **PEST:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used pest utilities for changing formats of inputs and output files for ease of manipulation in creating figures for the report.
- **ArcGIS®:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used graphical tools for model input/output review. ArcGIS was used in pre-processing some input files and creating output graphics for the report.
- **TecPlot:** (*Guide to Using Groundwater Vistas* [Rumbaugh and Rumbaugh, 2007].) Used to create graphics of the simulated output from MODFLOW-MST and MT3D-MST in order to develop figures for the report.

5.2 Software Installation and Checkout

Safety Software (MODFLOW-2000-MST and MT3DMS-MST) was checked out and installed in accordance with procedures specified in CHPRC-00259. Executable files were obtained from the Software Owner, installation tests identified in CHPRC-00259 were performed and confirmed, and Software Installation and Checkout Forms were completed and approved for installations used to perform model runs reported in this calculation. A copy of the Software Installation and Checkout Forms for the

authorized users and authorized workstations for software used that requires this documentation are provided in Attachment A to this ECF.

5.3 Statement of Valid Software Application

The preparers of this calculation attest that the software identified above, and used for the calculations described in this calculation, is appropriate for the application and used within the range of intended uses for which it was tested and accepted by CHPRC. Because MODFLOW-2000-MST and MT3DMS-MST are graded as Level C software, use of this software is logged in the HISI under the corresponding entries (Identification Numbers 2517 and 2518). These software items were used within the limitations identified in CHPRC-00257. Installations of the software are operating correctly, as demonstrated by installation testing performed on the Tellus Subsurface Modeling Platform and documented in the Software Installation and Checkout Form (Attachment A).

6 Calculation

Following the methodology detailed in Section 3, 4 sets of simulations were conducted to support the feasibility study of the 200 East. Each set of simulations included simulations for each of the eight COCs for the average initial condition, and simulations with continuing source terms for nitrate, technetium-99, and uranium. Thus, one set of simulations included 11 individual MT3D simulations. Simulations are assumed to start at the commencement of the P&T remediation. All scenarios were completed for a simulated duration of 50 years. The results of these simulations are discussed in Section 7.

6.1 Assessing Plume Migration for Existing Plumes

The simulation outputs from each of the simulations mentioned previously were processed to create a set of figures to illustrate the fate and transport of the simulated contaminants. The figures created include plan view contour maps at simulation time of 0, 1, 2, 5, 10, 15, 20, 25, 30, and 50 years and summary charts for the mean, 90th percentile, and maximum concentration for full domain of the model. An example of the figures shows results for the nitrate simulation for average concentration initial conditions in Figure 6.1 and 6.2. The following sections describe the information that can be obtained from these figures. The figures for the selected simulation sets conducted for this ECF are included in Attachment B.

6.1.1 Plan View Contours

Figure 6.1 shows plan view contour plots for the technetium-99 plume after 20 years of simulation. Several aspects of the figure help identify the simulations. There is a title in the upper right-hand corner that describes the scenario simulated and the time of year. In this case the simulation time is at 20 years. The title indicates that this simulation was for average initial concentration conditions, where no remediation action is considered for either BP-5 or PO-1 (e.g., No Action). The color ramp for the contours is designed that the first colored contour interval (light blue) represents concentrations between 0.5 and 1.0 times the cleanup level of 900 pCi/L for techneitium-99 and the second interval (darker blue) represents concentrations above the cleanup level. The concentrations shown are the maximum for any given location regardless of depth.

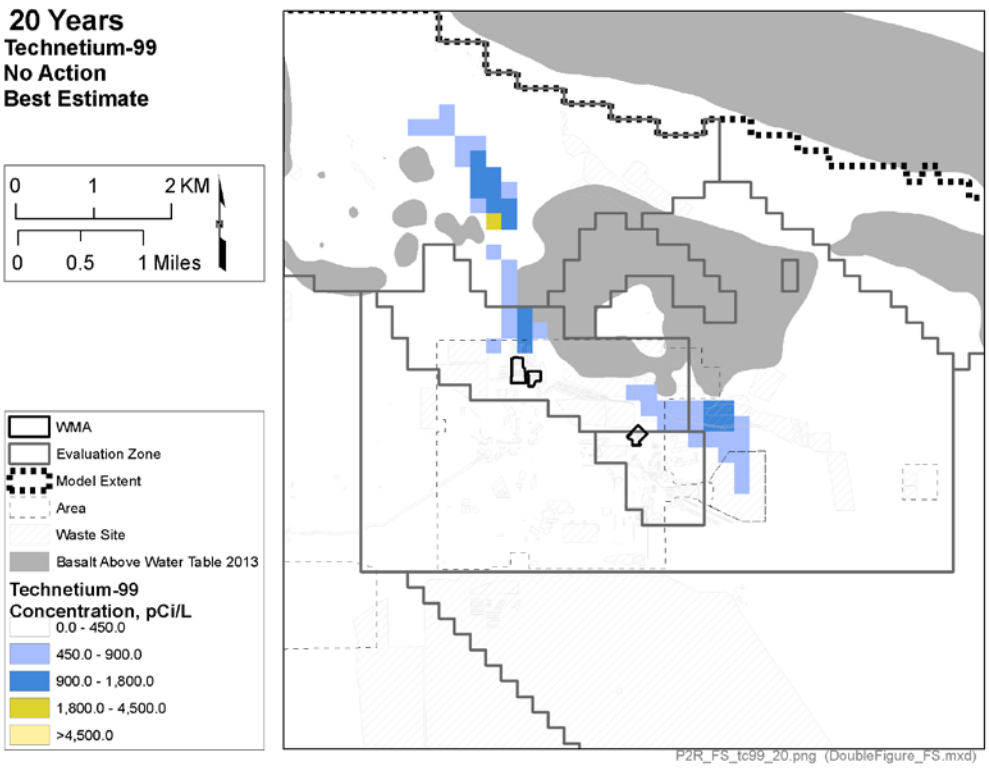

Figure 6.1 – Plan view contours of the nitrate plume at simulation time 20 years based on average concentration initial conditions.

6.1.2 Statistical Summary Chart

The charts shown in Figure 6.2 provide a statistical summary of the plume migration over the domain of the model. The charts indicate the contaminant concentration on the ordinate axis and simulation time in years on the abscissa. Figure 6.2 shows the mean, 90th percentile, peak concentration within the boundaries of the modeling area, and also shows the total area whose concentration exceeds the drinking water standard. The mean value represents an arithmetic mean concentration for all cells within the specified subregion or the entire model domain. The 90th percentile is estimated by tabulating all estimated concentration values, sorting the values, assigning a Weibull plotting position to determine rank, and selecting the concentration value corresponding to the 90th percentile value. The peak concentration is the concentration with the highest magnitude from any estimated concentration. In figures simulating a departure from the remedial evaluation case, the simulated results for the remedial evaluation case is shown in faint grey behind in order to provide a comparison to the no action scenario.

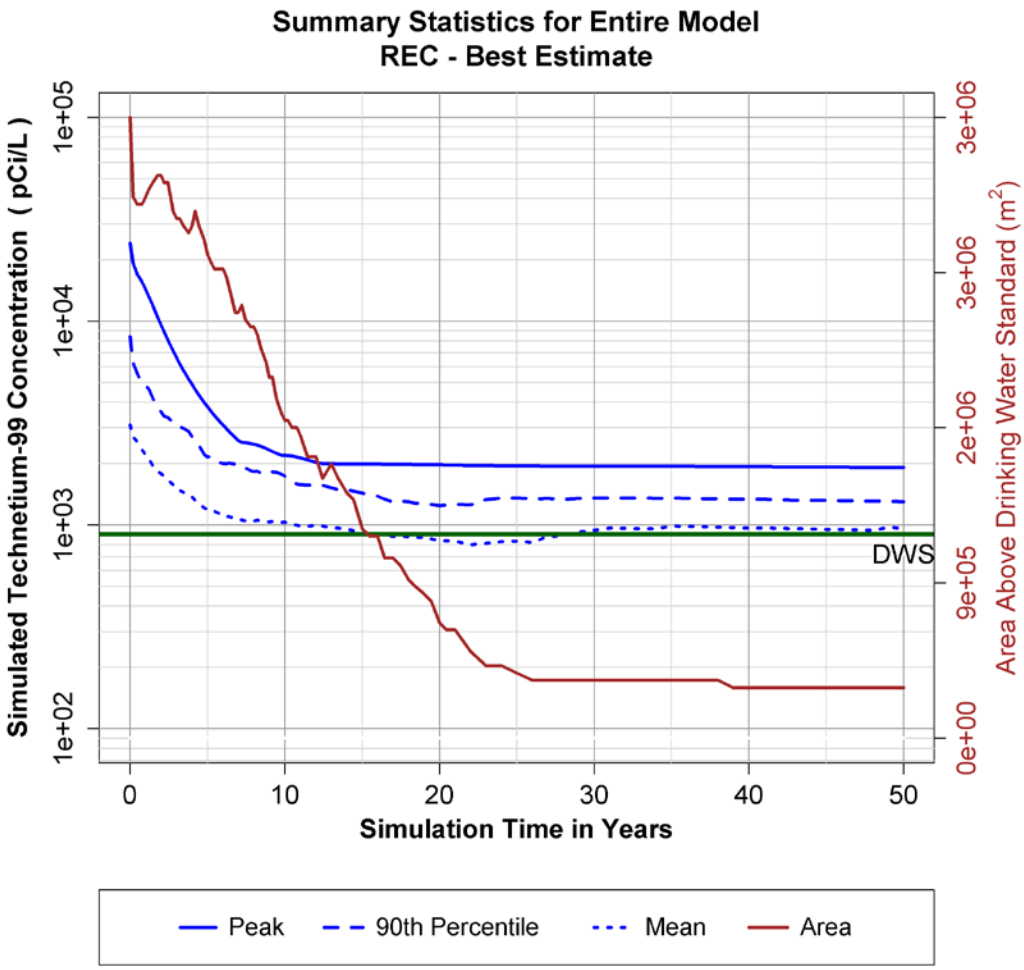

Figure 6.2 – Statistical summary of simulated concentration within subregions of the model domain for the cyanide plume for average concentration initial conditions.

7 Results

Four sets of simulations were conducted as part of the scenario analysis. The total number of F&T simulations for these simulation sets is 4. Plume maps and statistics plots are provided for technetium-99 and uranium. Extraction summaries are provided for all simulated constituents. Results from these simulations are documented in the figures and charts discussed in Attachment B.

Tables 7-1 through 7-4 were developed to provide a summary of the relative differences in time to clean up in years for the various scenarios executed as part of this ECF. Tables 7-1 through 7-4 show the time to cleanup based on 90th percentile concentration within their respective domains for the selected scenarios for the average concentration conditions without continuing sources. The domains for Tables 7-1 through 7-4 are as follows: B Complex Area, Waste Management Area C, B Plant (also refers to the Greater 200 East Area), and Gable Gap Area, respectively. These time to cleanup numbers were used to develop the FS for 200-BP-5 and 200-PO-1.

Table 7.1 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Complex Area.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	25	50*	25	32	1	50*	1	1
2	-250/0	23	31	27	32	1	32	1	1
3	-350/100	22	30	23	29	1	30	1	1
4	-425/100	7	26	16	25	1	9	1	1

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as “50*”)

Table 7.2 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Waste Management Area C.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	5	19	23	50*	0	24	0	14
2	-250/0	6	18	1	50*	0	1	0	14
3	-350/100	6	18	17	50*	0	1	0	14
4	-425/100	7	18	1	50*	0	1	0	13

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as “50*”)

Table 7.3 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the B Plant Area (including the Greater 200 East Area).

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	22	50*	50*	50*	50*	34	0	29
2	-250/0	5	33	50*	50*	50*	35	0	28
3	-350/100	5	35	50*	50*	50*	34	0	28
4	-425/100	5	37	50*	50*	50*	0	0	28

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as “50*”)

Table 7.4 – Time (in years) for the simulated concentrations for the eight COCs to fall and remain below the cleanup level for the Gable Gap Area.

Scenario	Total Rate (GPM)	Technetium-99	Uranium	Nitrate	Iodine-129	Strontium-90	Cyanide	Chromium	Tritium
1	0/0	50*	0	50*	50*	50*	50*	0	0
2	-250/0	50*	0	50*	50*	50*	50*	0	0
3	-350/100	15	0	50*	50*	50*	9	0	0
4	-425/100	18	0	13	50*	50*	9	0	0

Notes:

a. An asterisk indicates cleanup times exceed the modeling duration (i.e. cleanup time greater than 50 years is denoted as "50*")

8 References

CHPRC-00257, 2010, *MODFLOW and Related Codes Functional Requirements Document*, Rev. 1, CH2M Hill Plateau Remediation Company, Richland, Washington.

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ECF-HANFORD-13-0037, 2014, *Development of Source Terms for Inclusion in Fate and transport Modeling for Remedial Investigation/Feasibility Studies of the 200-BP-5 and 200-PO-1 Groundwater Operable Unit*s, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0080139H.

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Mitchell, 1999, The ESRI Guide to GIS Analysis, Volume 1: Geographic Patterns and Relationships.

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SSPA, 2012b, *Documentation for: MT3DMS-SSPA Build 006 Modifications and options added to MT3DMS*, S.S. Papadopulos and Associates, Inc. Bethesda, Maryland.

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Attachment A

Software and Installation 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 & Related Codes Software Version No.: Bld 6

EXECUTABLE INFORMATION:

2. Executable Name (include path):

```
MD5 sums of executable files tested:
c2d687beee9d58dc615995ce8220d9ea [redacted]/bin/mf2k-chprc06sp.x
e396d1c03769a966f529b2480bd17c26 [redacted]/bin/mf2k-chprc06dp.x
ae88ad1ee47b2a368716d9c13394b73a [redacted]/bin/mf2k-mst-chprc06sp.x
80429a2d296461a6b69425b0f9e25077 [redacted]/bin/mf2k-mst-chprc06dp.x
69cc646caea7dba83b2eb44a9fafed8d [redacted]/bin/mt3d-mst-chprc06sp.x
4795224002dba418ebe47aa507fcac42 [redacted]/bin/mt3d-mst-chprc06dp.x
```

3. Executable Size (bytes): Uniquely identified by MD5 signatures listed above.

COMPILATION INFORMATION:

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

   WD56054 (PNNL Property System); RANSAC Linux Cluster

5. Operating System (include version number):

   Red Hat Enterprise Linux WS 3 (Taroon Update 7)

INSTALLATION AND CHECKOUT INFORMATION:

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

   Tellus Modeling Platform

7. Operating System (include version number):

   Linux
   2.6.18-308.4.1.el5 #1 SMP Tue Apr 17 17:08:00 EDT 2012 x86_64 x86_64 x86_64 GNU/Linux

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

TEST CASE INFORMATION:

9. Directory/Path:

   [redacted]bin

10. Procedure(s):

    CHPRC-00259 Rev 2, MODFLOW and Related Codes Software Test Plan

11. Libraries:

    N/A (static linking)

12. Input Files:

    Test suite per CHPRC-00259 Rev. 2 installed in [redacted]/test/modflow/build-6/

13. Output Files:

    Test results in [redacted]/test/modflow/build-6;
    Results summarized in log file run-install-tests-all-nodes.log

14. Test Cases:

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

Page 1 of 2 A-6005-149 (REV 0)

CHPRC SOFTWARE INSTALLATION AND CHECKOUT FORM (continued)

1. Software Name: MODFLOW and Related Codes Software Version No.: Bld 6

14. Test Cases:

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

15. Test Case Results:

Exact match for MF2K and MF2K-MST executable files and single-precision MT3DMS-MST single-precision executable file. A minor text difference was detected in MT3DMS-MST double-precision output was evaluated and found insignificant. All tests are rated PASS.

16. Test Performed By: WE Nichols

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

18. Disposition (include HISI update):

This supercedes prior installation test of CHPRC Build 6 of these executables performed to revalidate this installation following OS upgrade (configuation change).

Prepared By:

19. [redacted] Digitally signed by William E. Nichols DN: cn=William E. Nichols, o=CHPRC, ou=Risk & Modeling Integration, email=william_e_nichols@rl.gov, c=US Date: 2014.02.14 11:12:45 -08'00' (Signature) | WE Nichols (Print) | (Date)

20. Test Personnel:

Sign	Print	Date
	WE Nichols	

Approved By:

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

Page 2 of 2 A-6005-149 (REV 0)

Attachment B

Simulation results from Selected P&T Scenarios

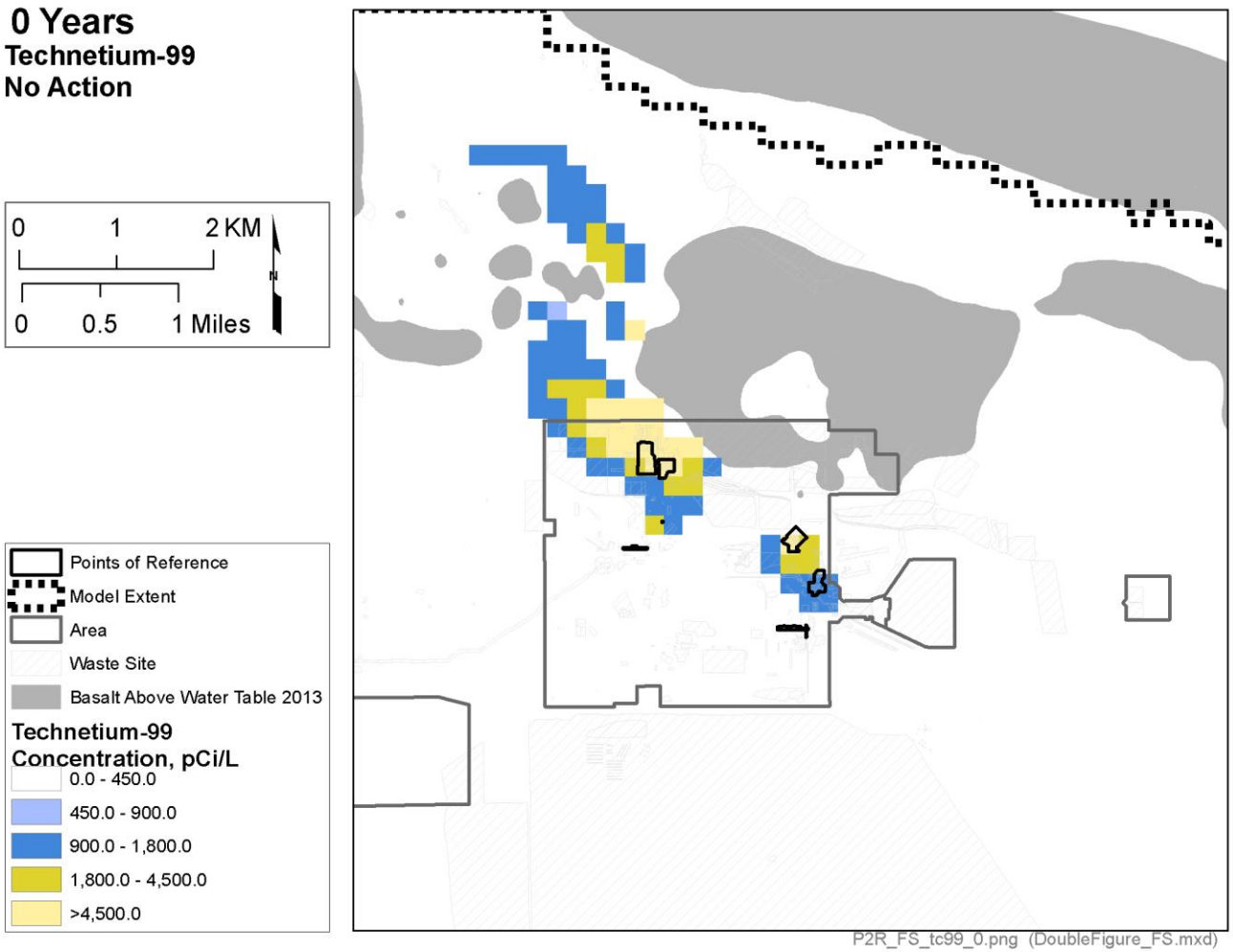

Figure B-1 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the remedial evaluation case simulation.

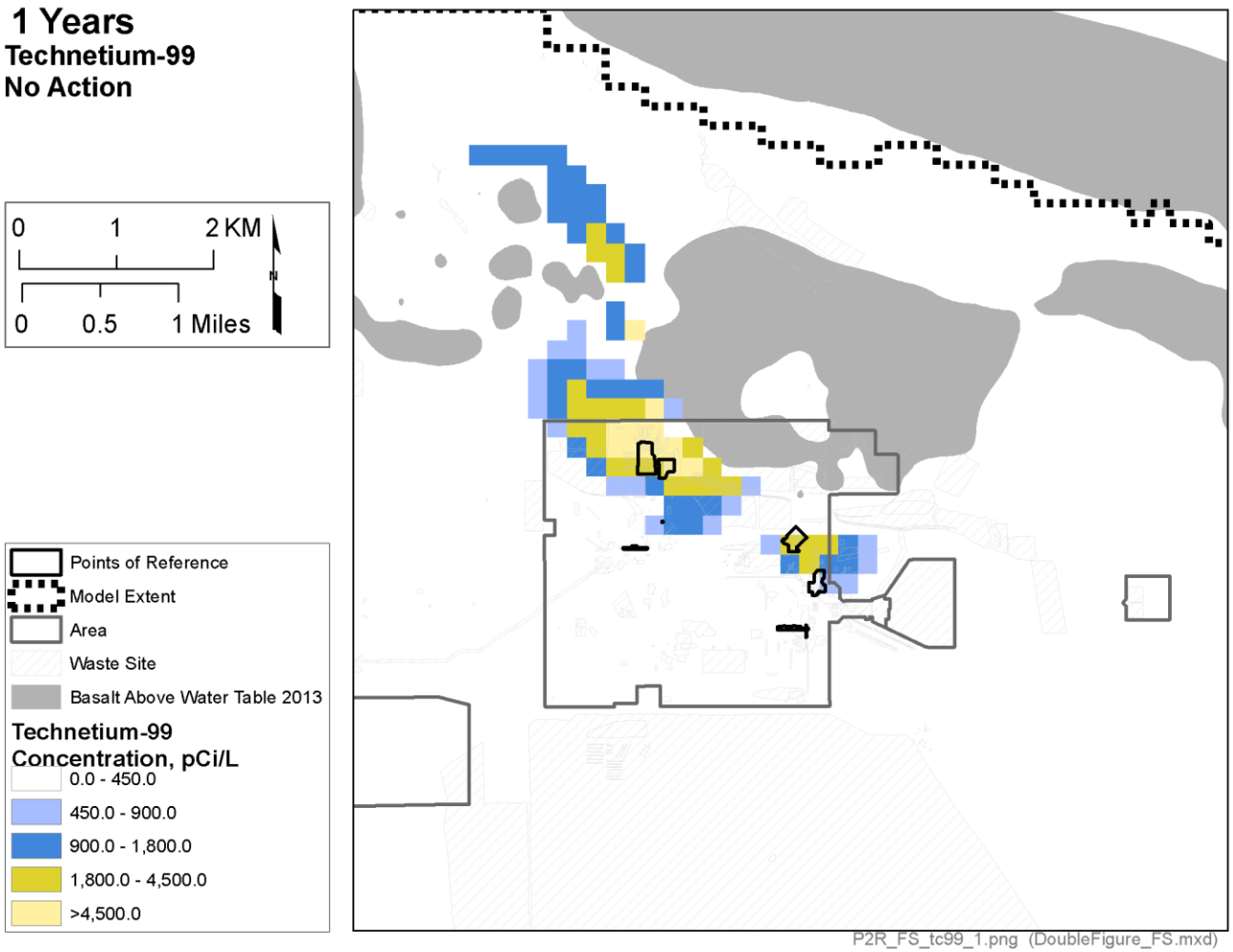

Figure B-2 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the remedial evaluation case simulation.

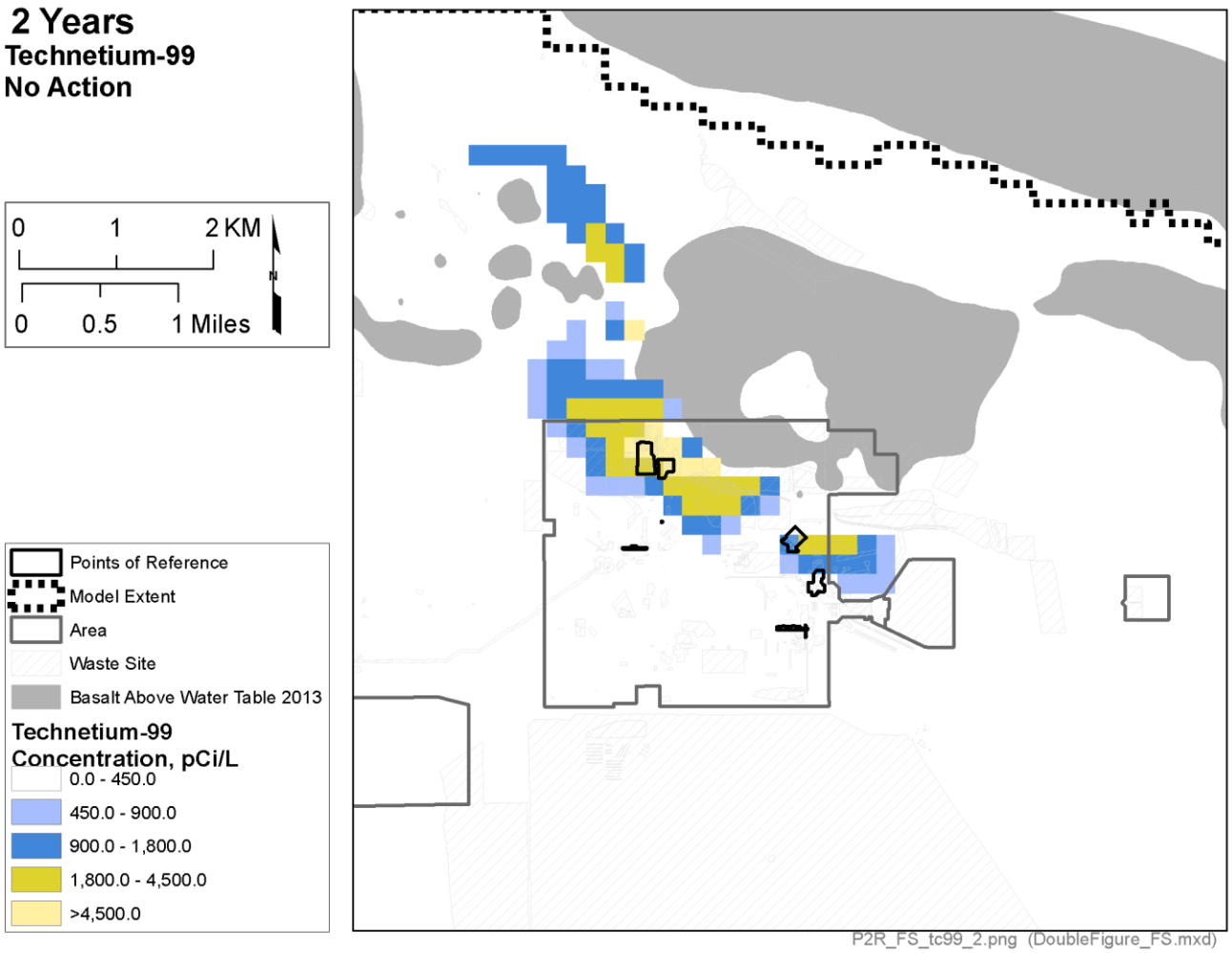

Figure B-3 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the remedial evaluation case simulation.

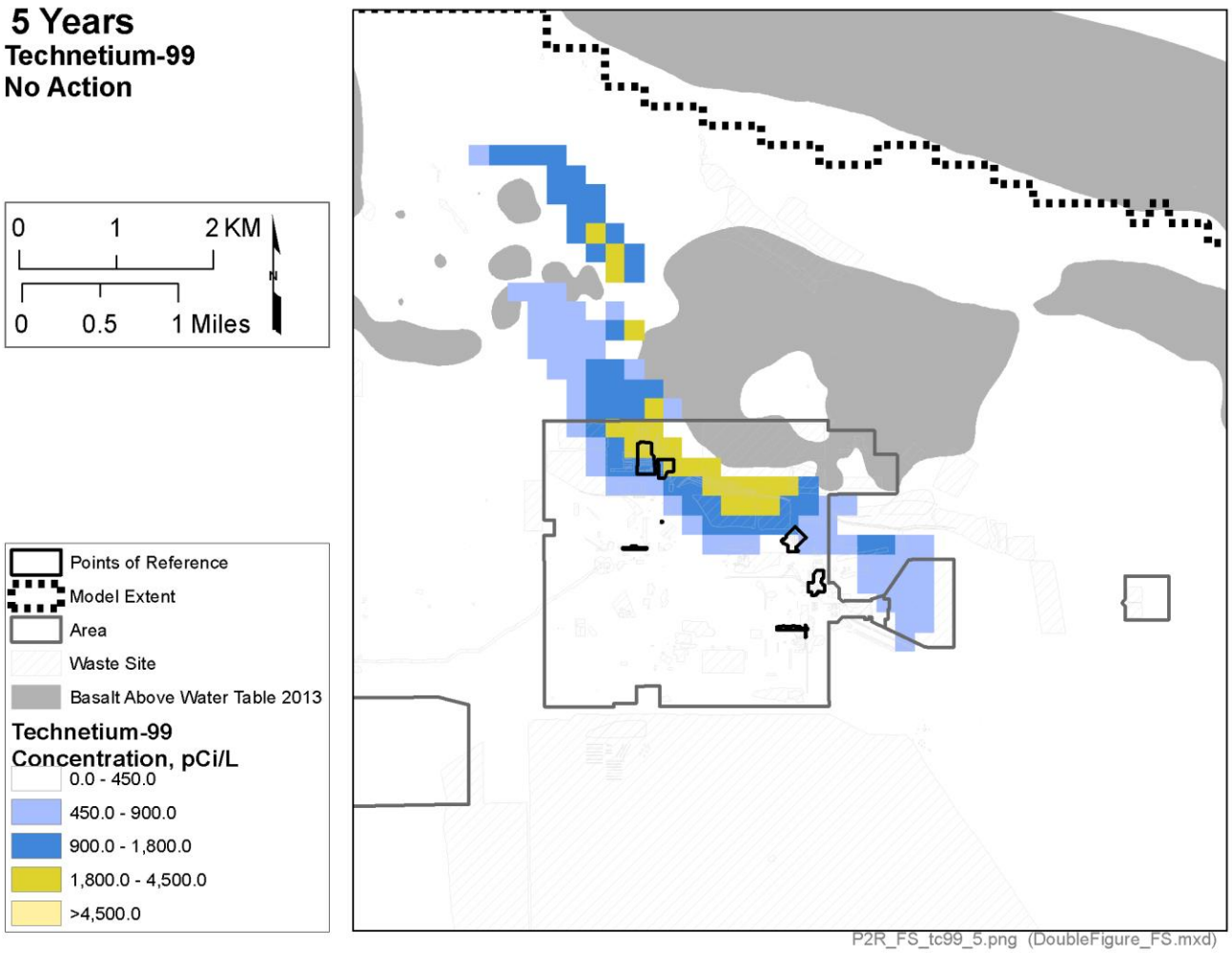

Figure B-4 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the remedial evaluation case simulation.

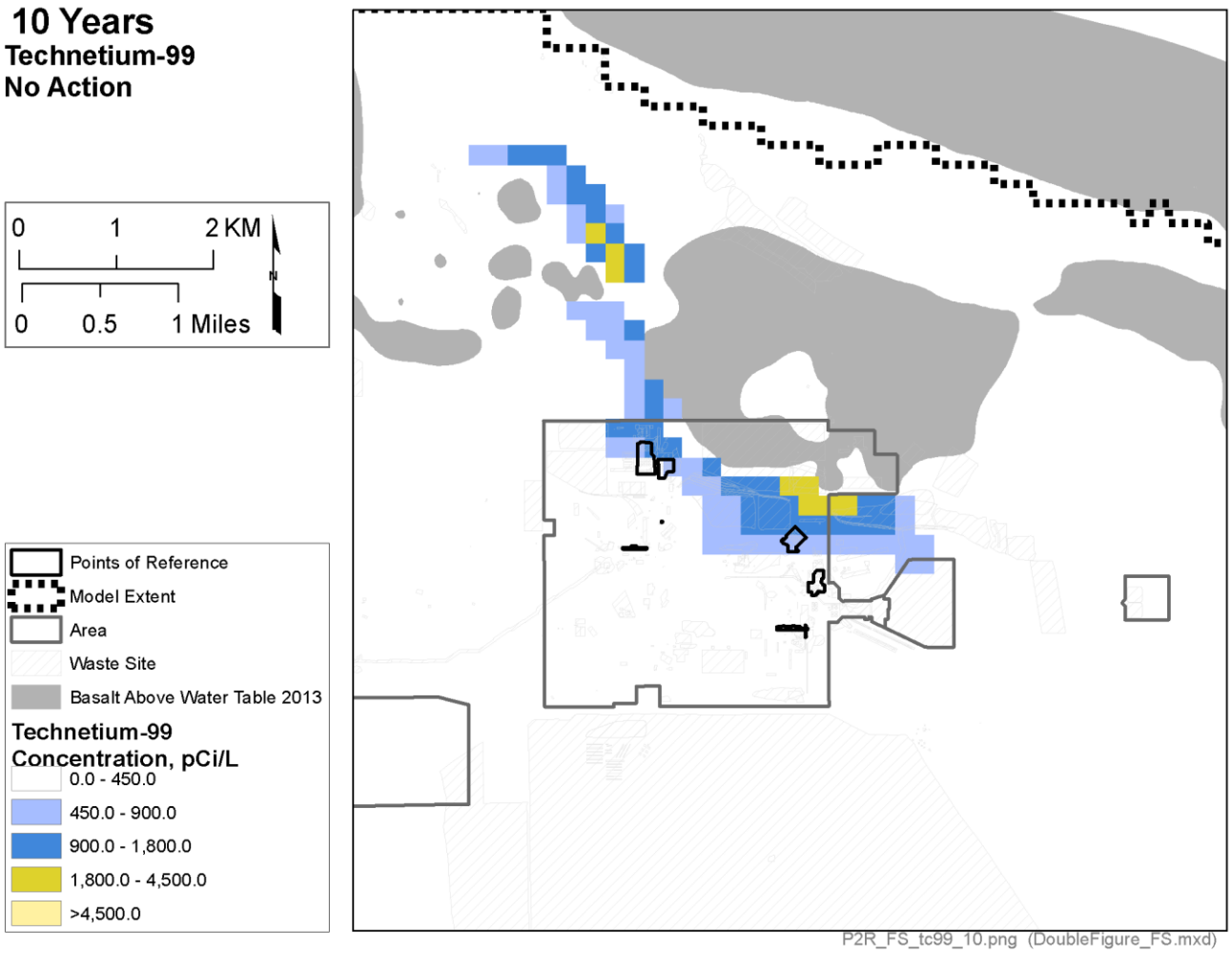

Figure B-5 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the remedial evaluation case simulation.

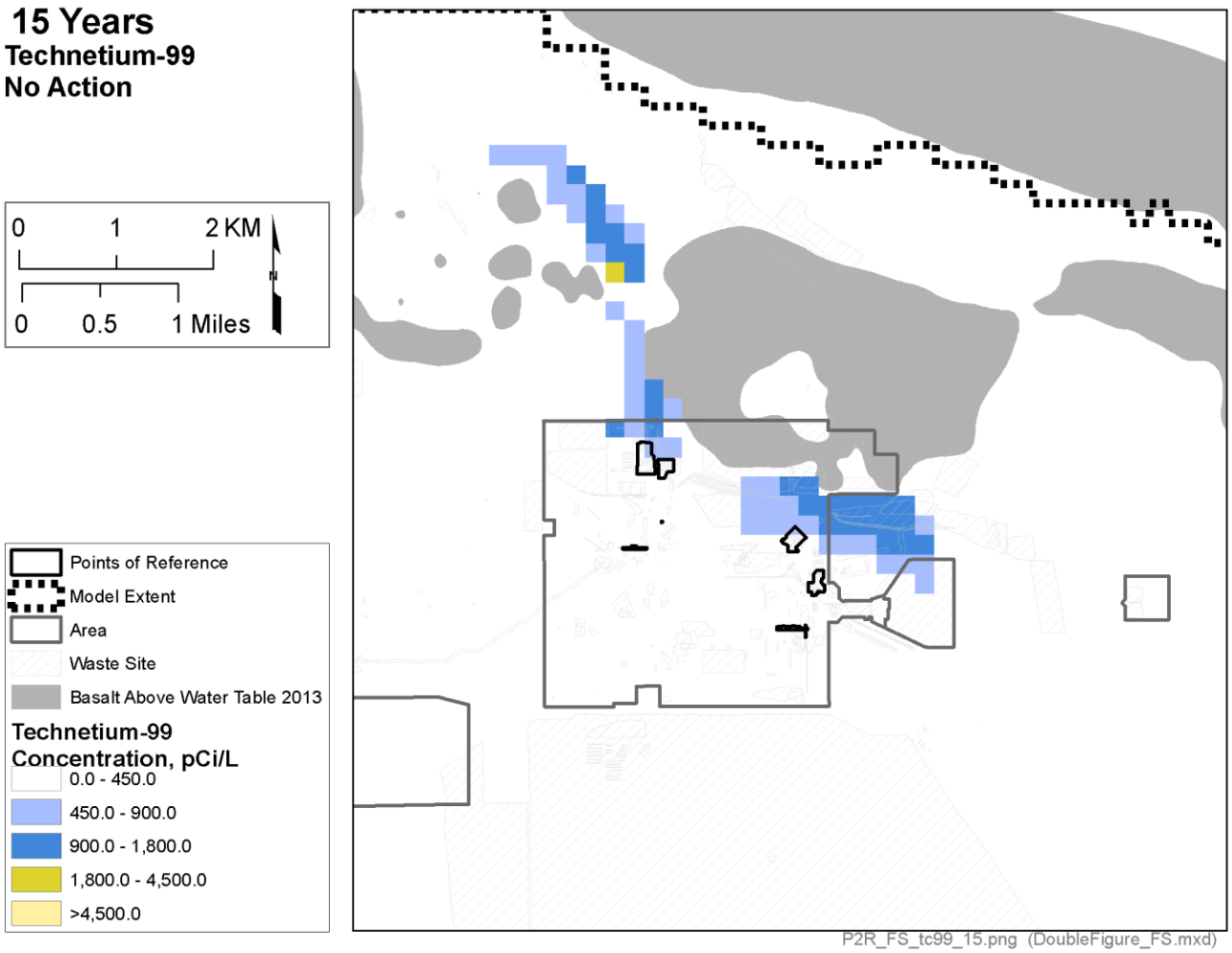

Figure B-6 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the remedial evaluation case simulation.

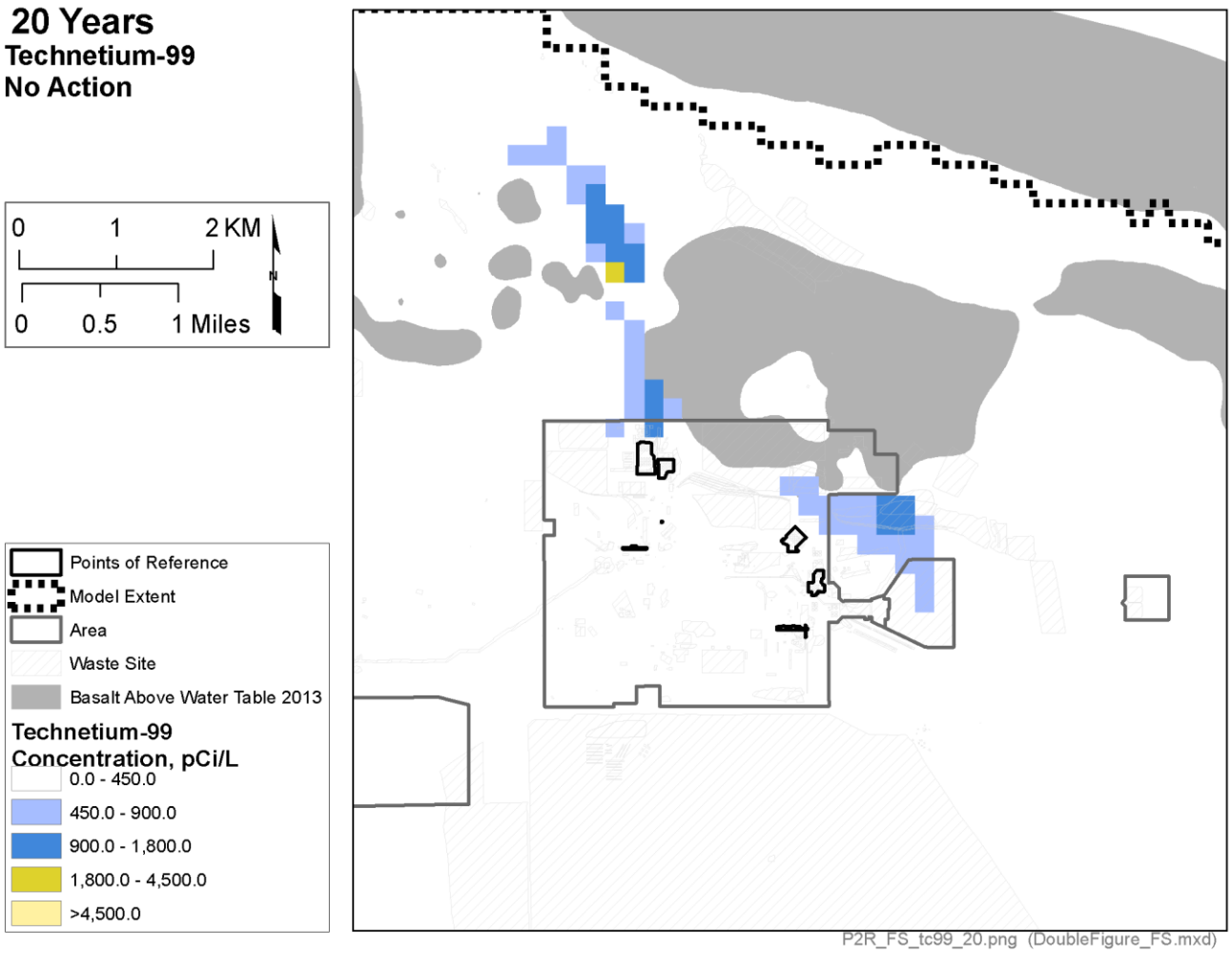

Figure B-7 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the remedial evaluation case simulation.

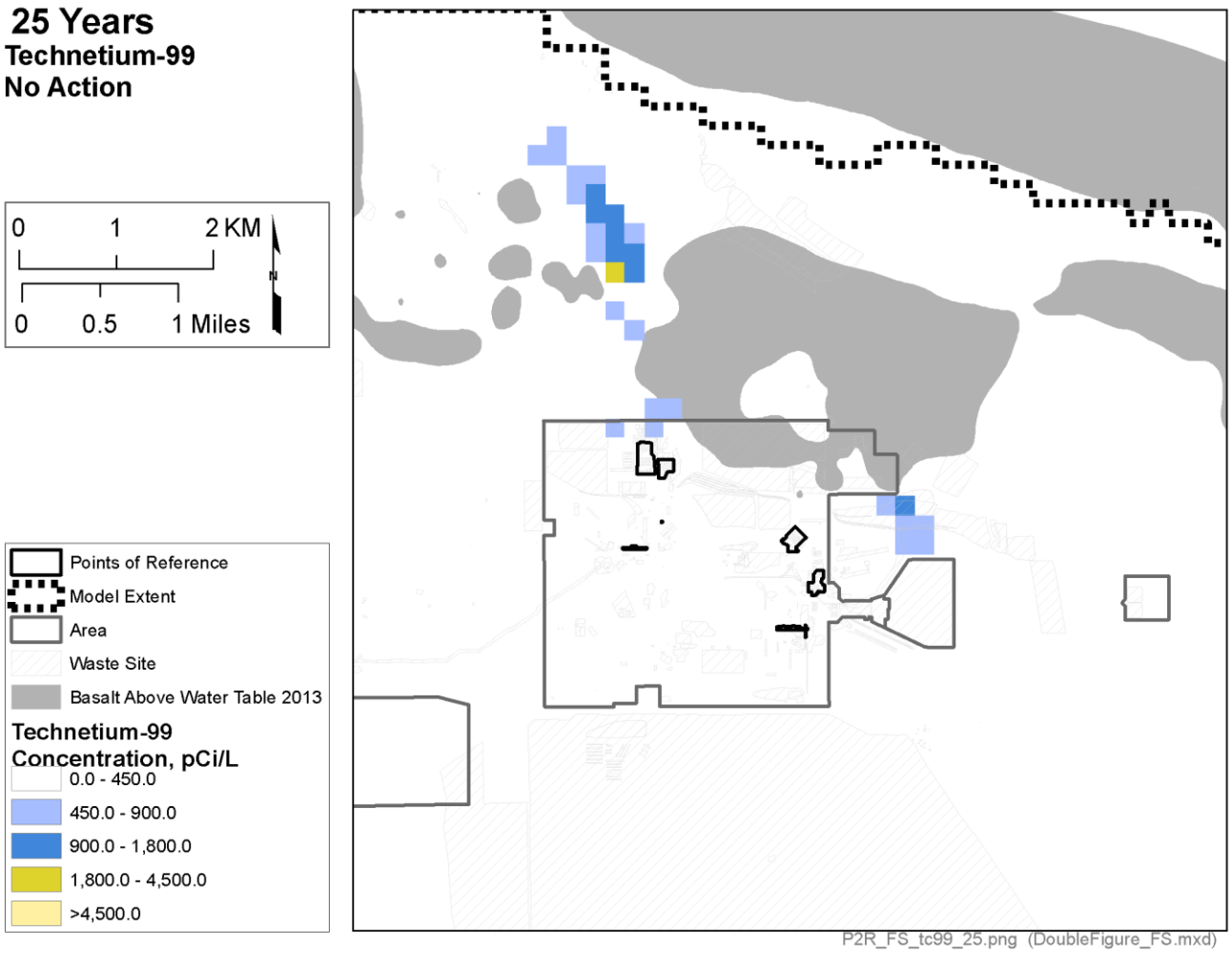

Figure B-8 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the remedial evaluation case simulation.

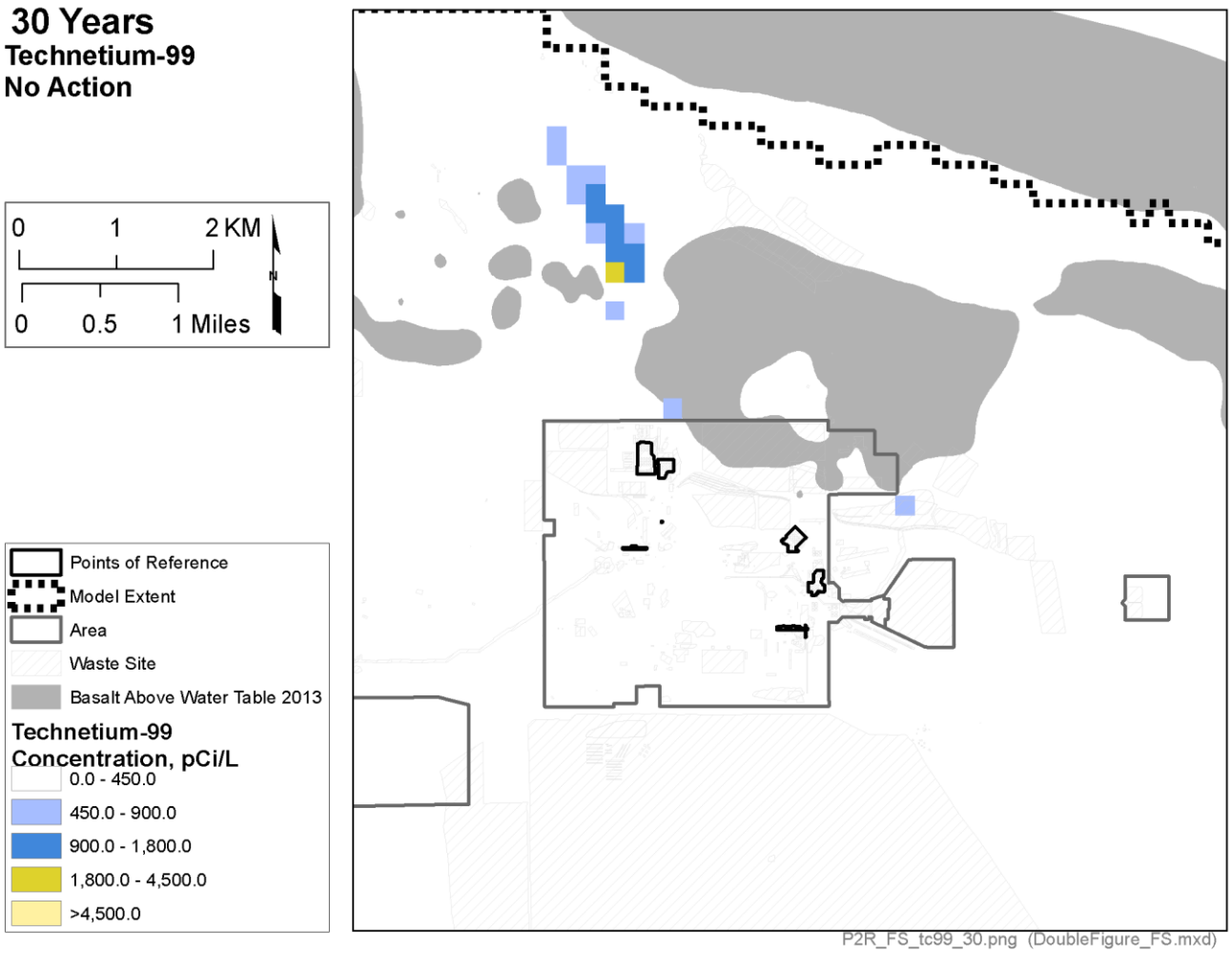

Figure B-9 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the remedial evaluation case simulation.

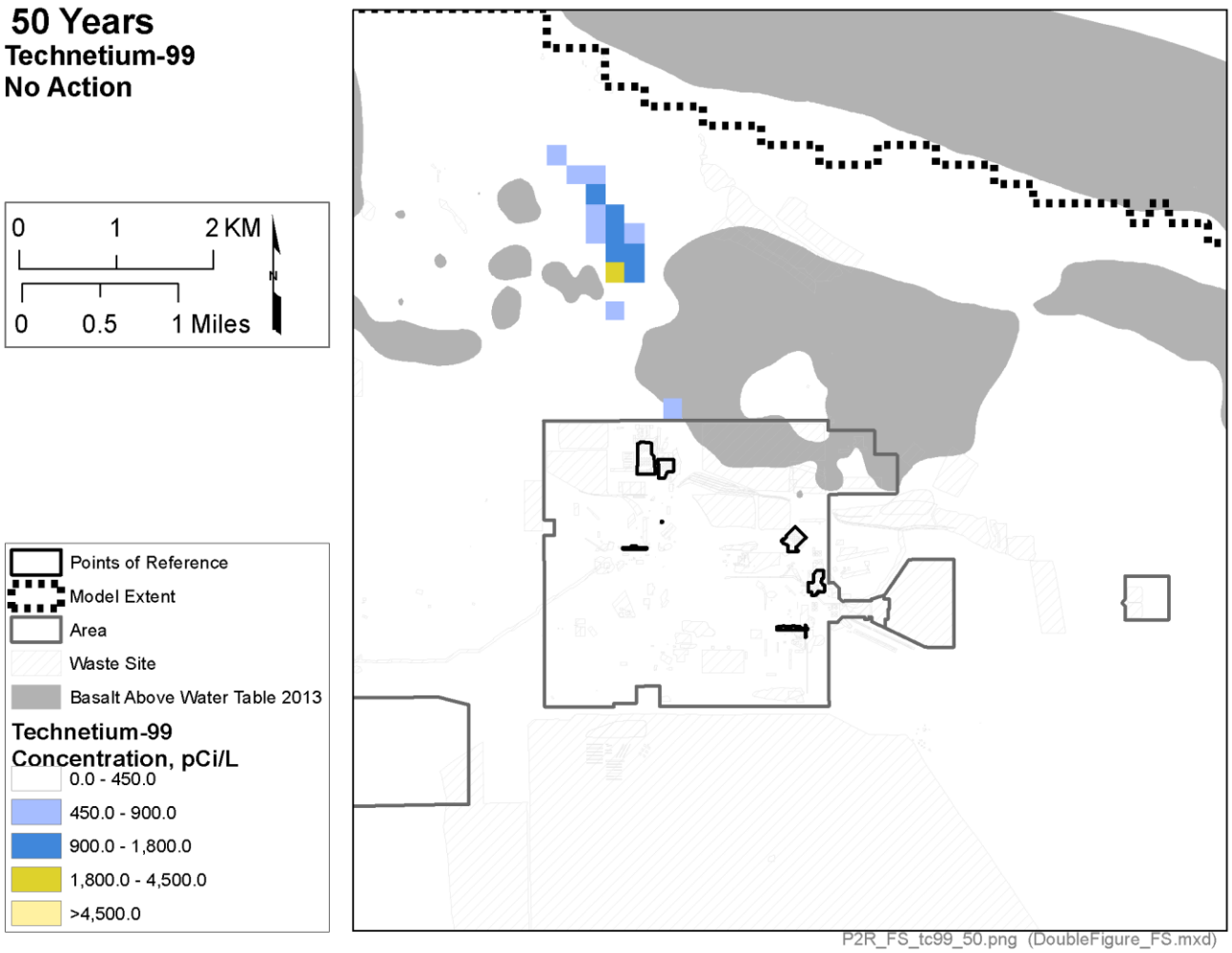

Figure B-10 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the remedial evaluation case simulation.

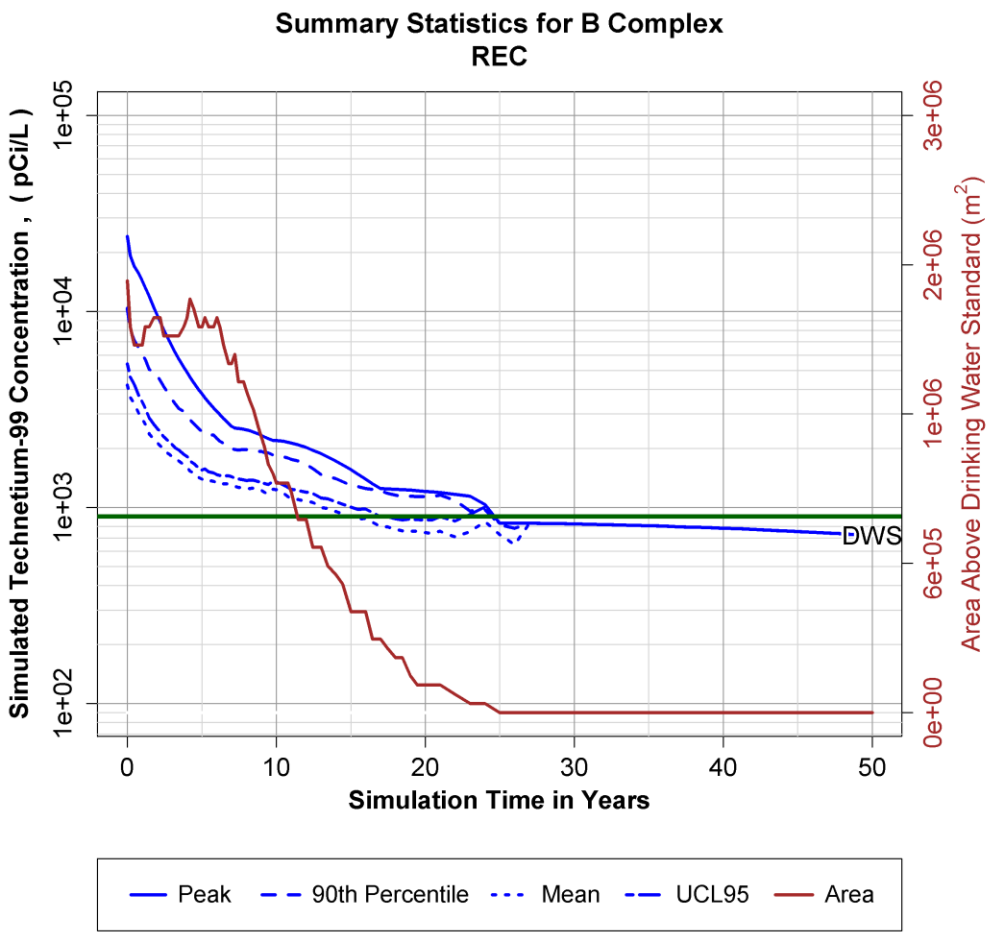

Figure B-11 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

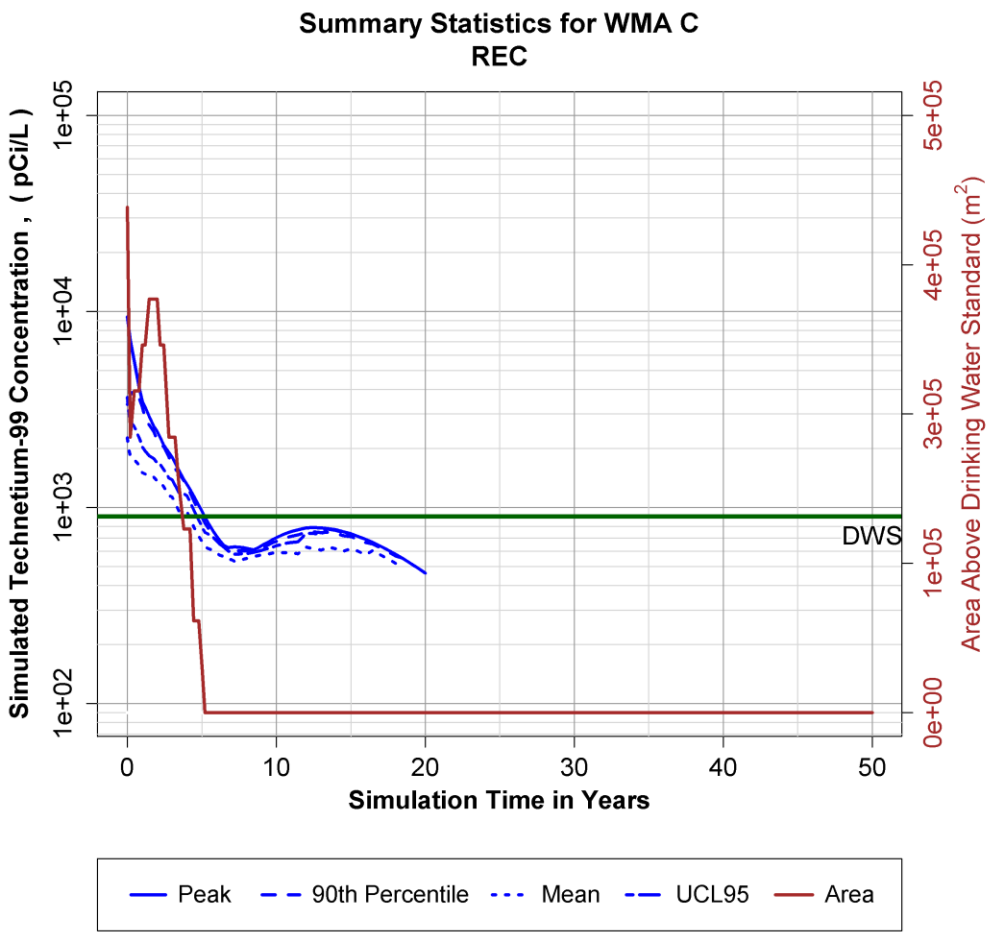

Figure B-12 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

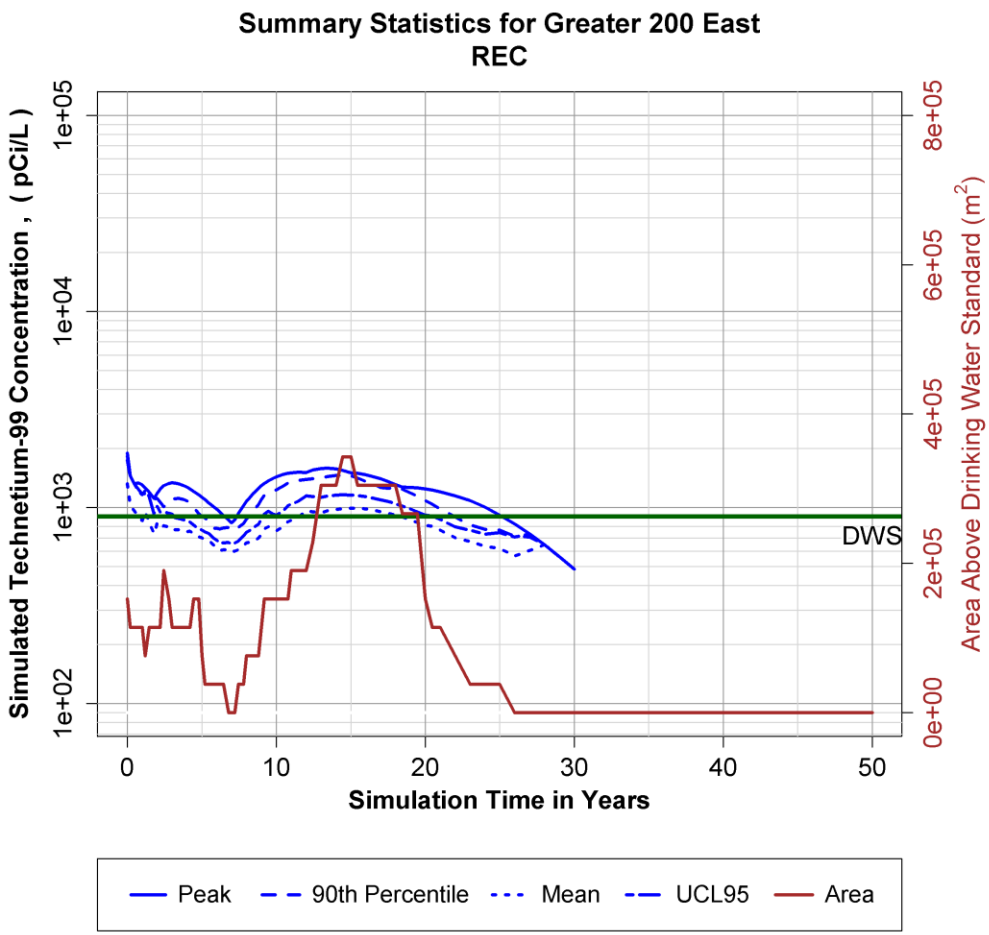

Figure B-13 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

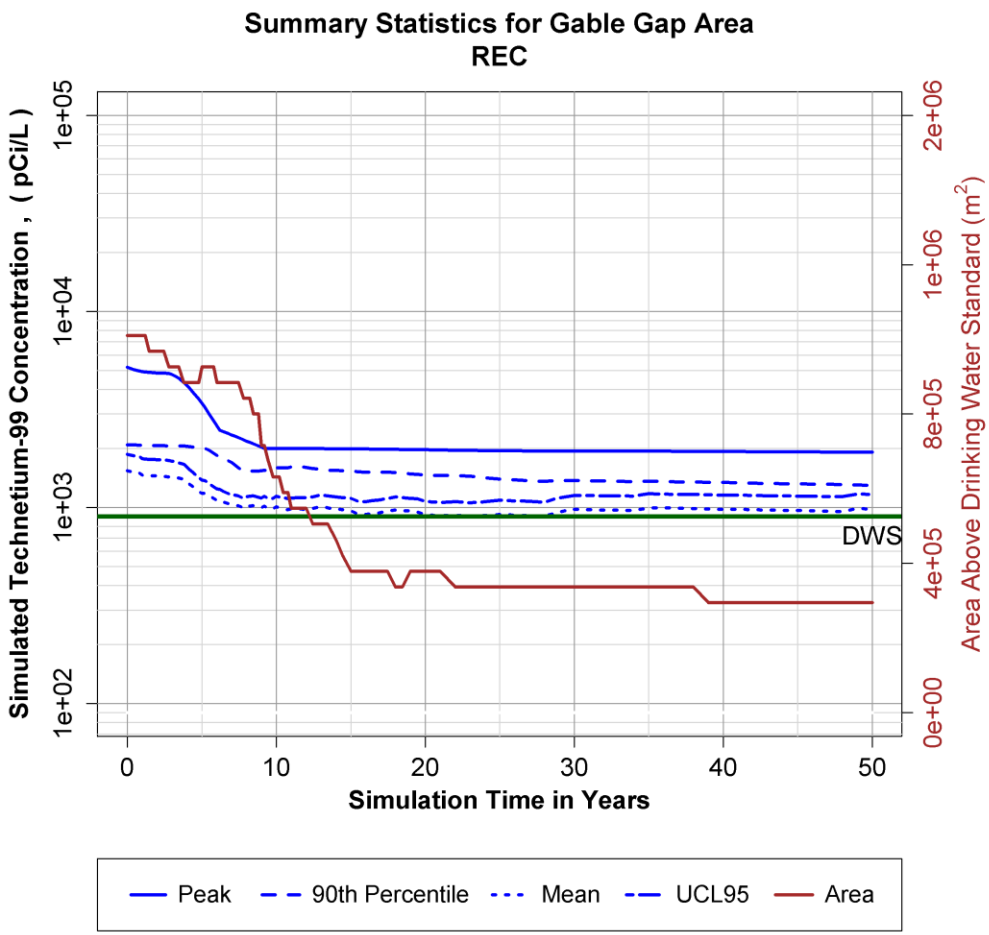

Figure B-14 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation.

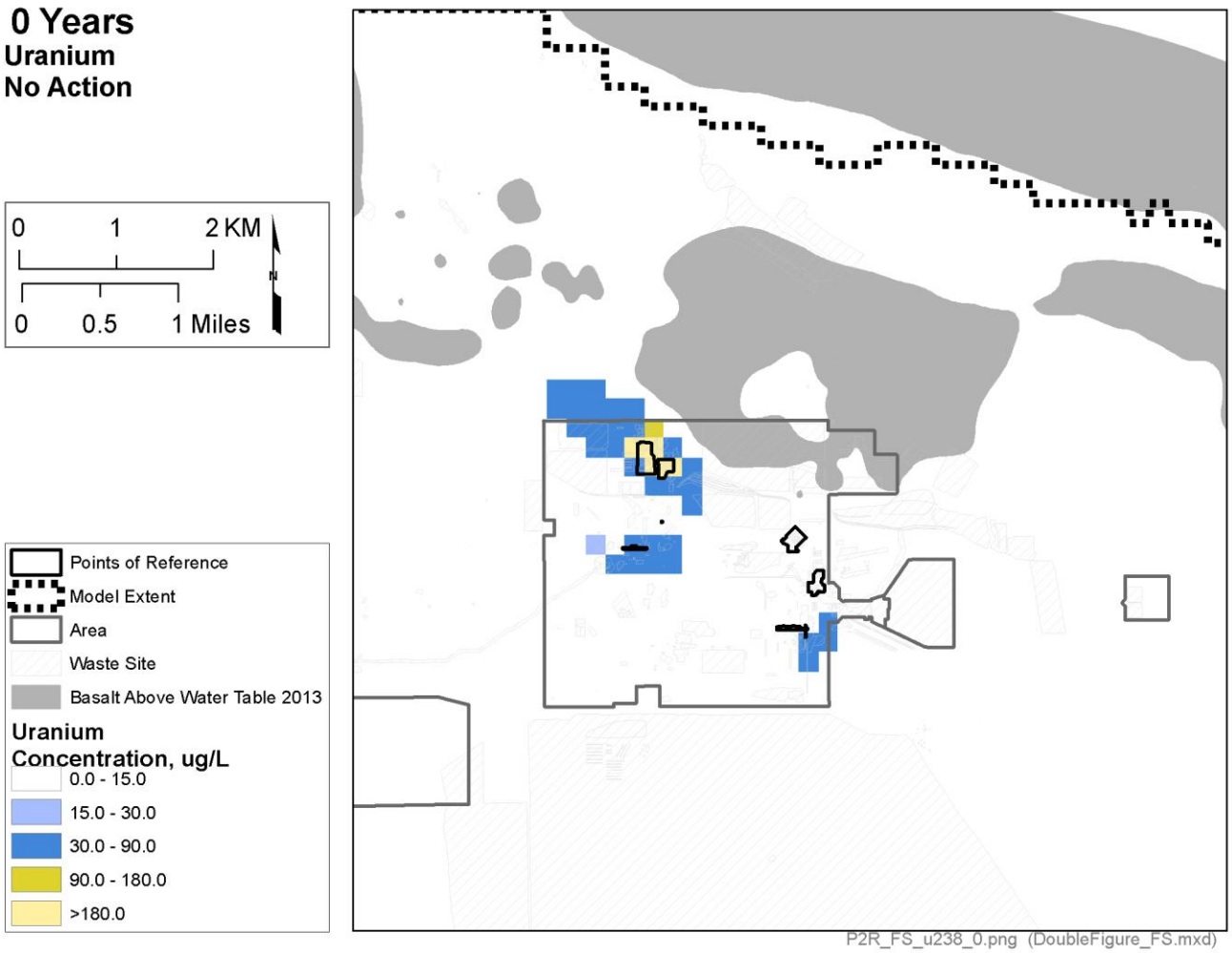

Figure B-15 - Plan view contours of the uranium plume at simulation time 0 years based on the remedial evaluation case simulation.

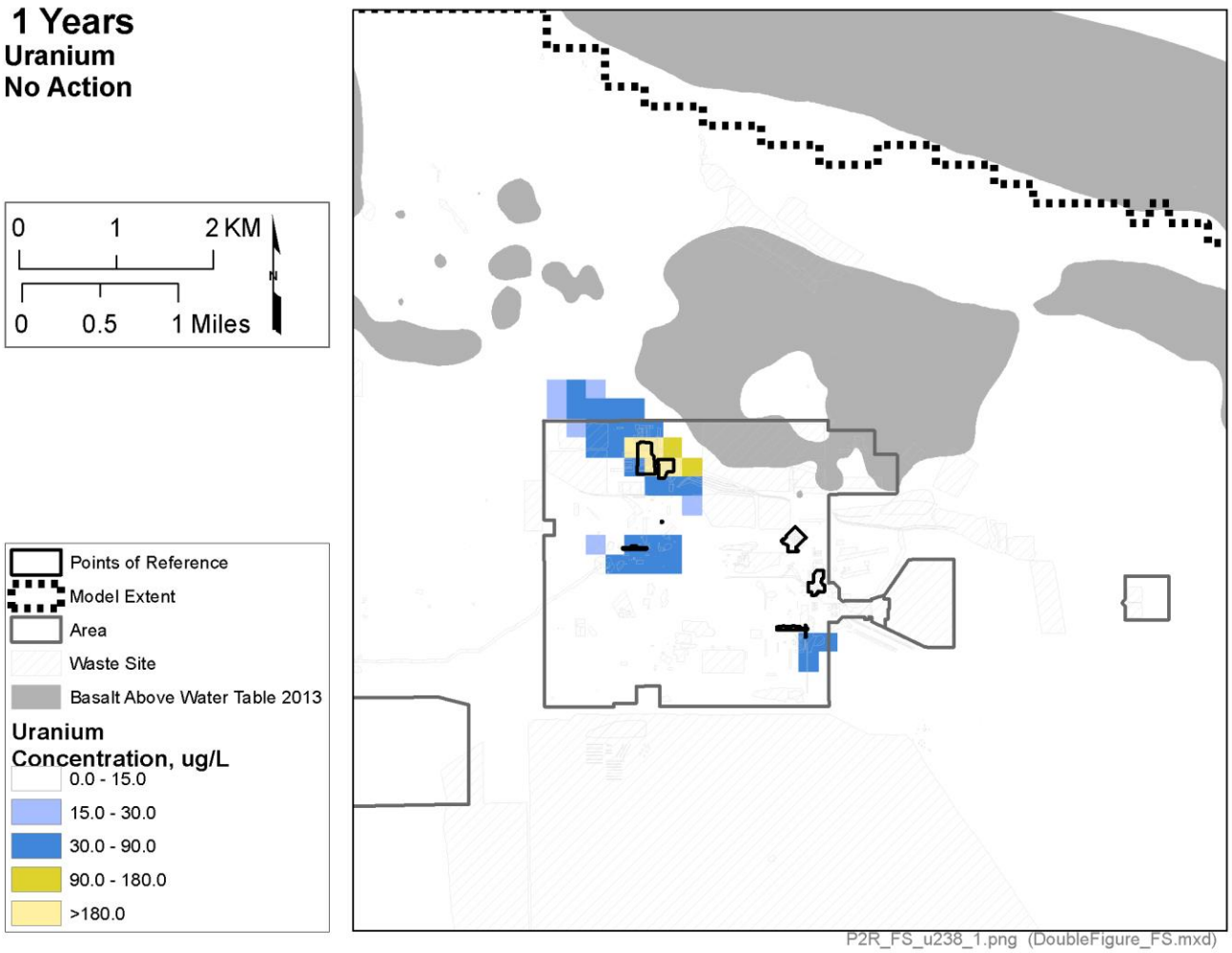

Figure B-16 - Plan view contours of the uranium plume at simulation time 1 years based on the remedial evaluation case simulation.

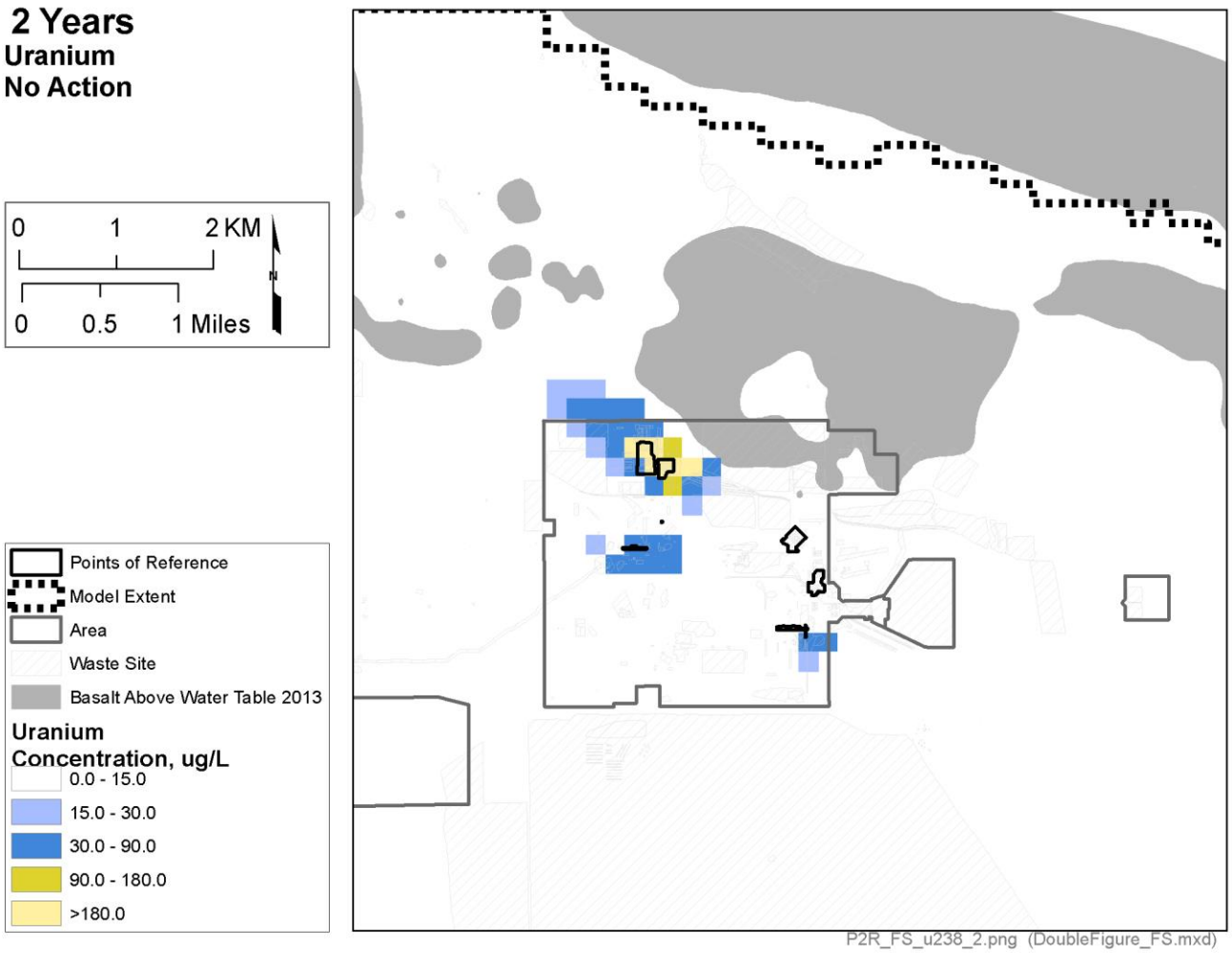

Figure B-17 - Plan view contours of the uranium plume at simulation time 2 years based on the remedial evaluation case simulation.

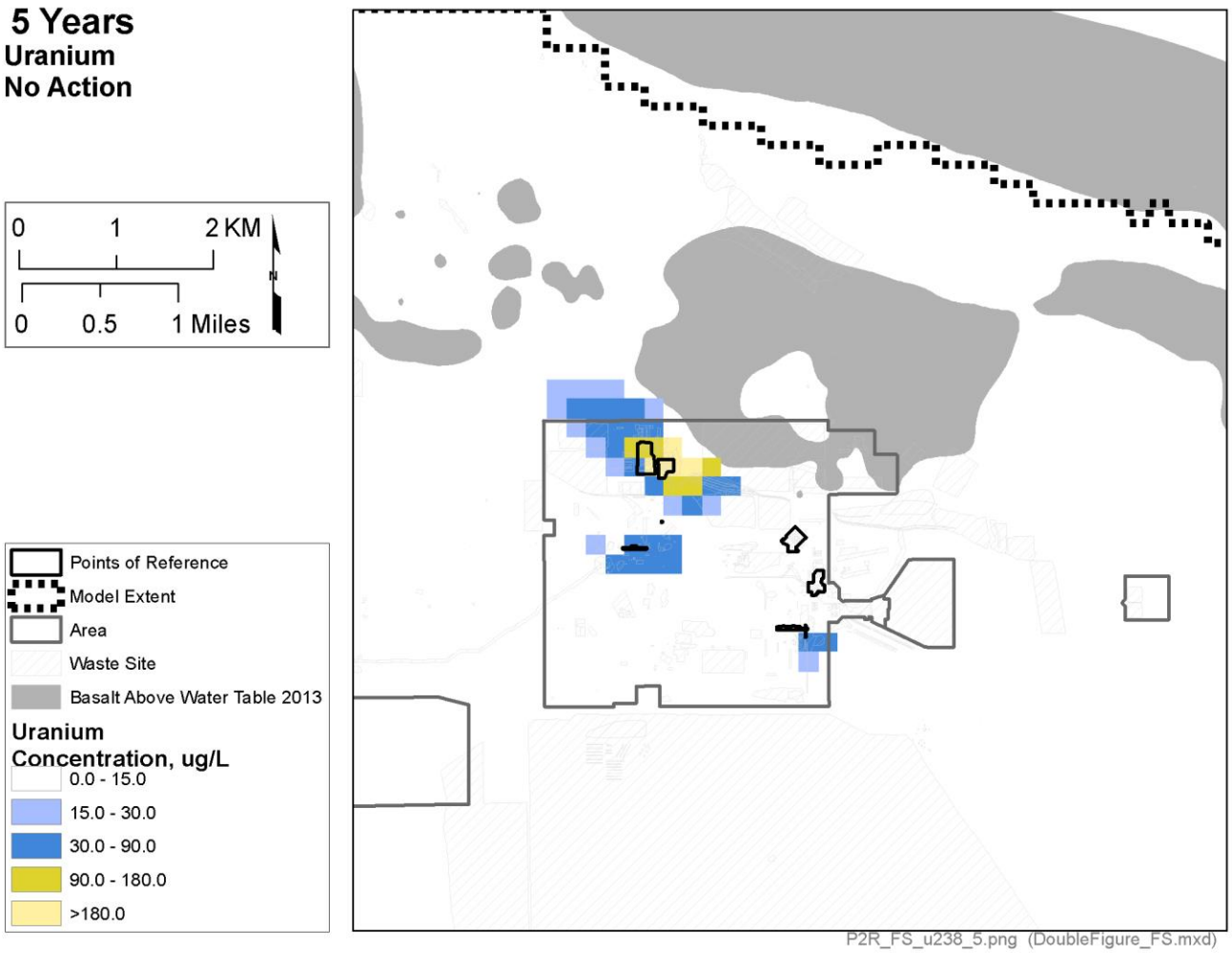

Figure B-18 - Plan view contours of the uranium plume at simulation time 5 years based on the remedial evaluation case simulation.

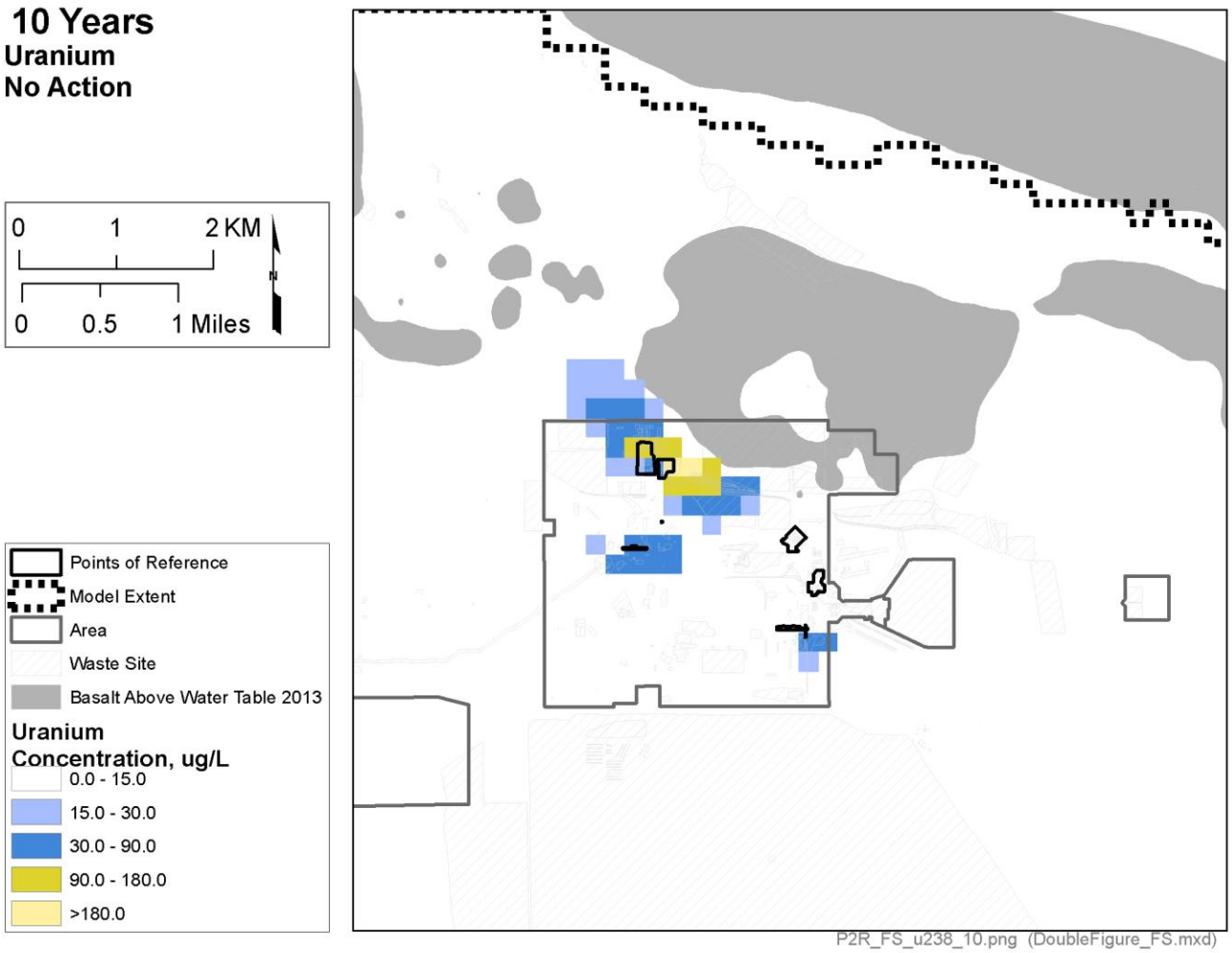

Figure B-19 - Plan view contours of the uranium plume at simulation time 10 years based on the remedial evaluation case simulation.

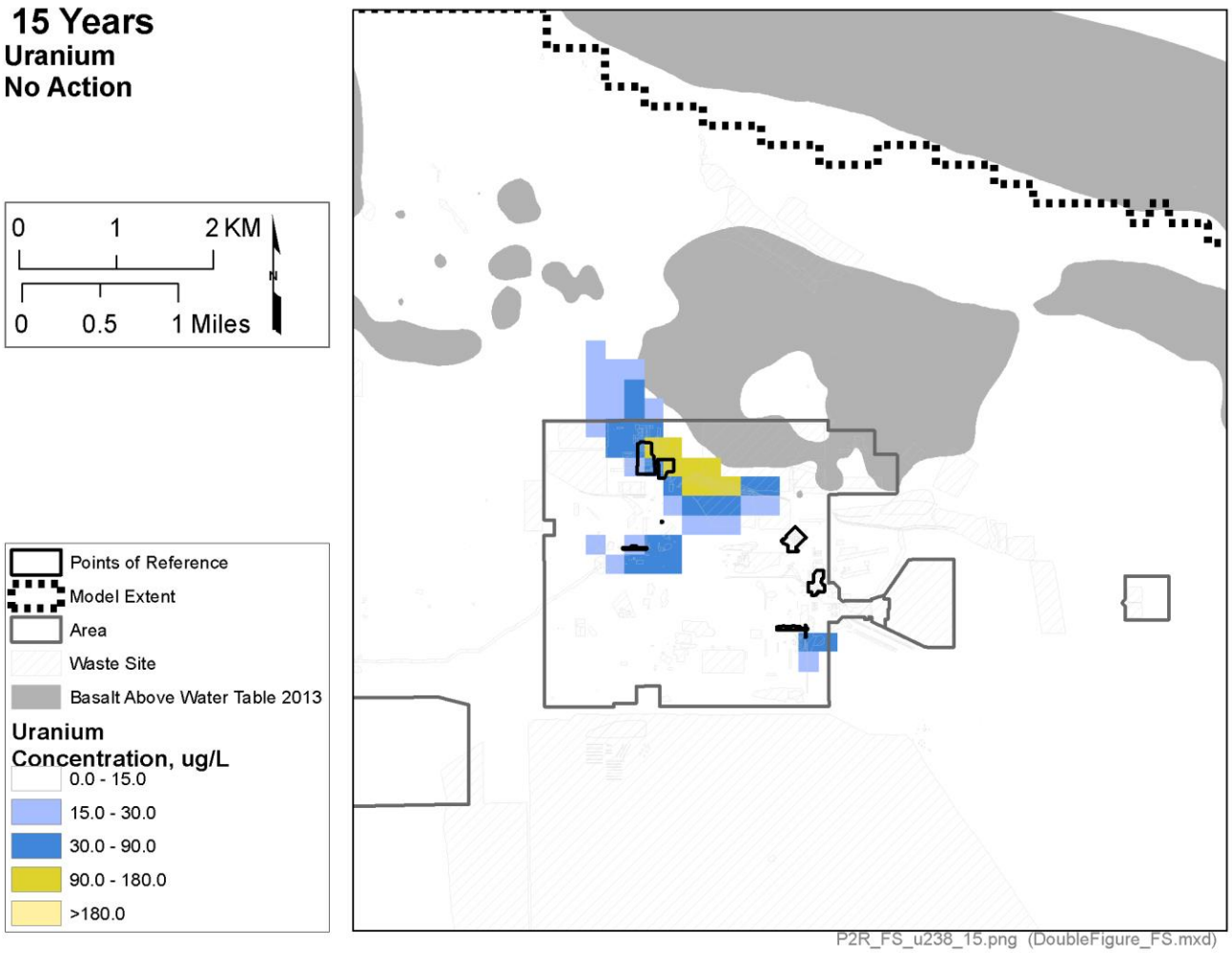

Figure B-20 - Plan view contours of the uranium plume at simulation time 15 years based on the remedial evaluation case simulation.

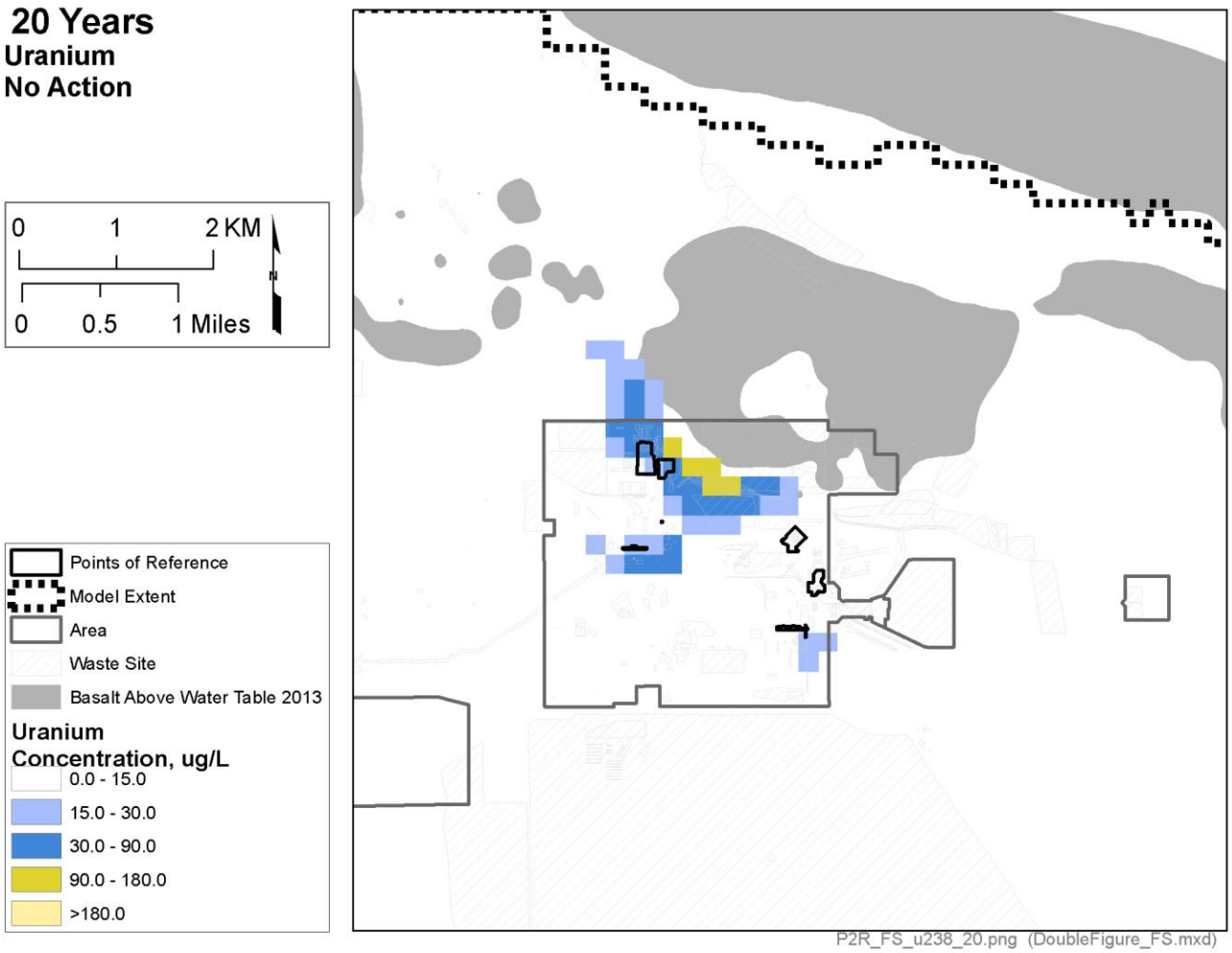

Figure B-21 - Plan view contours of the uranium plume at simulation time 20 years based on the remedial evaluation case simulation.

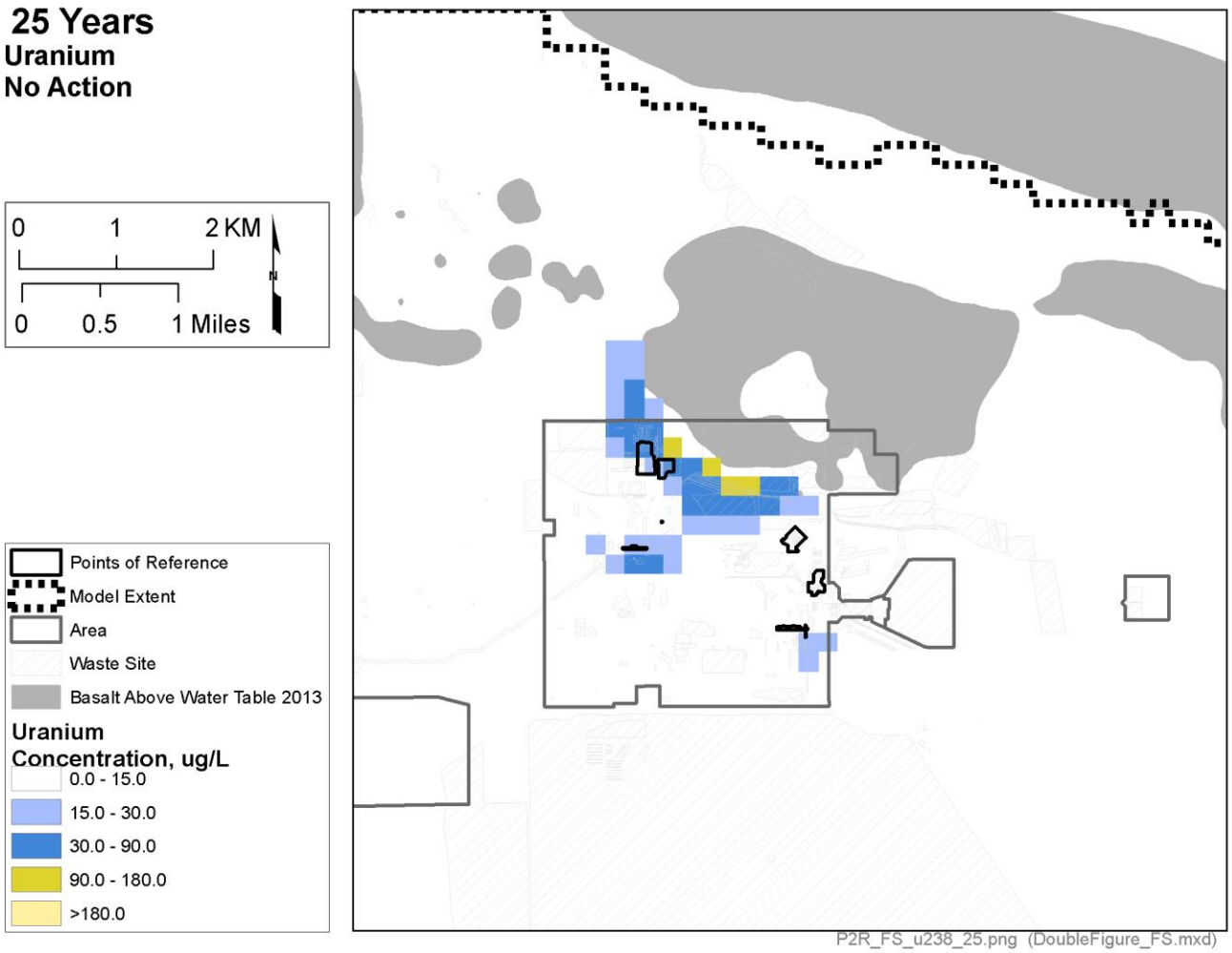

Figure B-22 - Plan view contours of the uranium plume at simulation time 25 years based on the remedial evaluation case simulation.

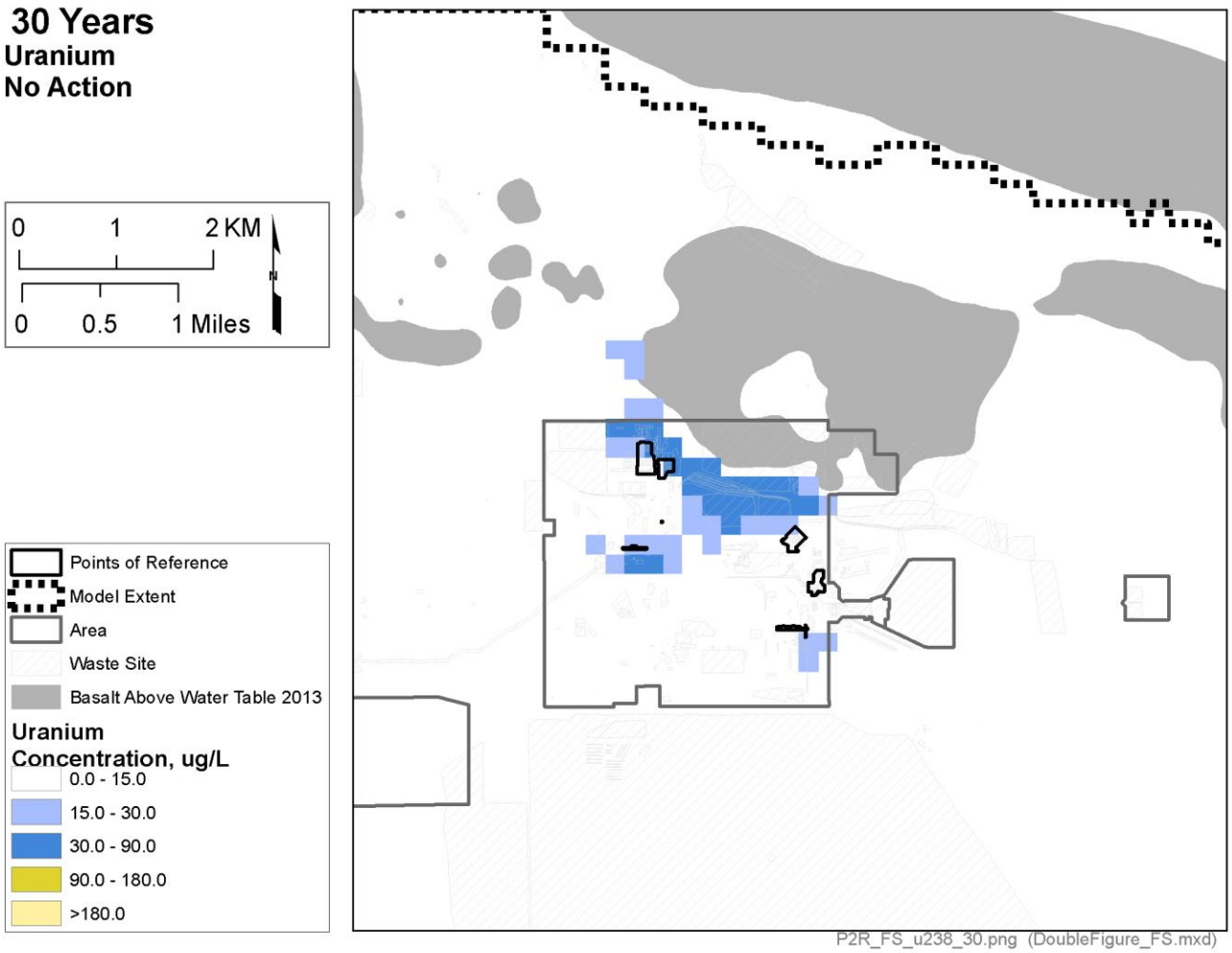

Figure B-23 - Plan view contours of the uranium plume at simulation time 30 years based on the remedial evaluation case simulation.

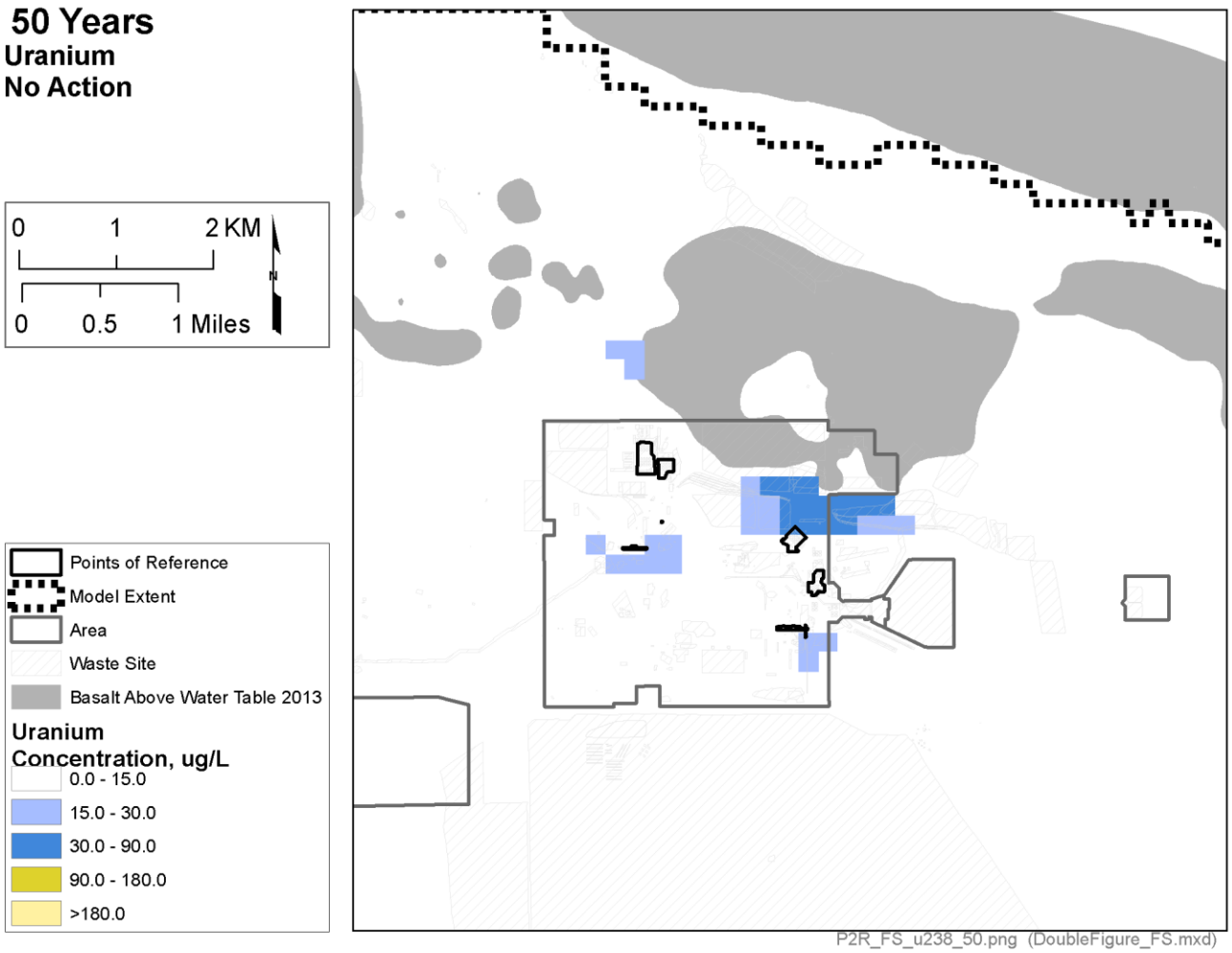

Figure B-24 - Plan view contours of the uranium plume at simulation time 50 years based on the remedial evaluation case simulation.

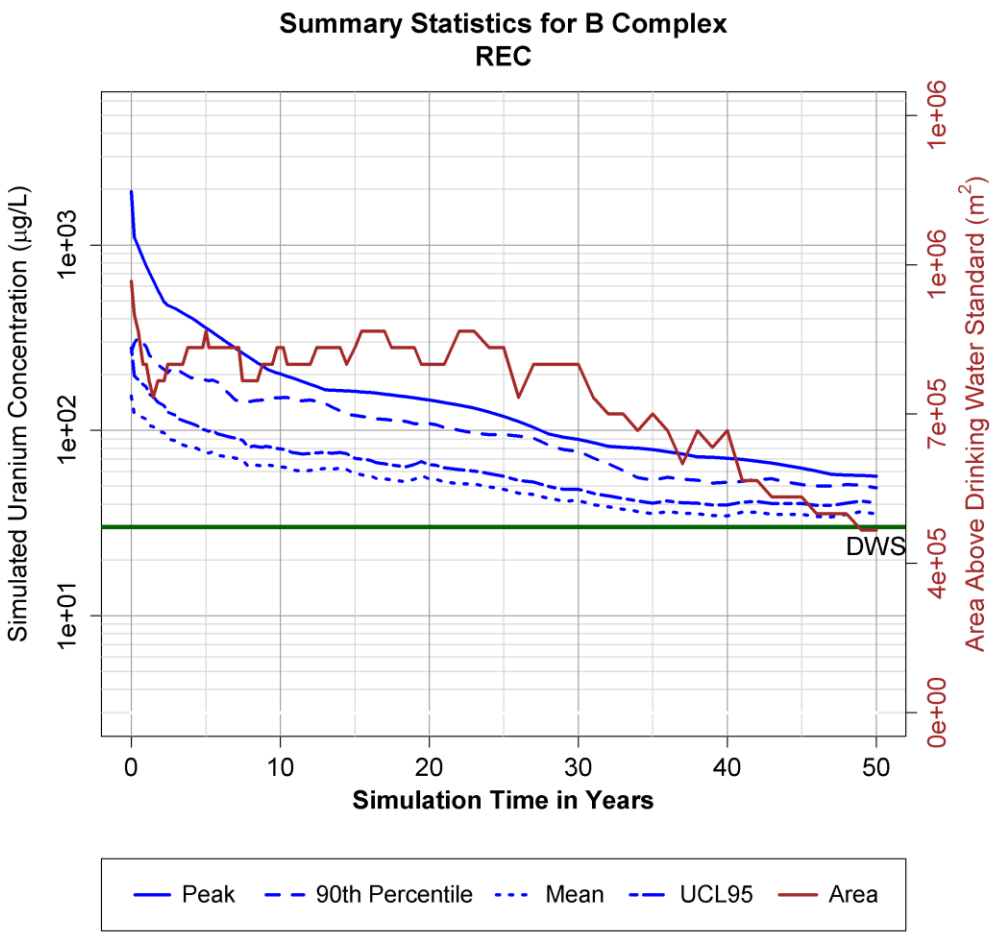

Figure B-25 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

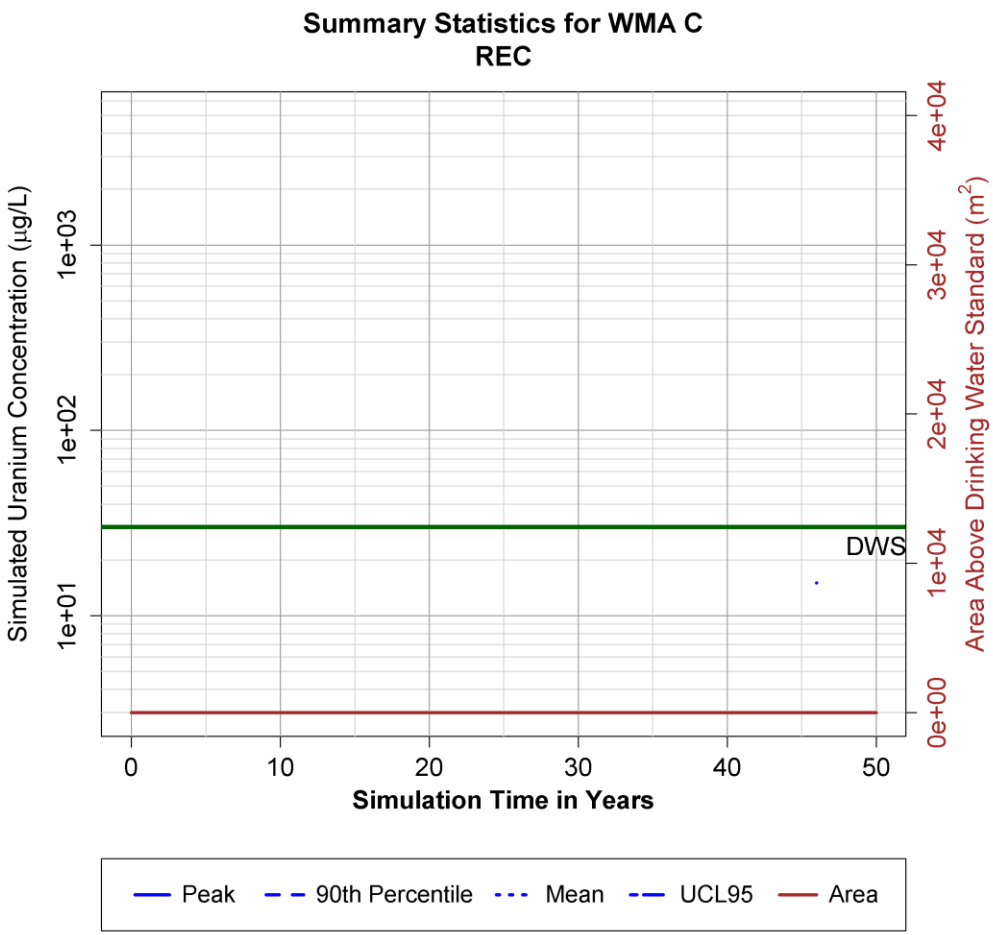

Figure B-26 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

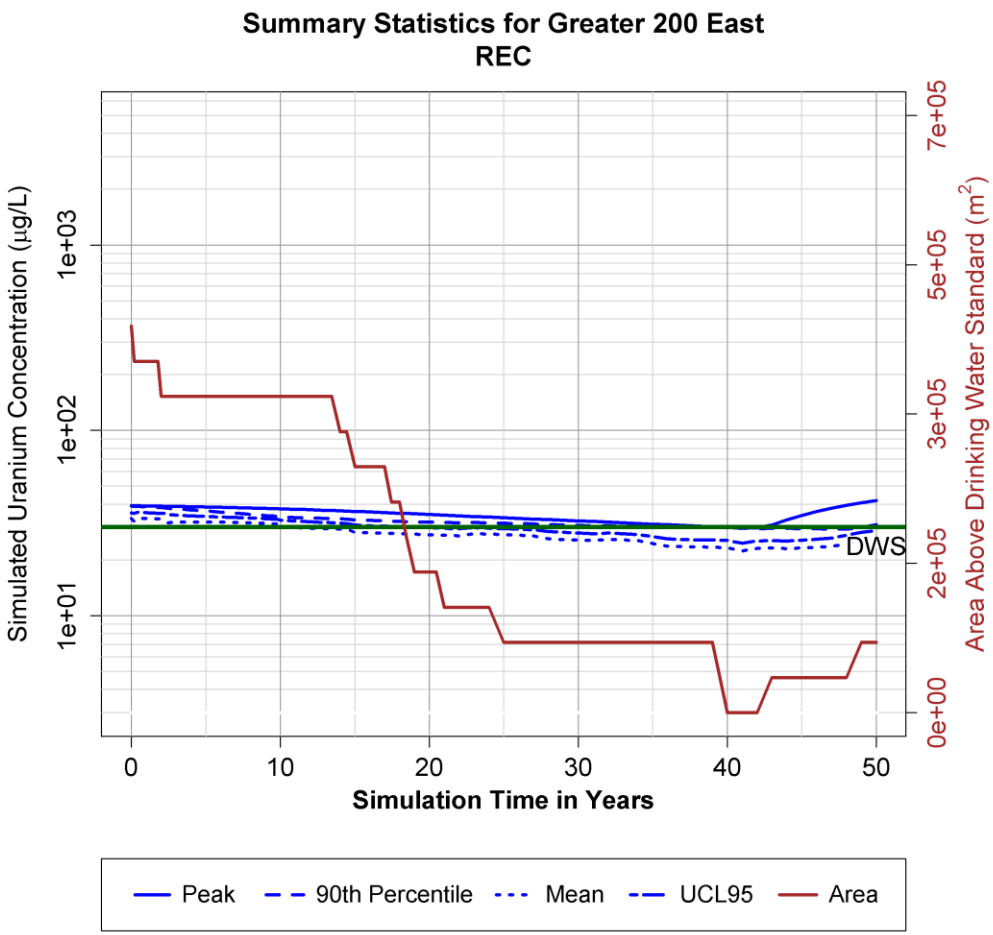

Figure B-27 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

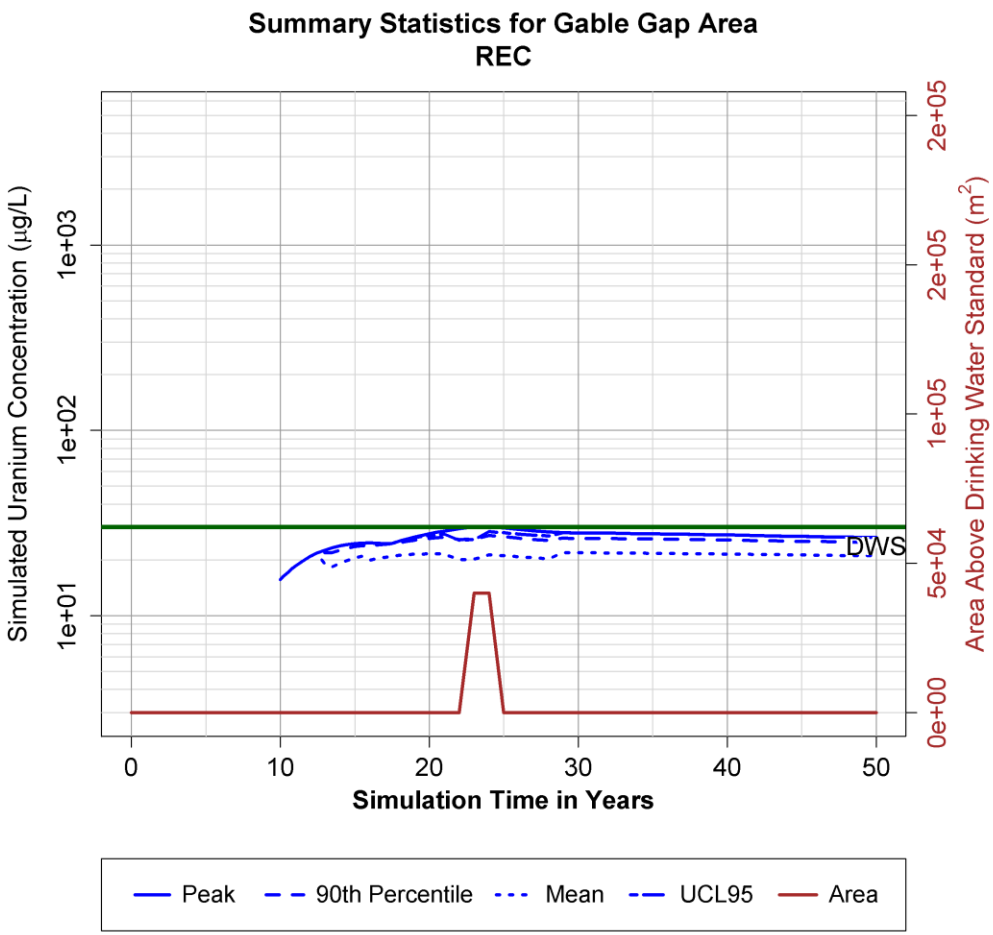

Figure B-28 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation.

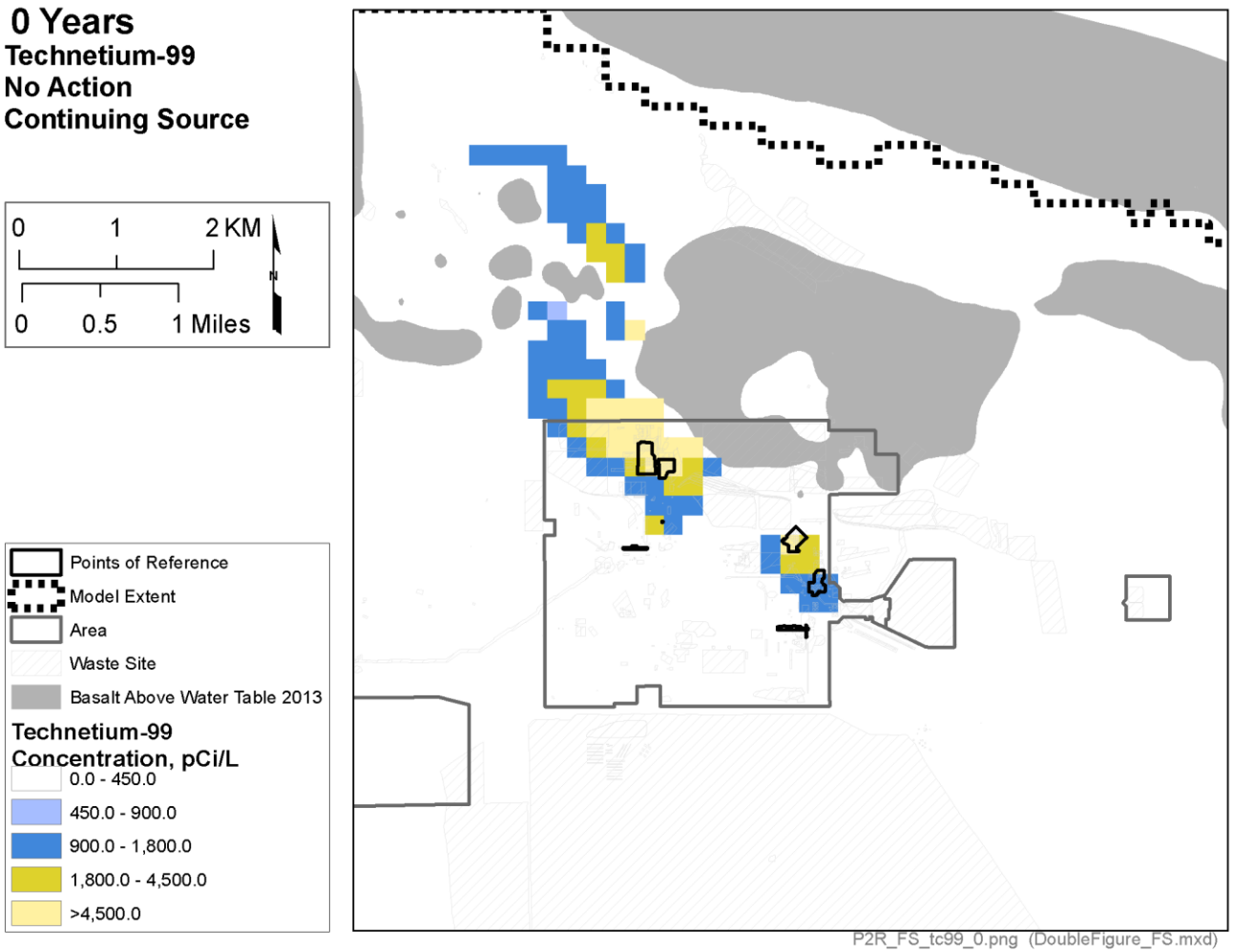

Figure B-29 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the remedial evaluation case simulation with a continuing source term.

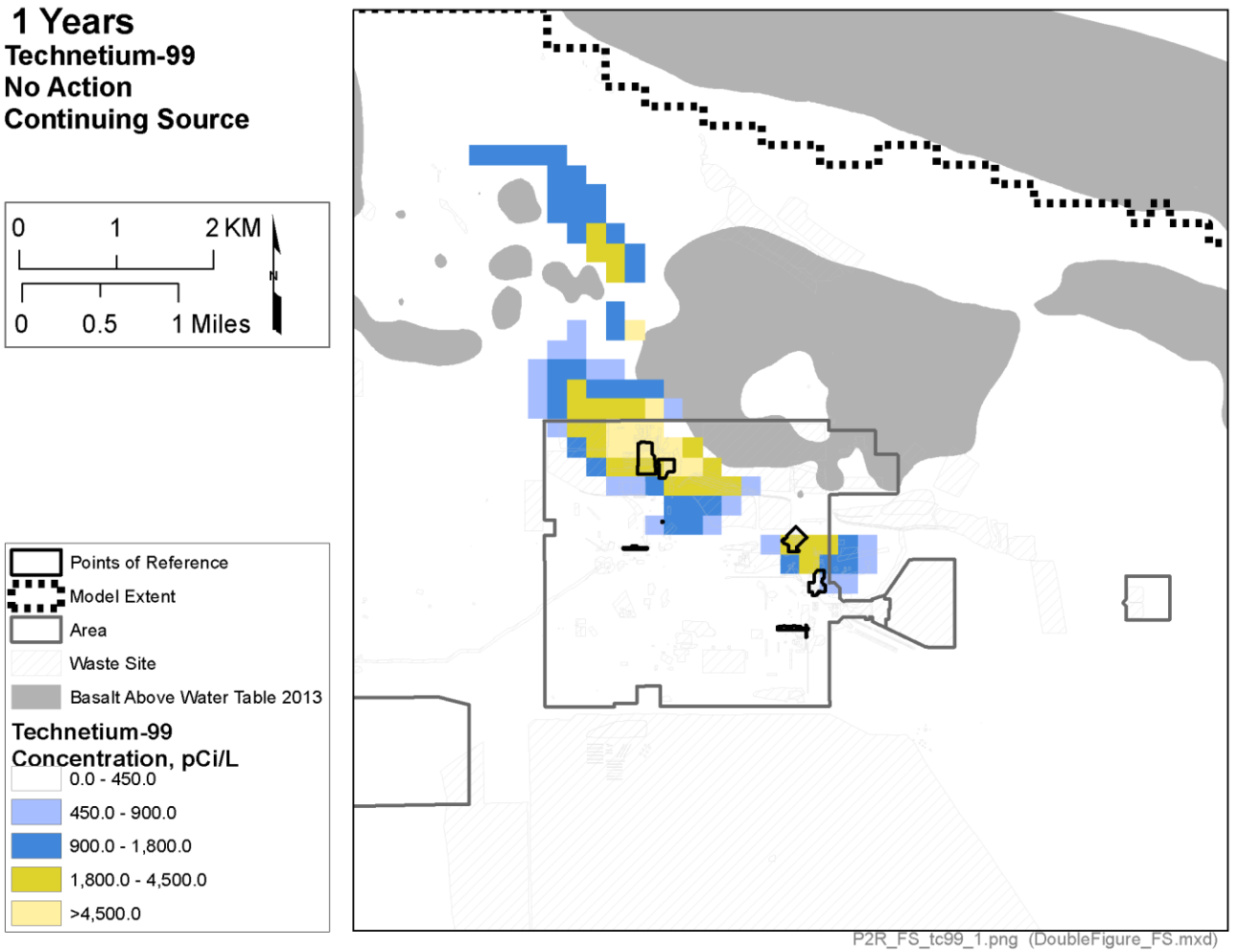

Figure B-30 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the remedial evaluation case simulation with a continuing source term.

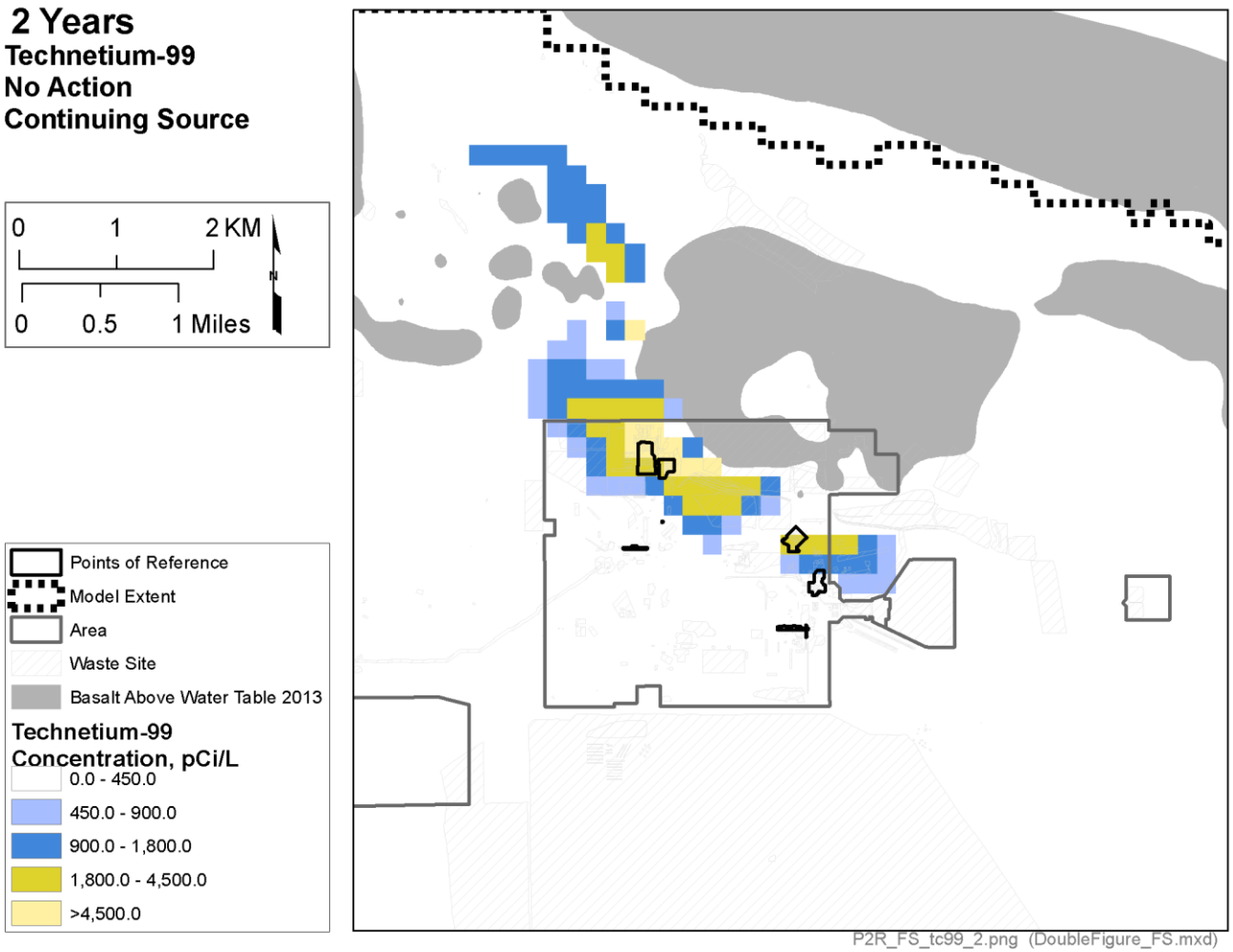

Figure B-31 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the remedial evaluation case simulation with a continuing source term.

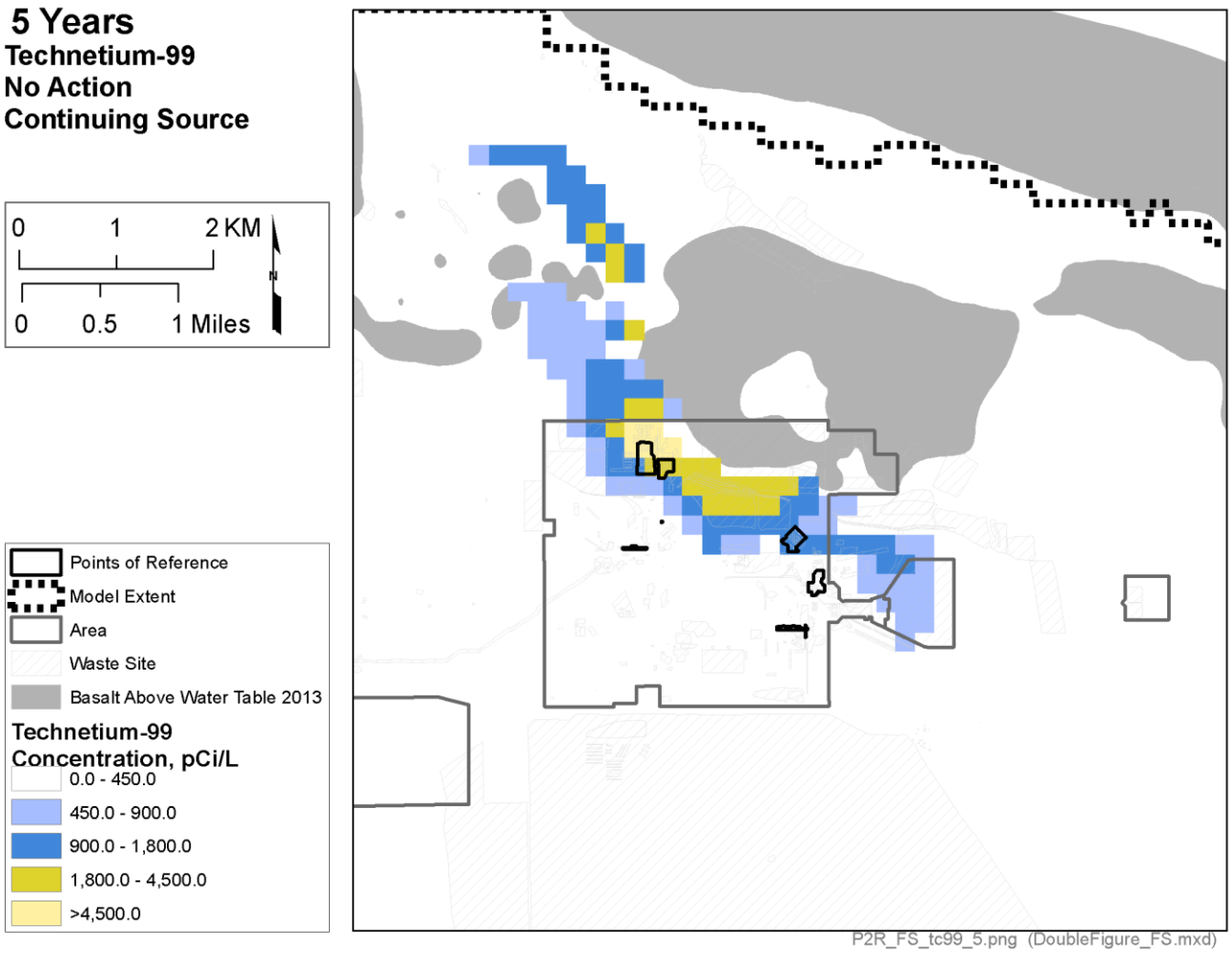

Figure B-32 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the remedial evaluation case simulation with a continuing source term.

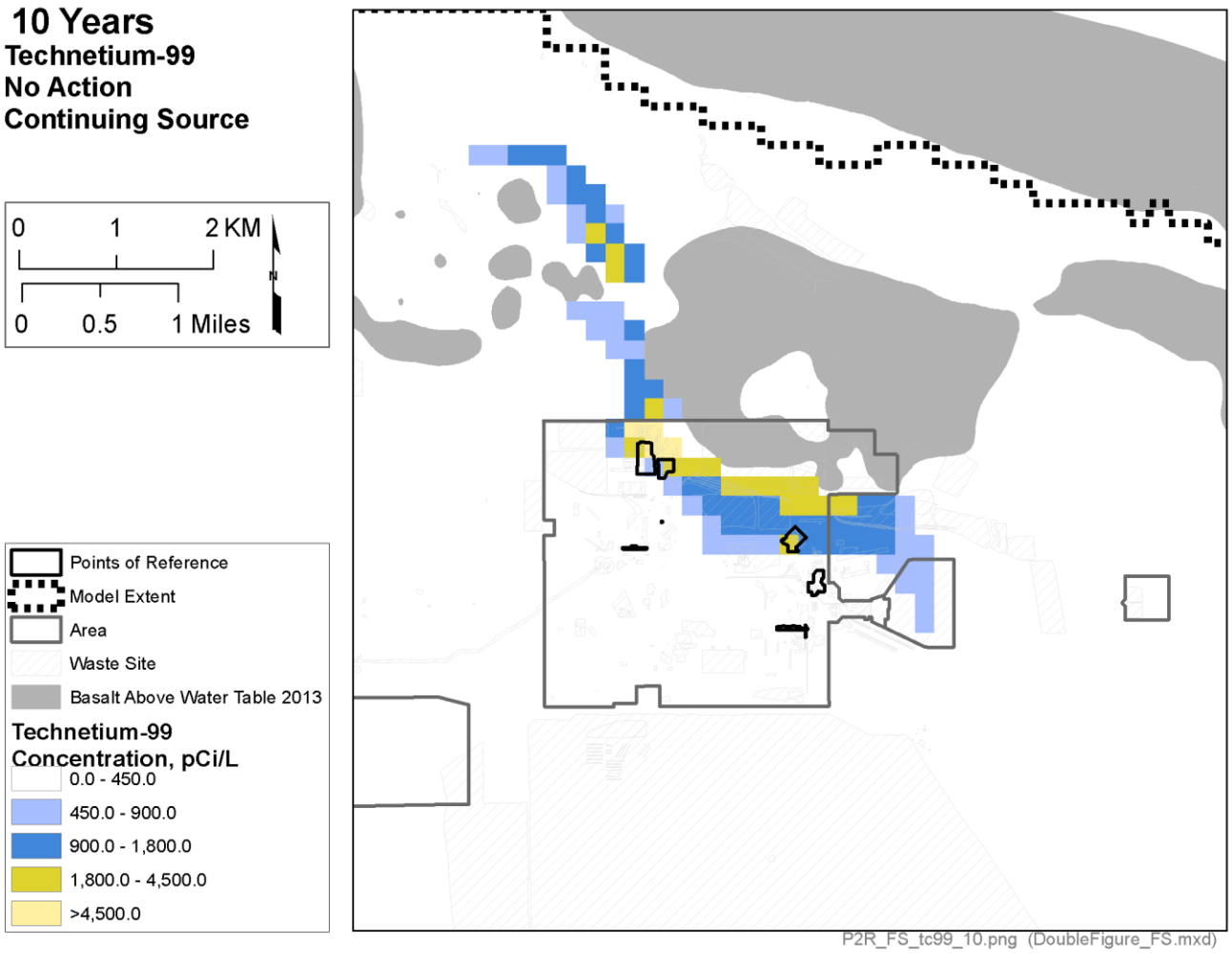

Figure B-33 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the remedial evaluation case simulation with a continuing source term.

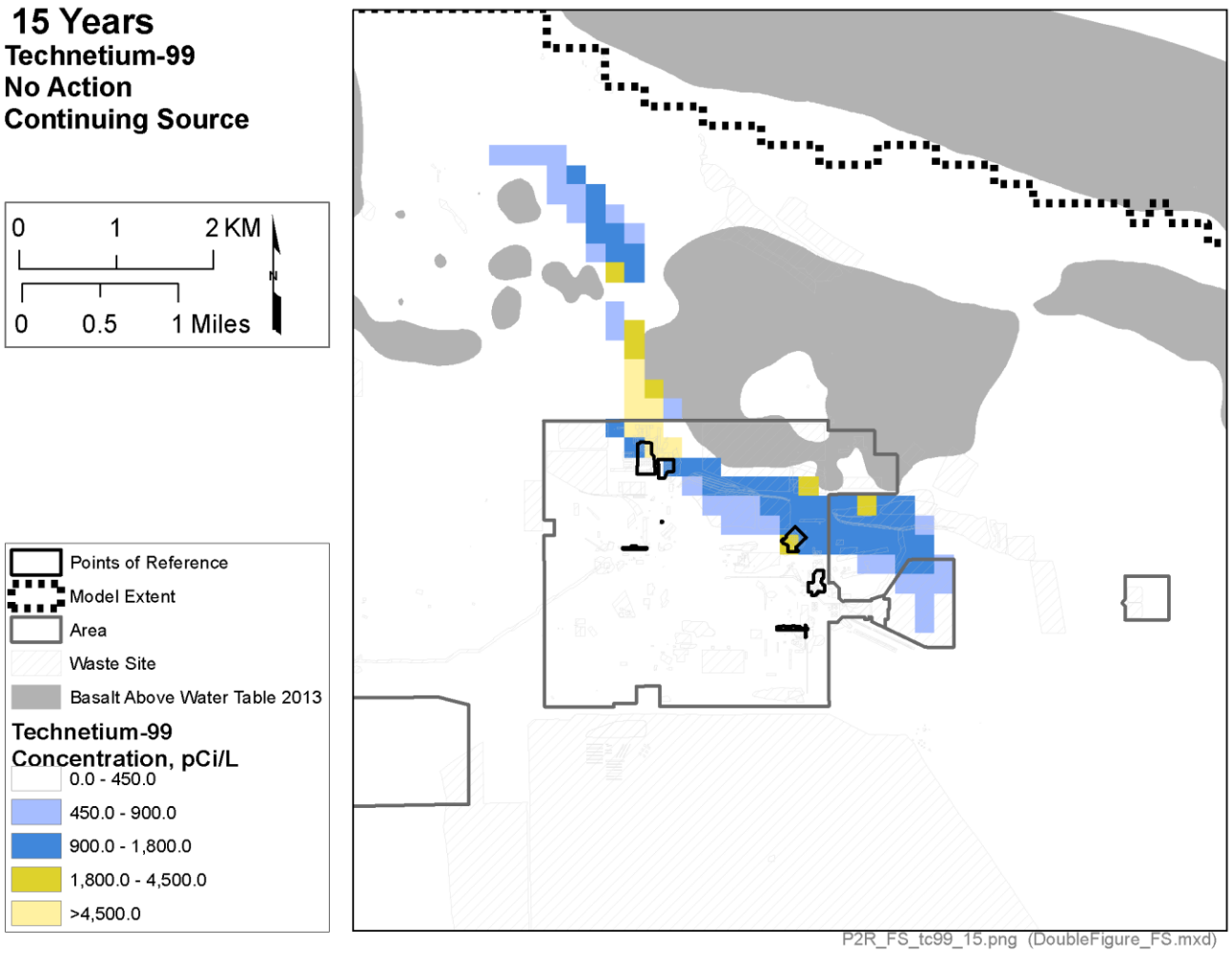

Figure B-34 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the remedial evaluation case simulation with a continuing source term.

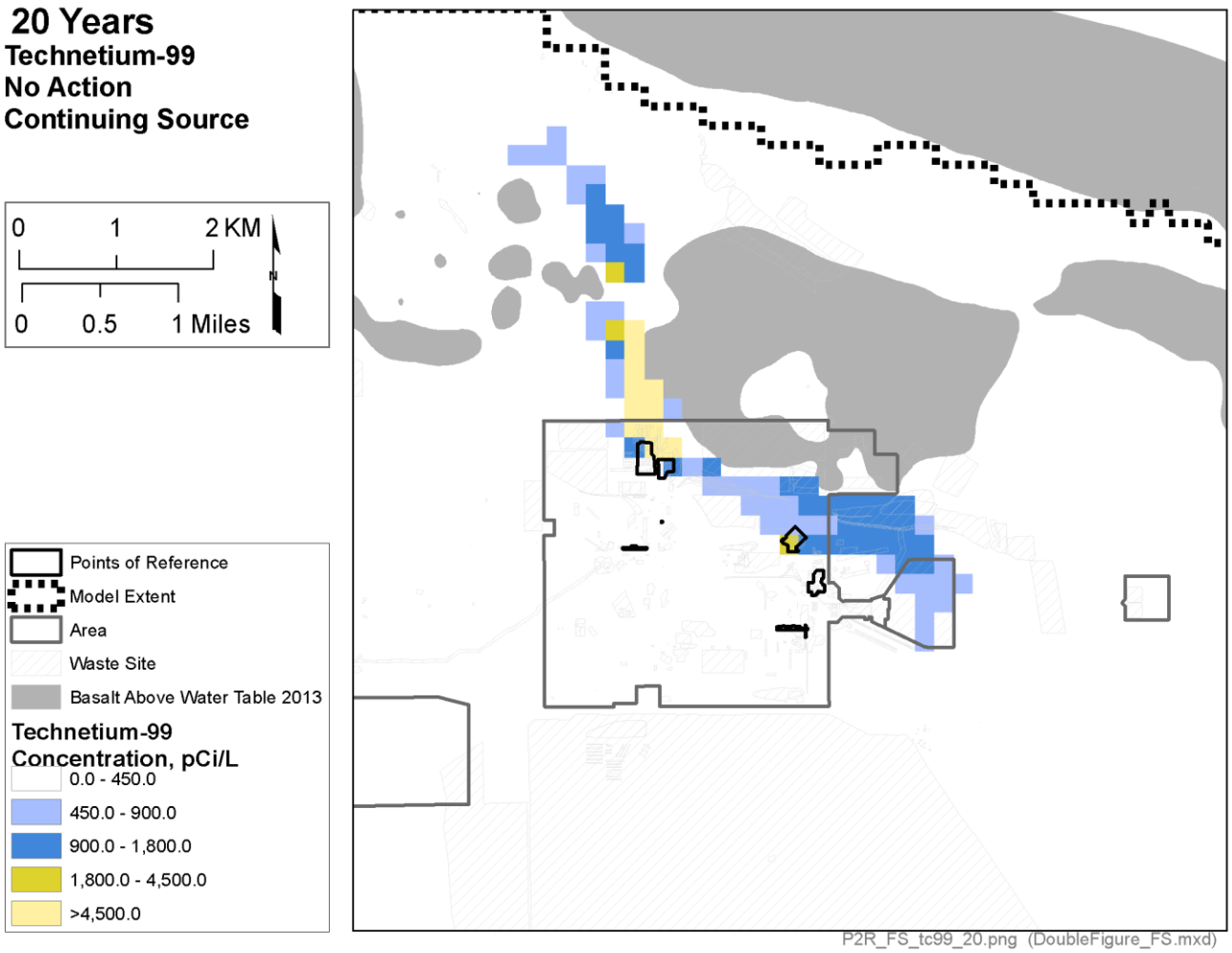

Figure B-35 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the remedial evaluation case simulation with a continuing source term.

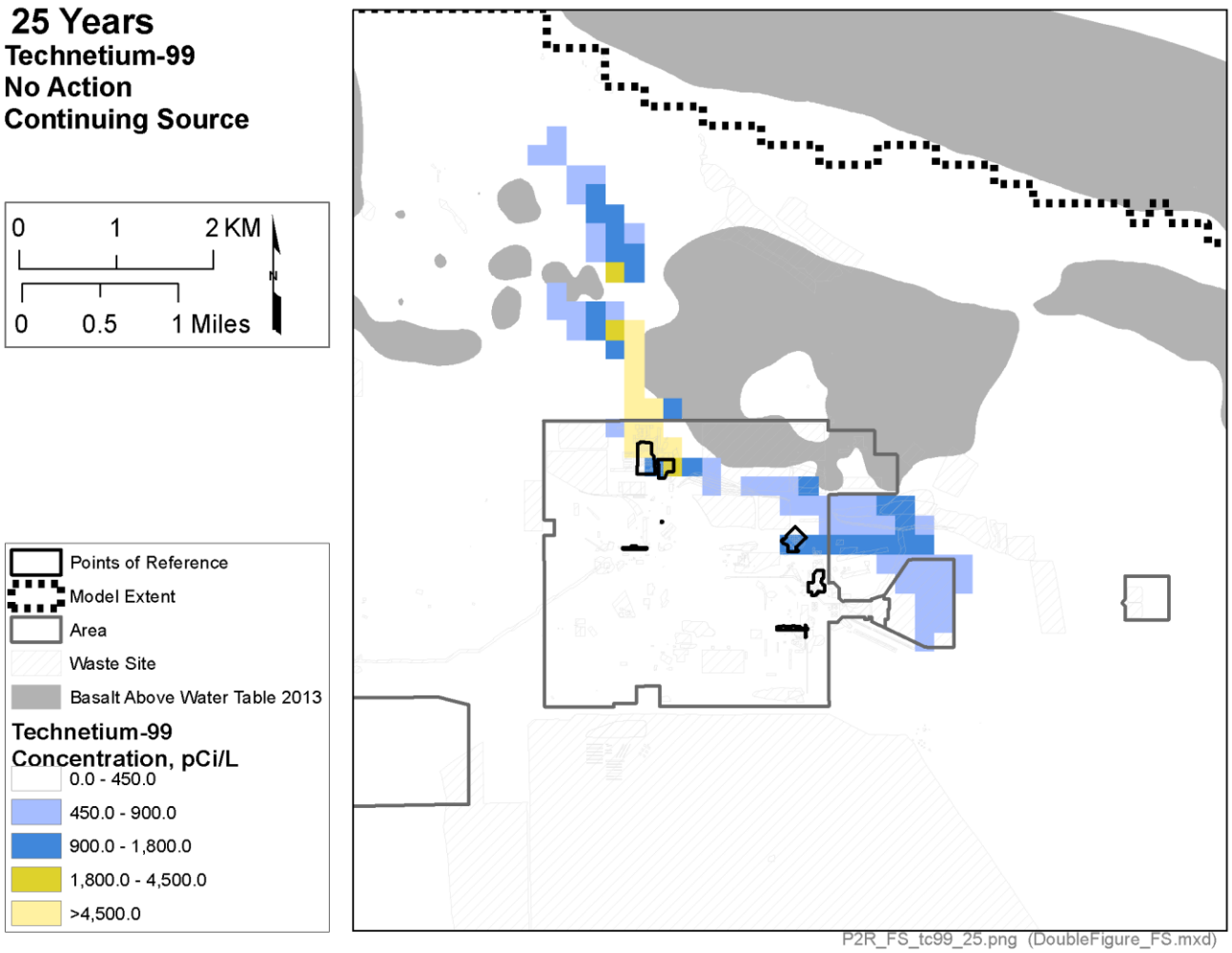

Figure B-36 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the remedial evaluation case simulation with a continuing source term.

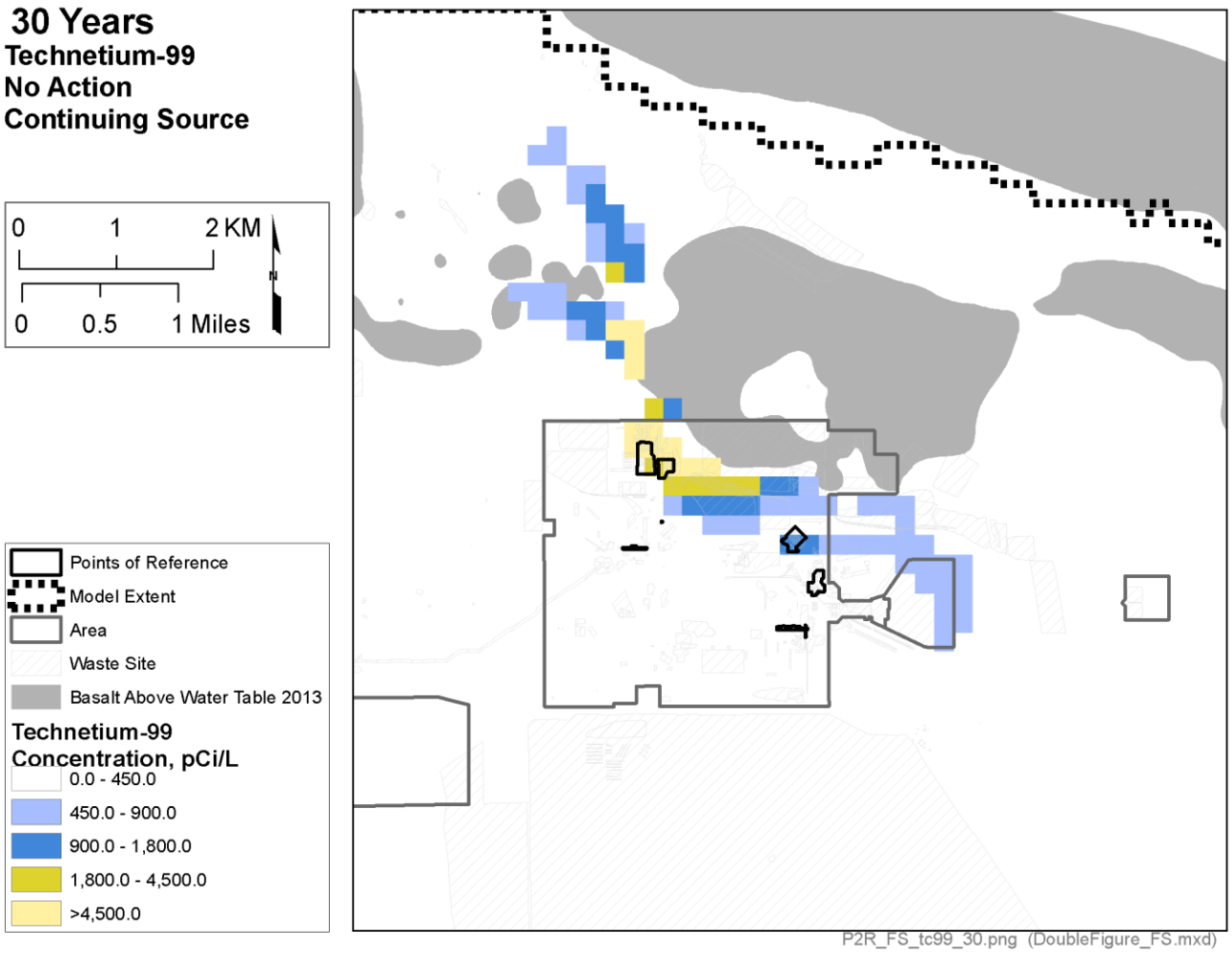

Figure B-37 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the remedial evaluation case simulation with a continuing source term.

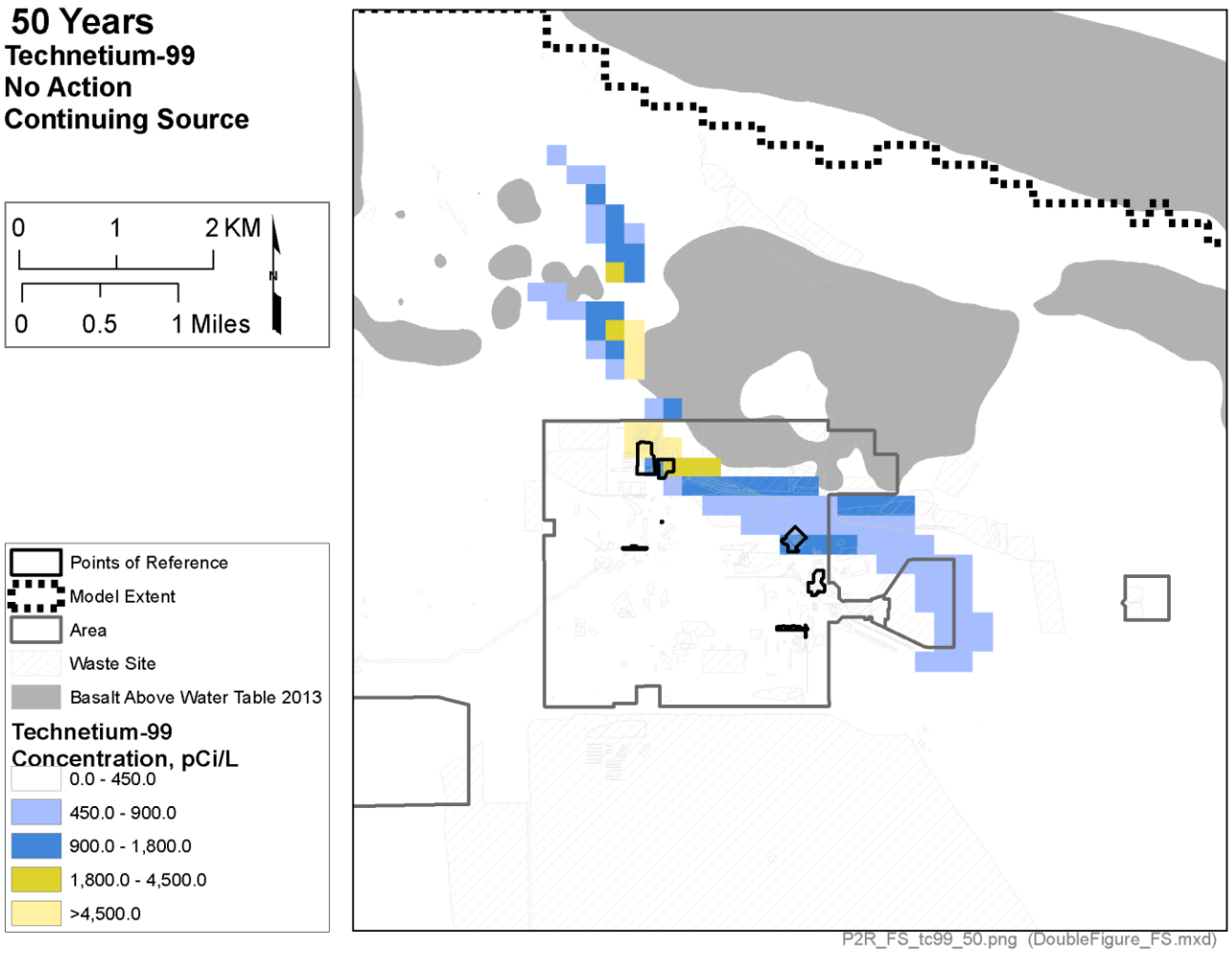

Figure B-38 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the remedial evaluation case simulation with a continuing source term.

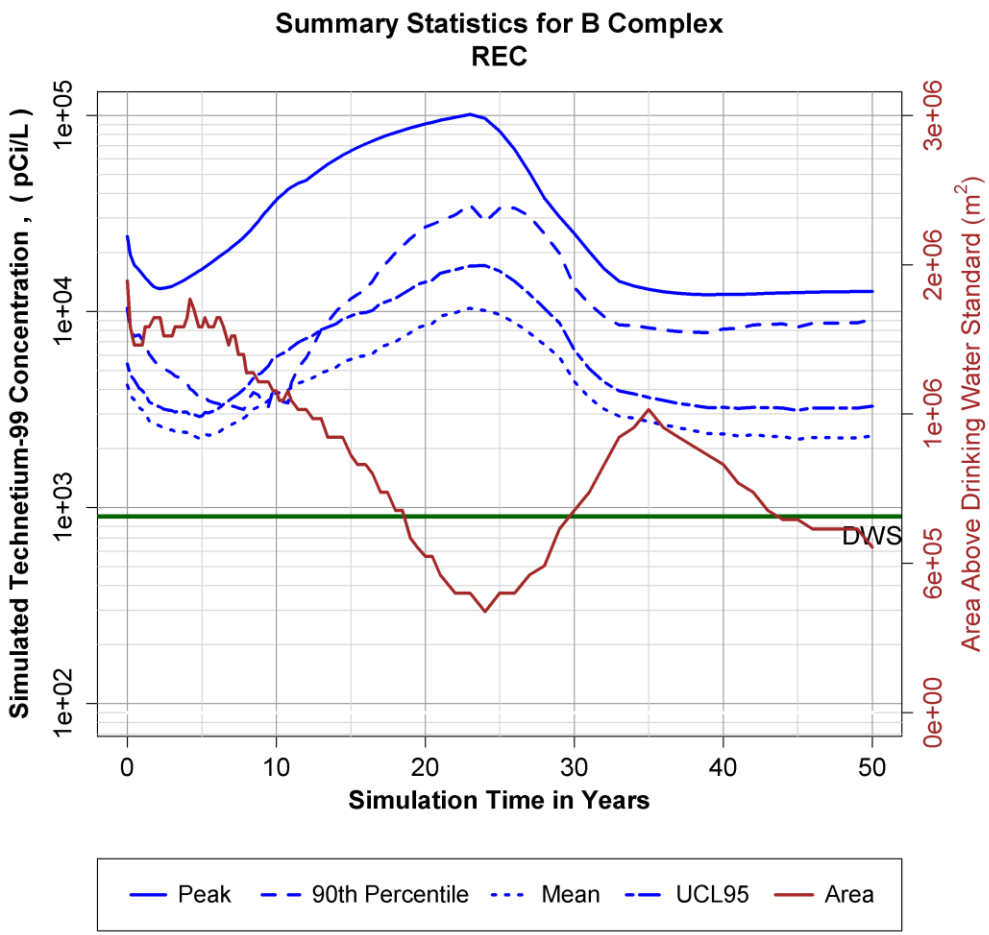

Figure B-39 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

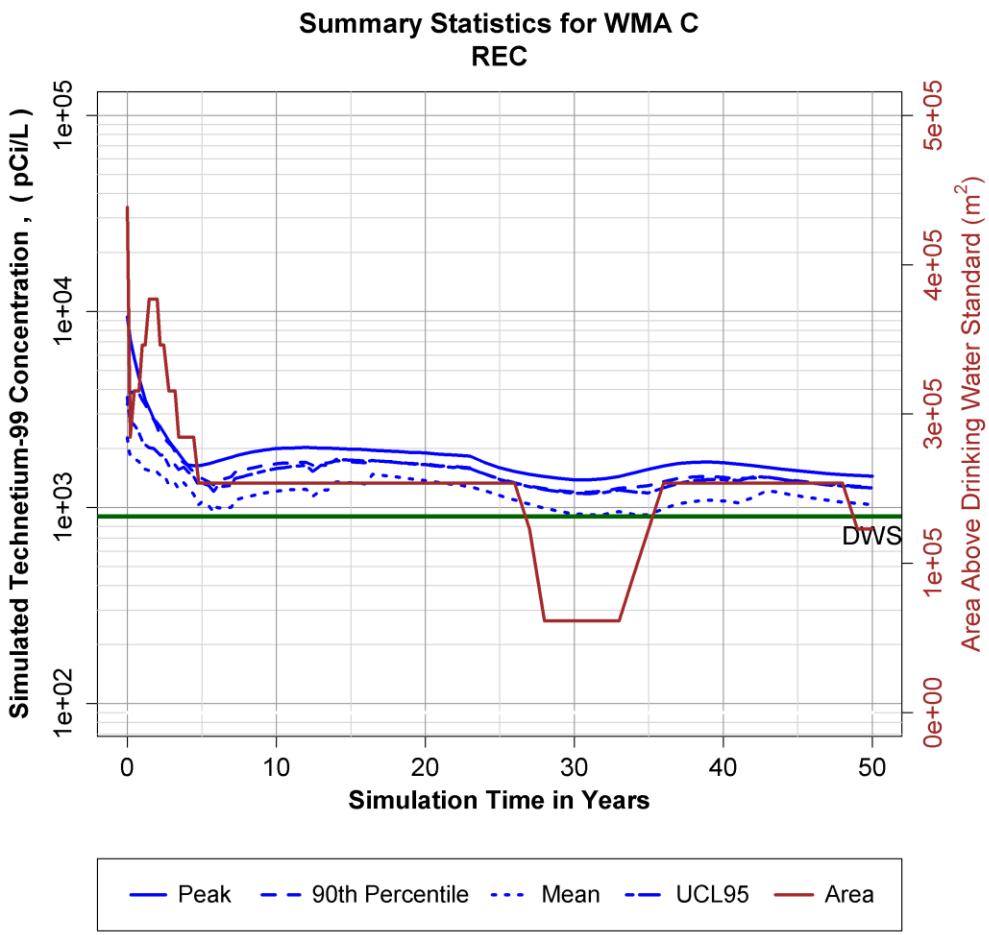

Figure B-40 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

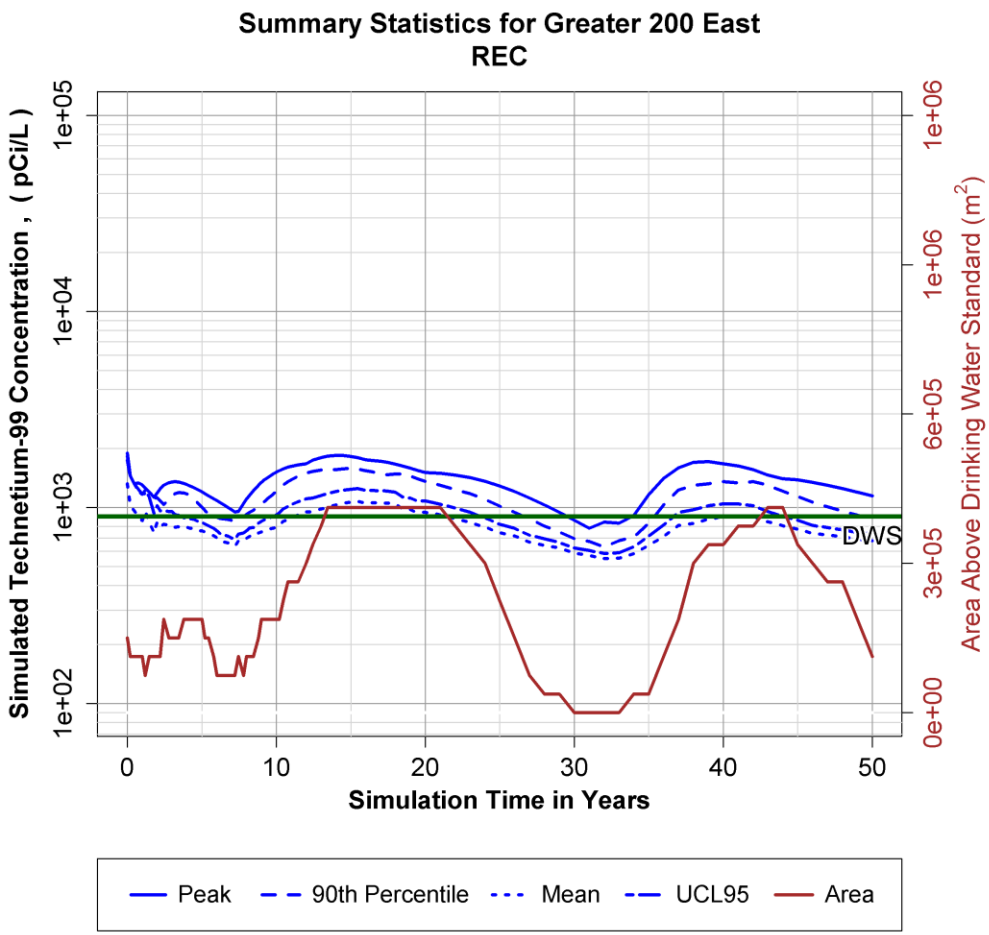

Figure B-41 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

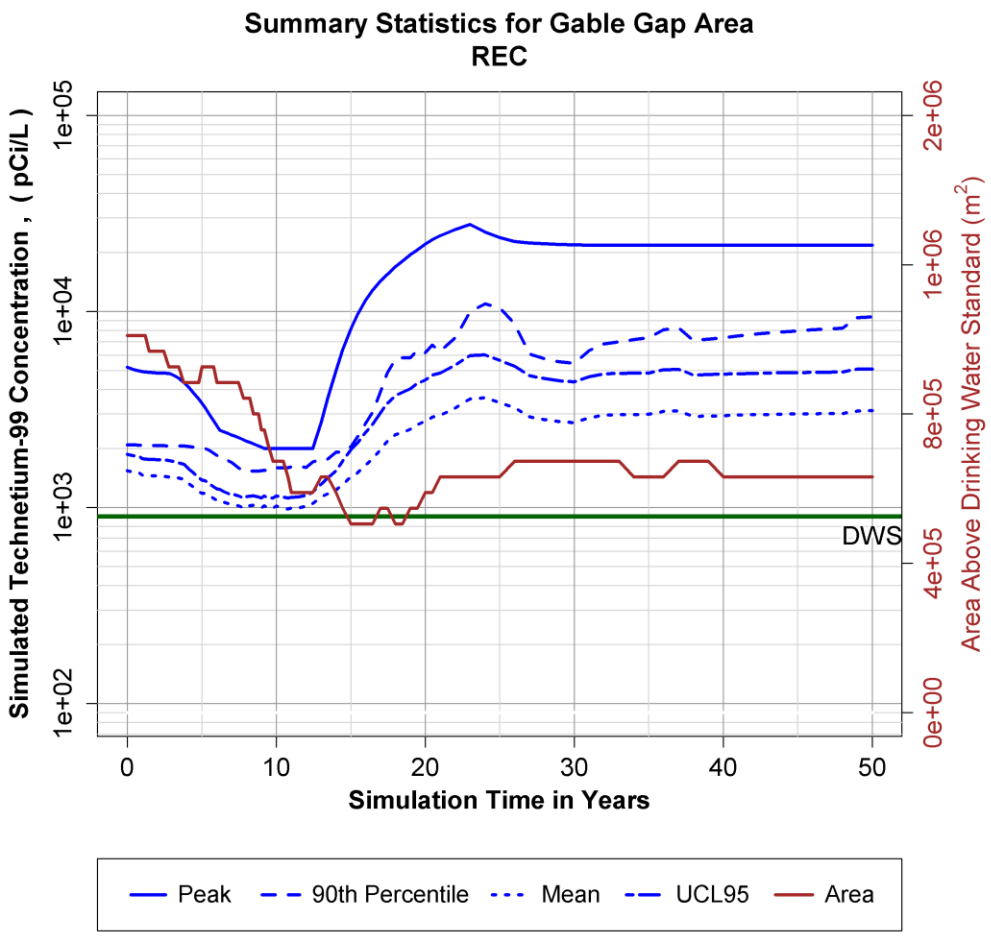

Figure B-42 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the remedial evaluation case simulation with a continuing source term.

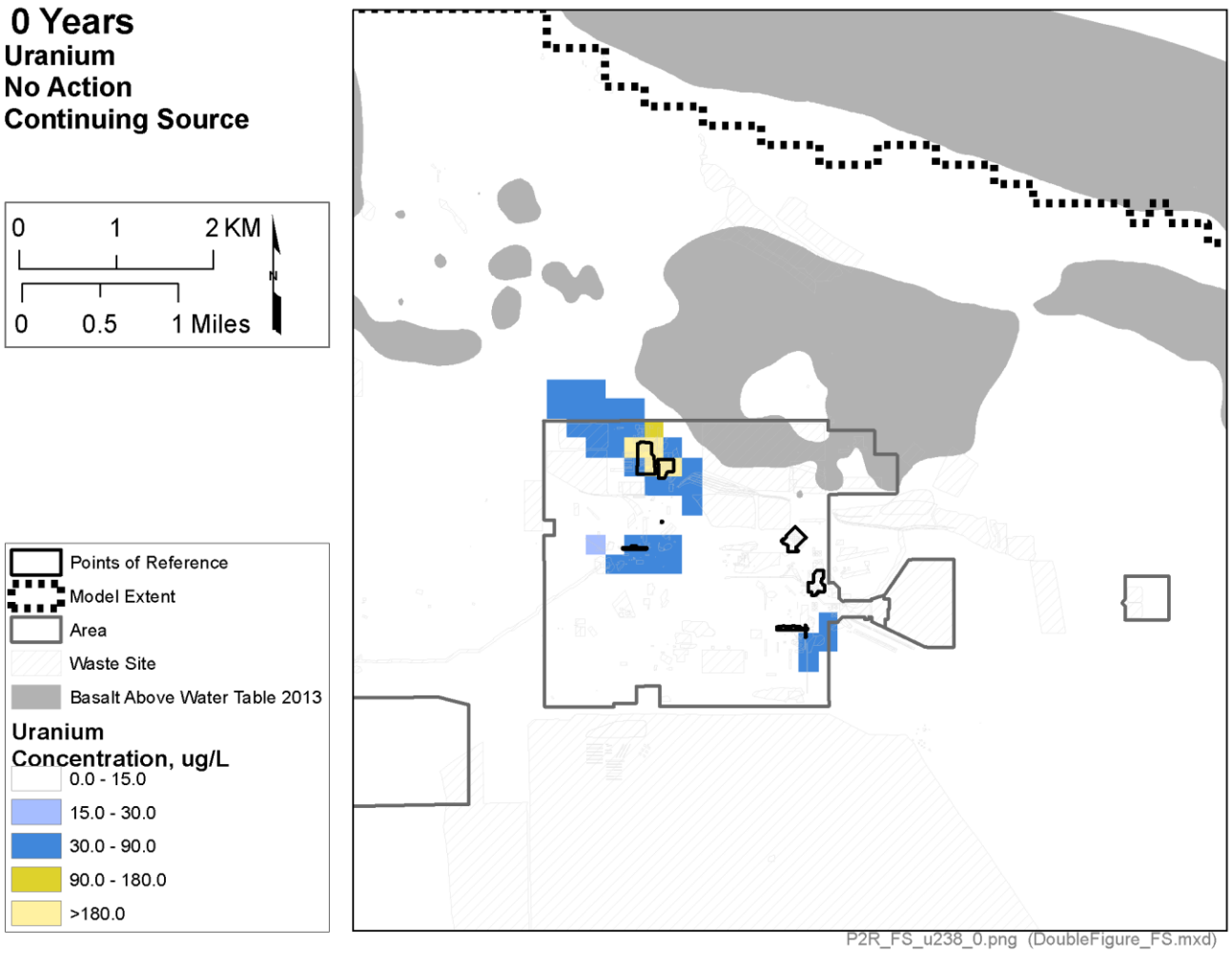

Figure B-43 - Plan view contours of the uranium plume at simulation time 0 years based on the remedial evaluation case simulation with a continuing source term.

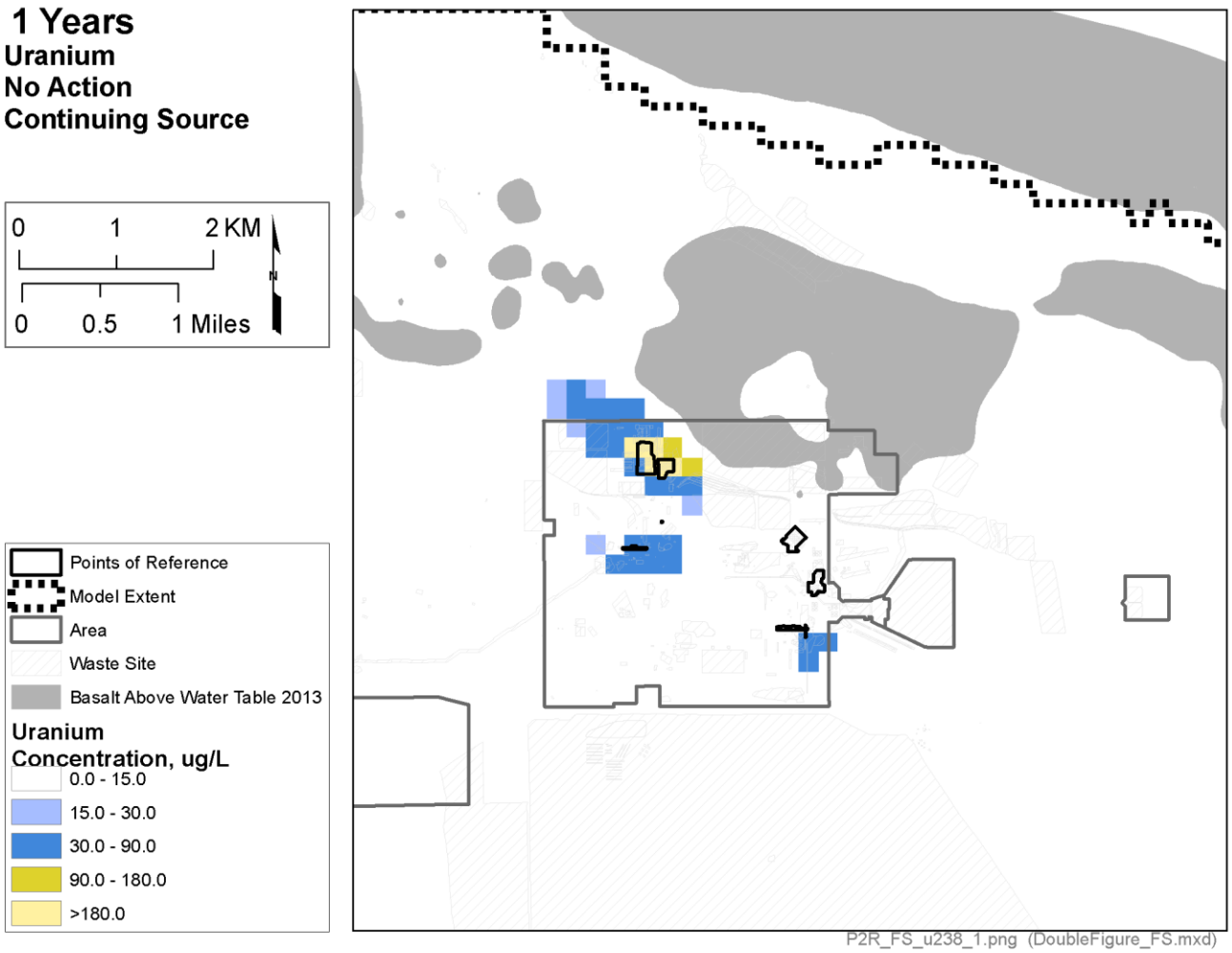

Figure B-44 - Plan view contours of the uranium plume at simulation time 1 years based on the remedial evaluation case simulation with a continuing source term.

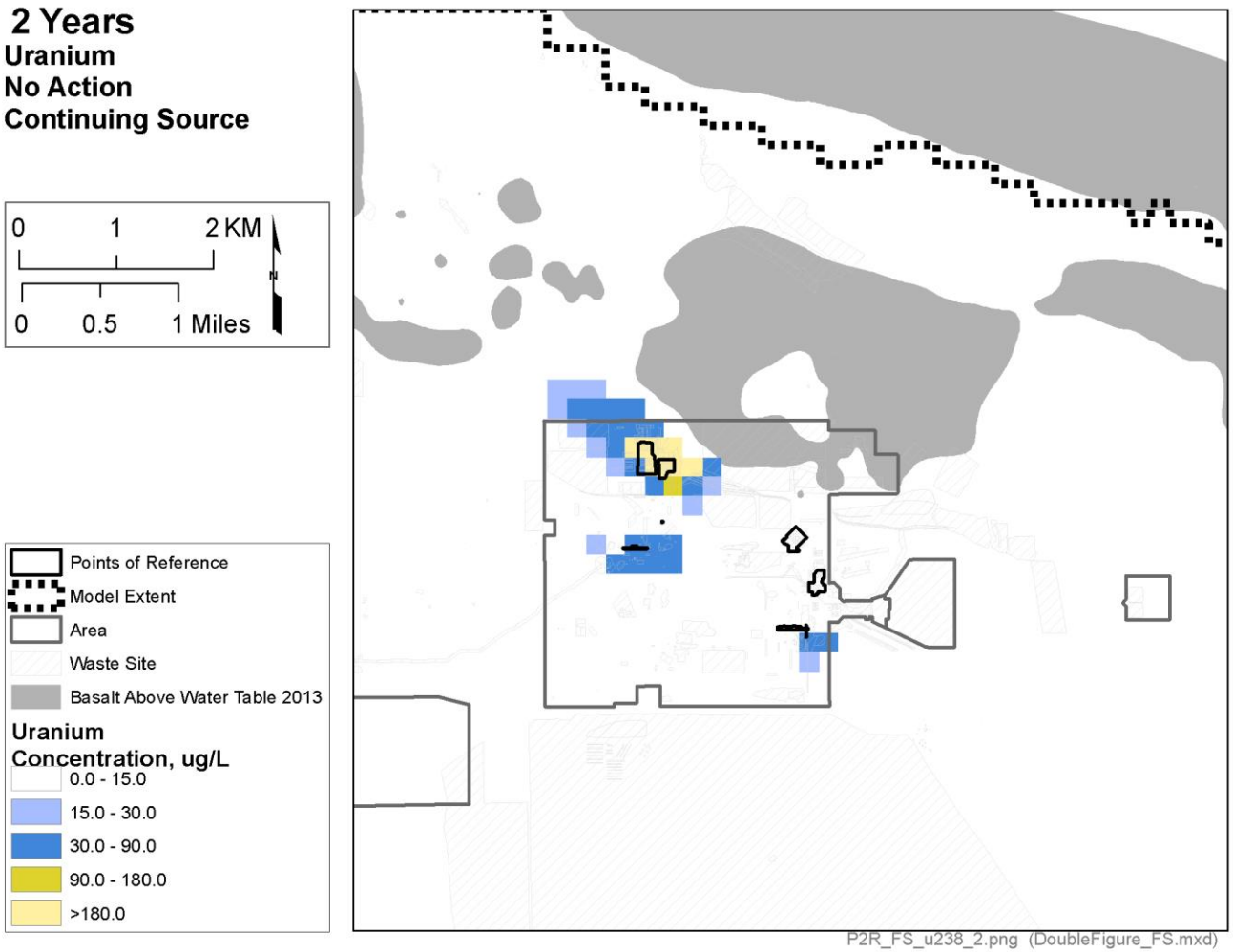

Figure B-45 - Plan view contours of the uranium plume at simulation time 2 years based on the remedial evaluation case simulation with a continuing source term.

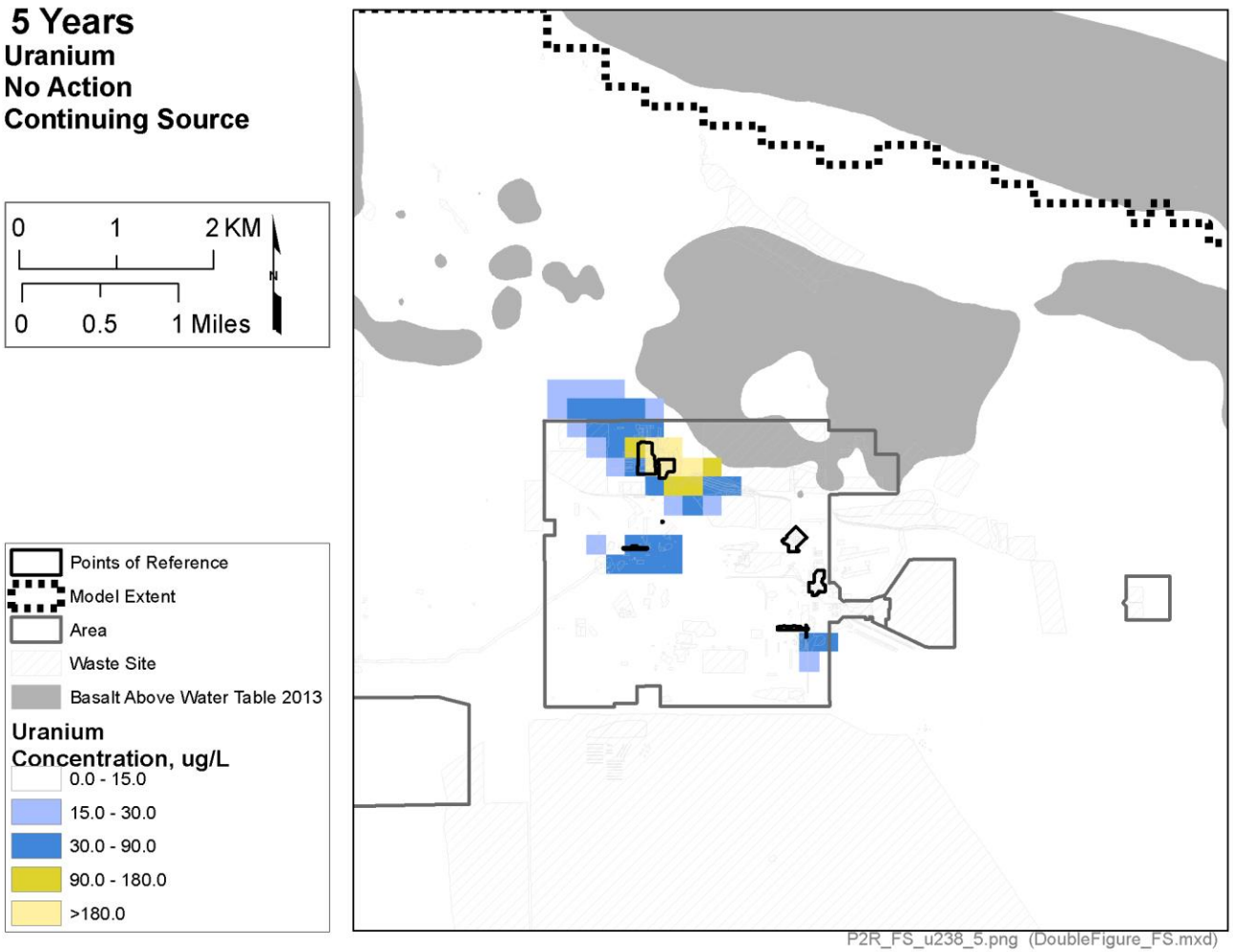

Figure B-46 - Plan view contours of the uranium plume at simulation time 5 years based on the remedial evaluation case simulation with a continuing source term.

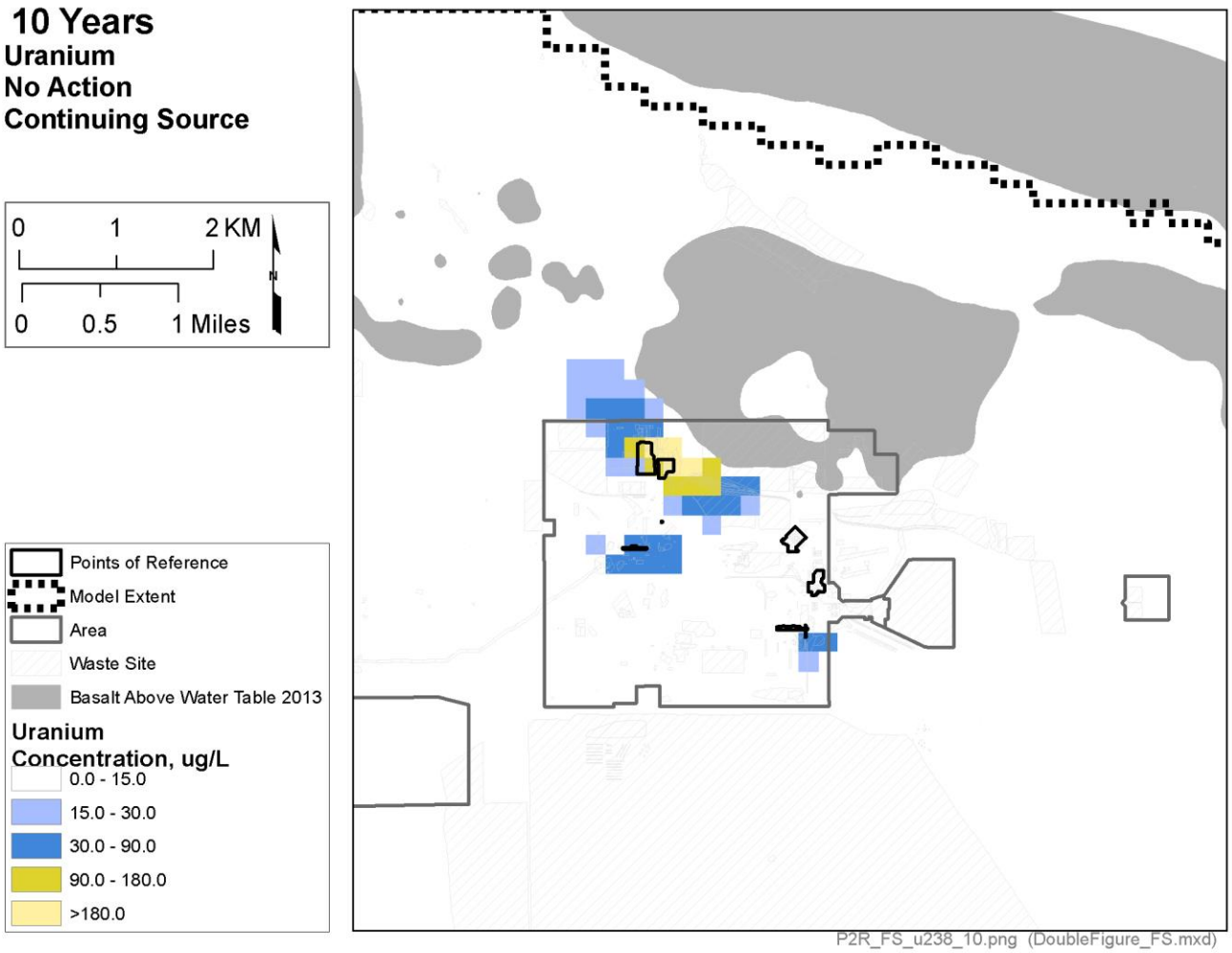

Figure B-47 - Plan view contours of the uranium plume at simulation time 10 years based on the remedial evaluation case simulation with a continuing source term.

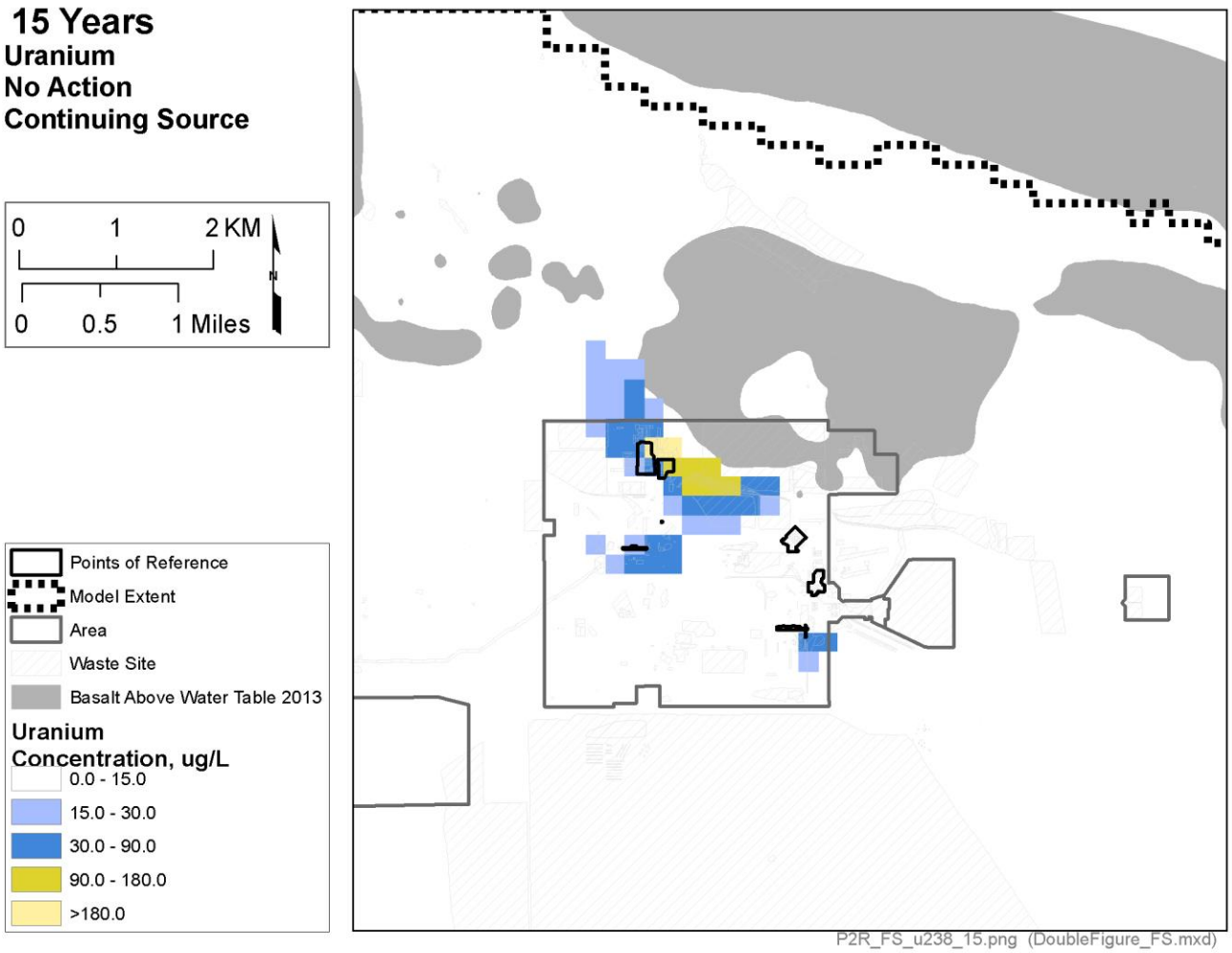

Figure B-48 - Plan view contours of the uranium plume at simulation time 15 years based on the remedial evaluation case simulation with a continuing source term.

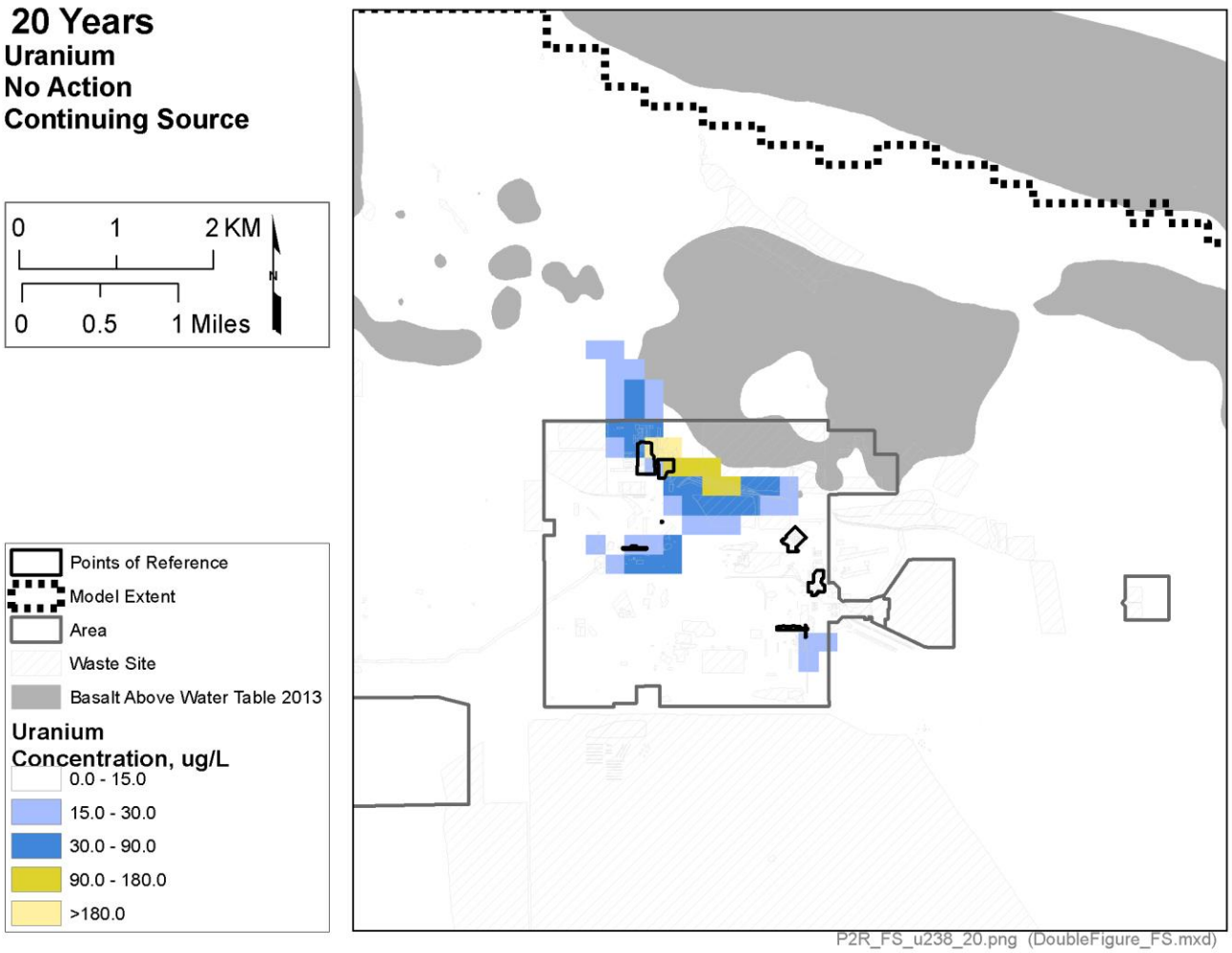

Figure B-49 - Plan view contours of the uranium plume at simulation time 20 years based on the remedial evaluation case simulation with a continuing source term.

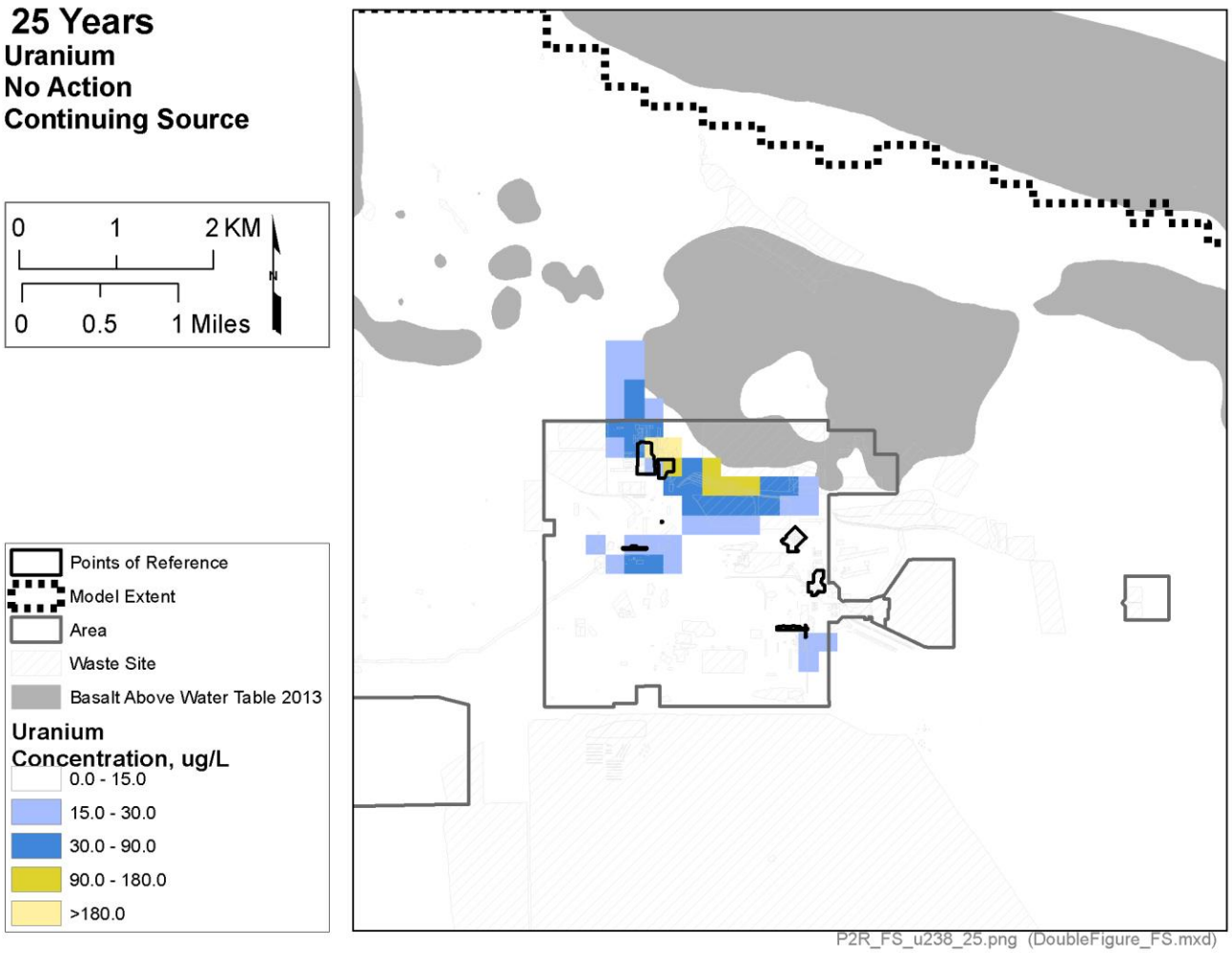

Figure B-50 - Plan view contours of the uranium plume at simulation time 25 years based on the remedial evaluation case simulation with a continuing source term.

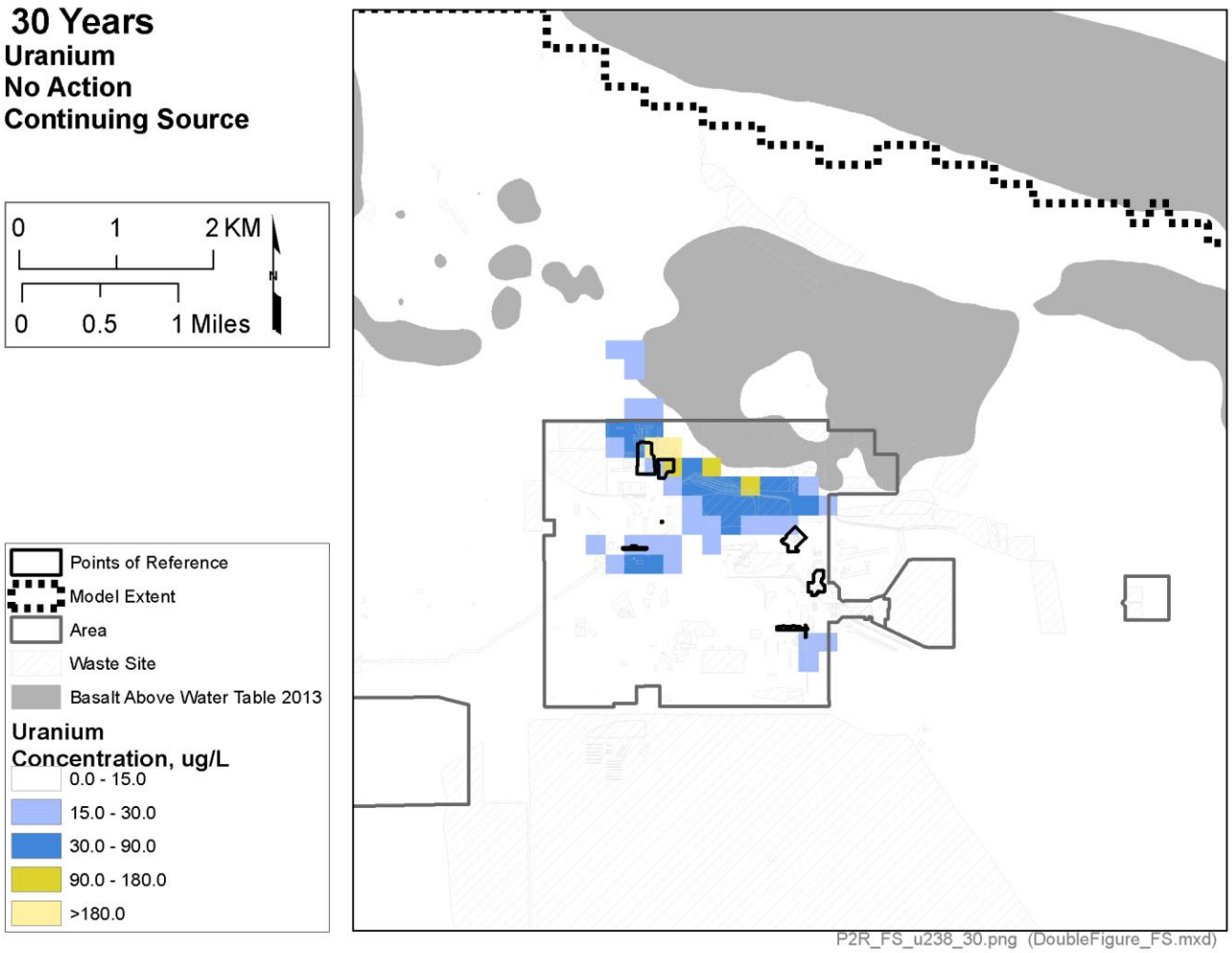

Figure B-51 - Plan view contours of the uranium plume at simulation time 30 years based on the remedial evaluation case simulation with a continuing source term.

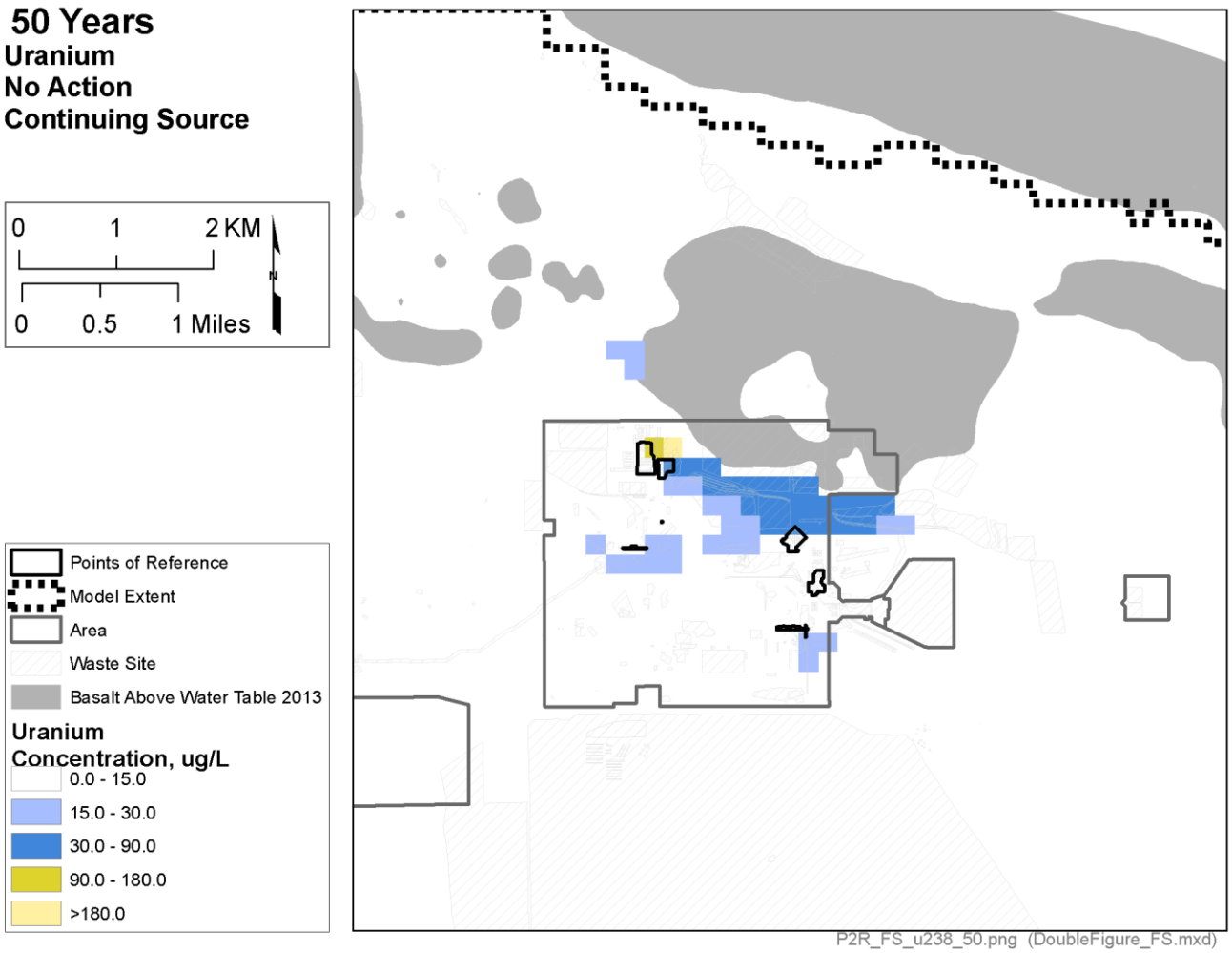

Figure B-52 - Plan view contours of the uranium plume at simulation time 50 years based on the remedial evaluation case simulation with a continuing source term.

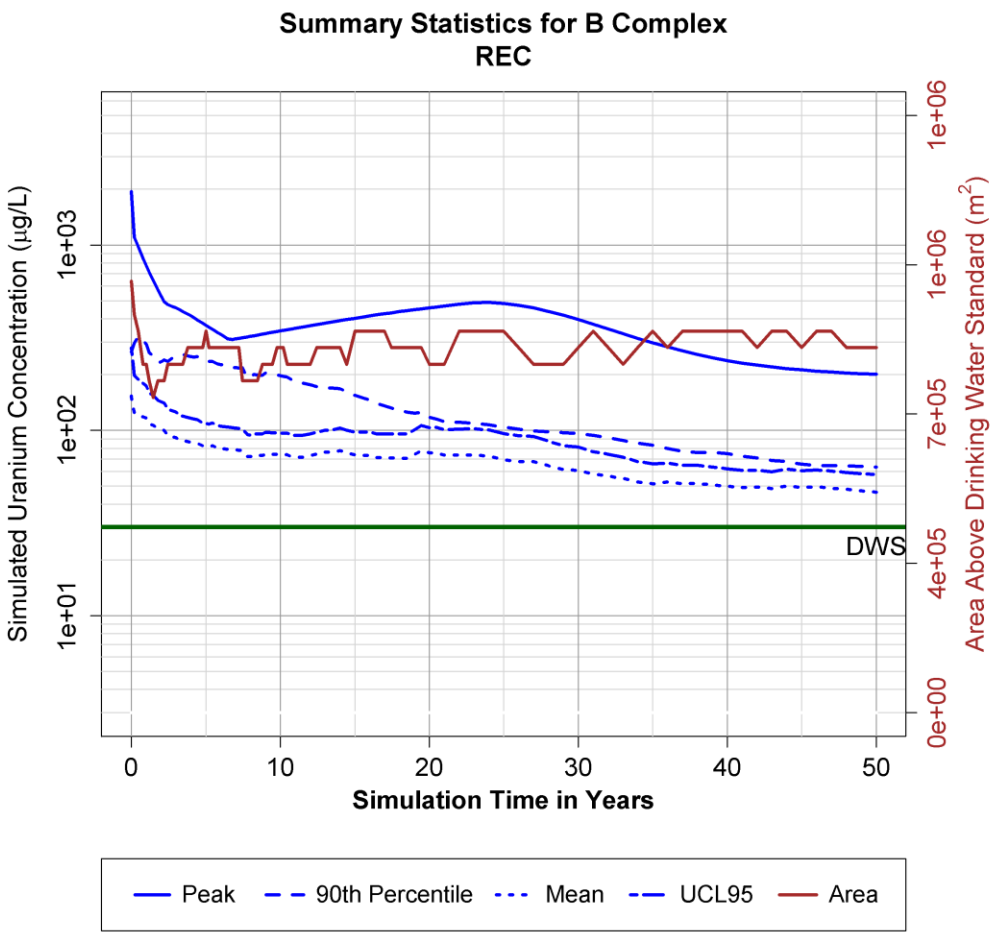

Figure B-53 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

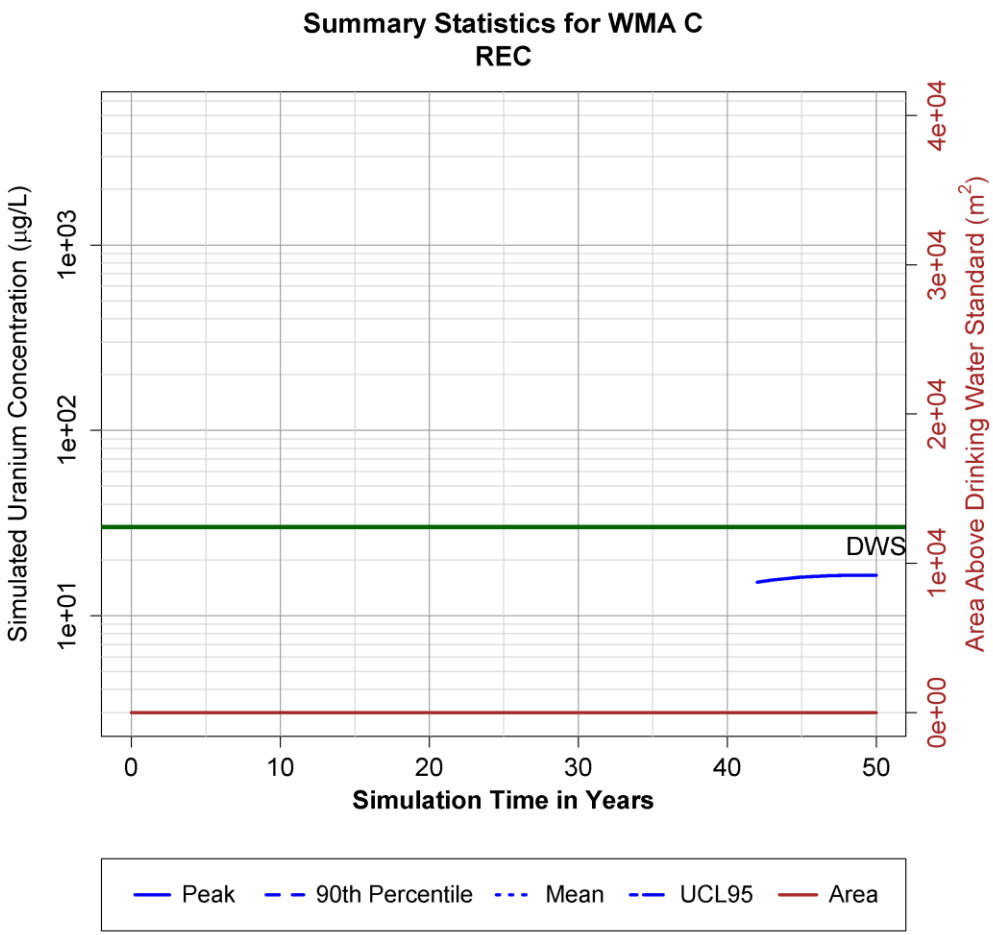

Figure B-54 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

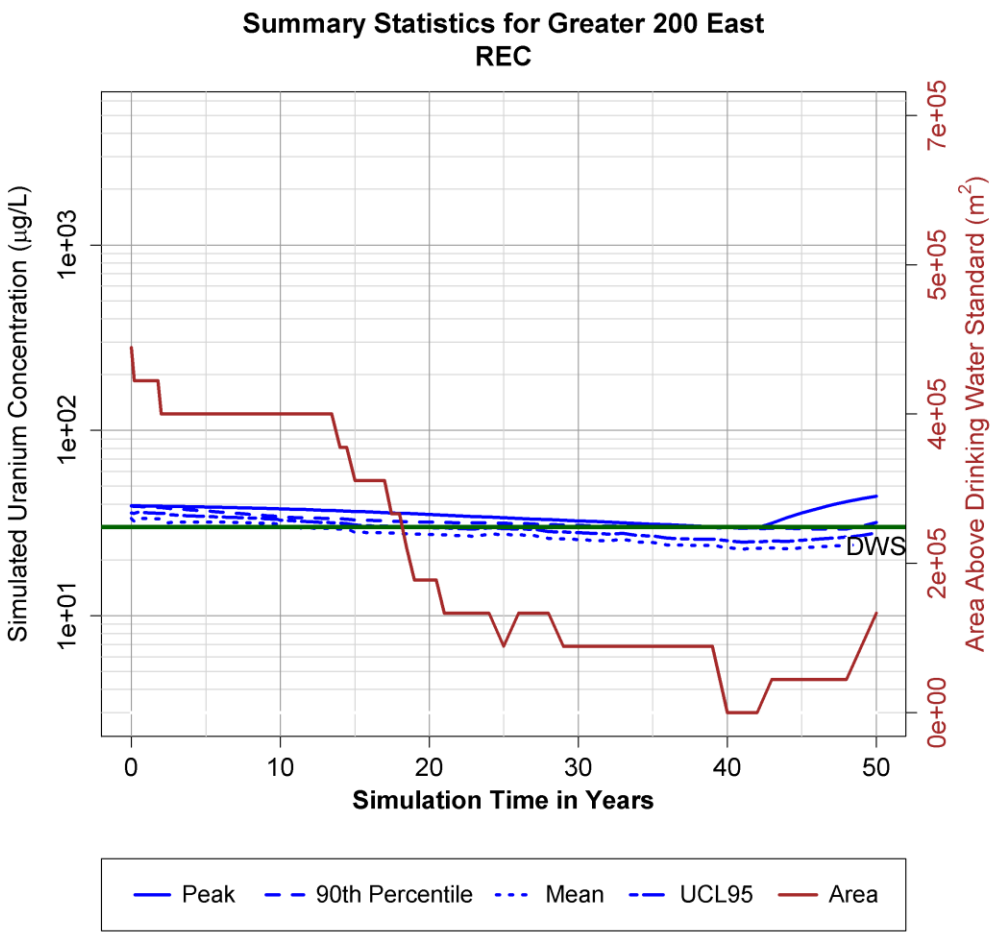

Figure B-55 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

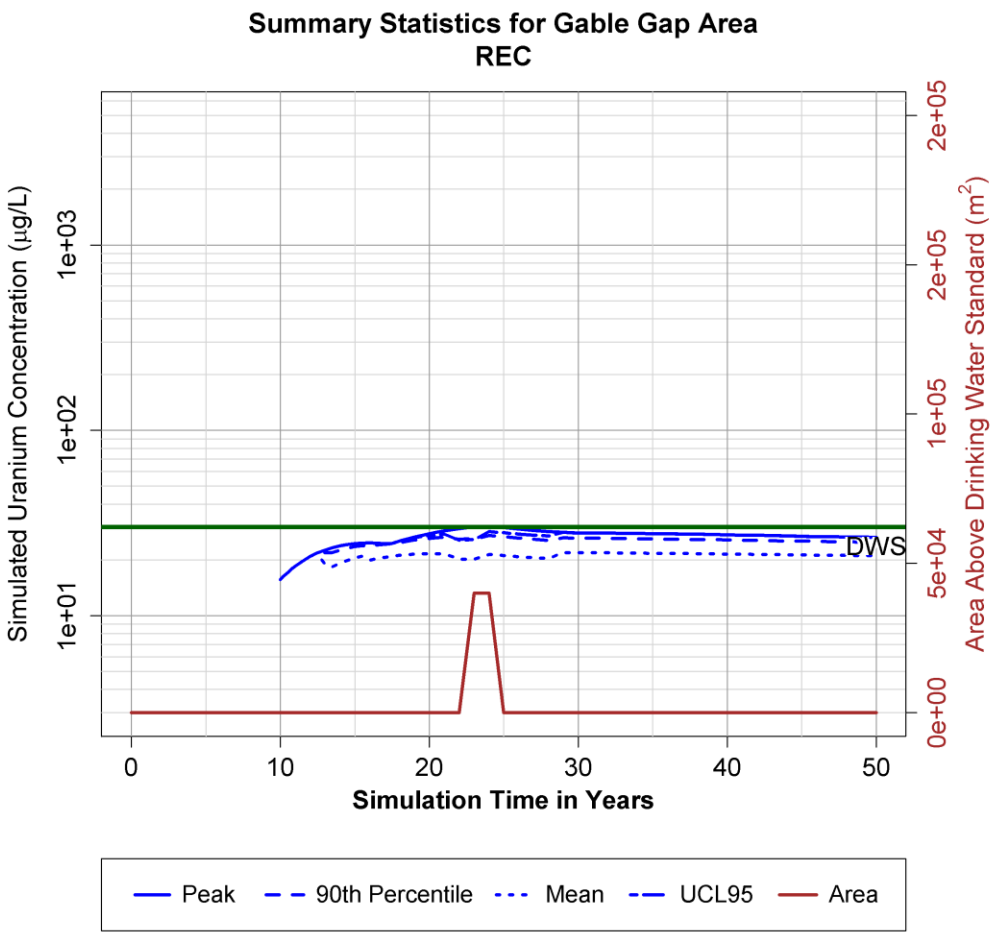

Figure B-56 - Statistical summary of simulated concentration within the model domain for the uranium plume for the remedial evaluation case simulation with a continuing source term.

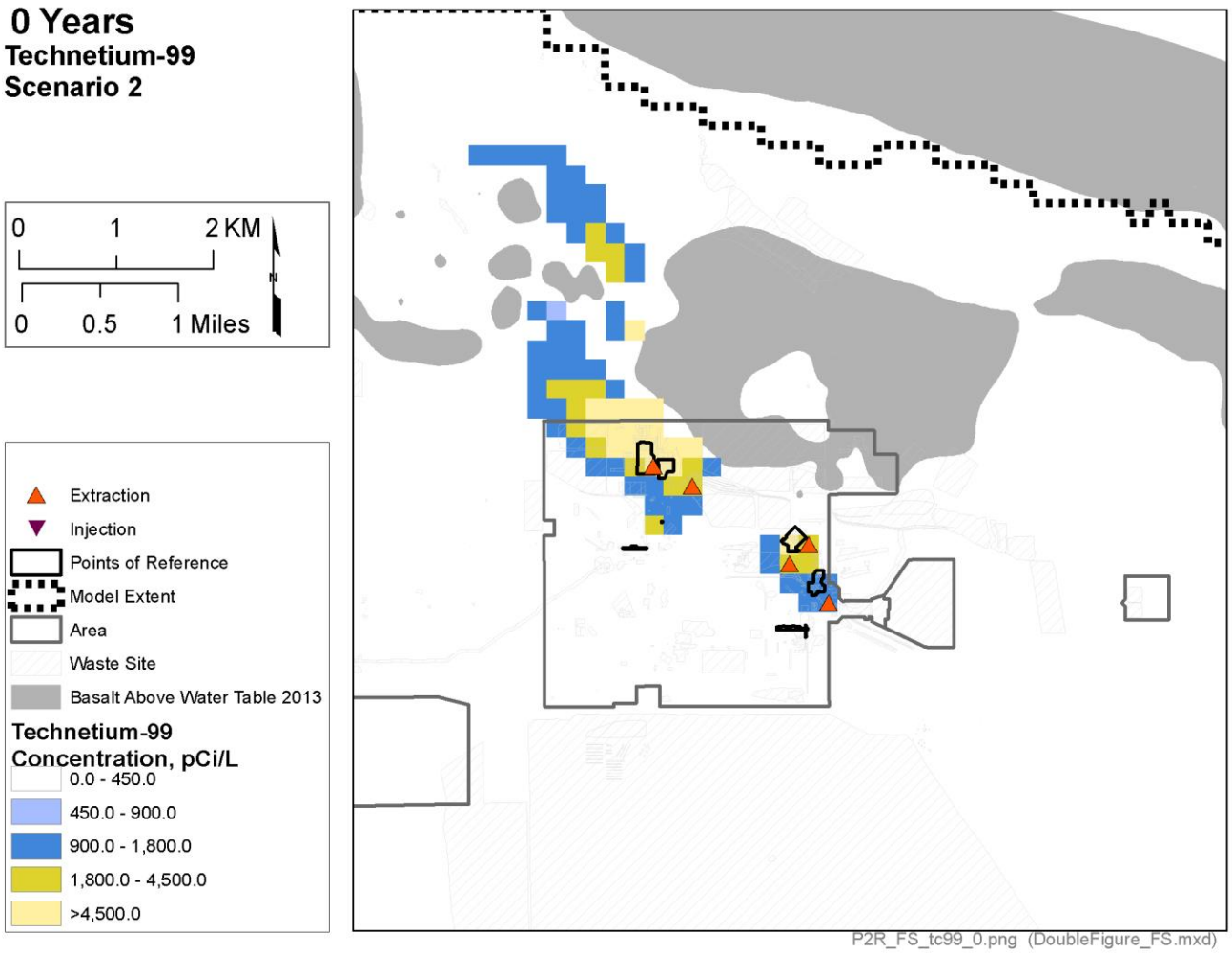

Figure B-57 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 2 simulation.

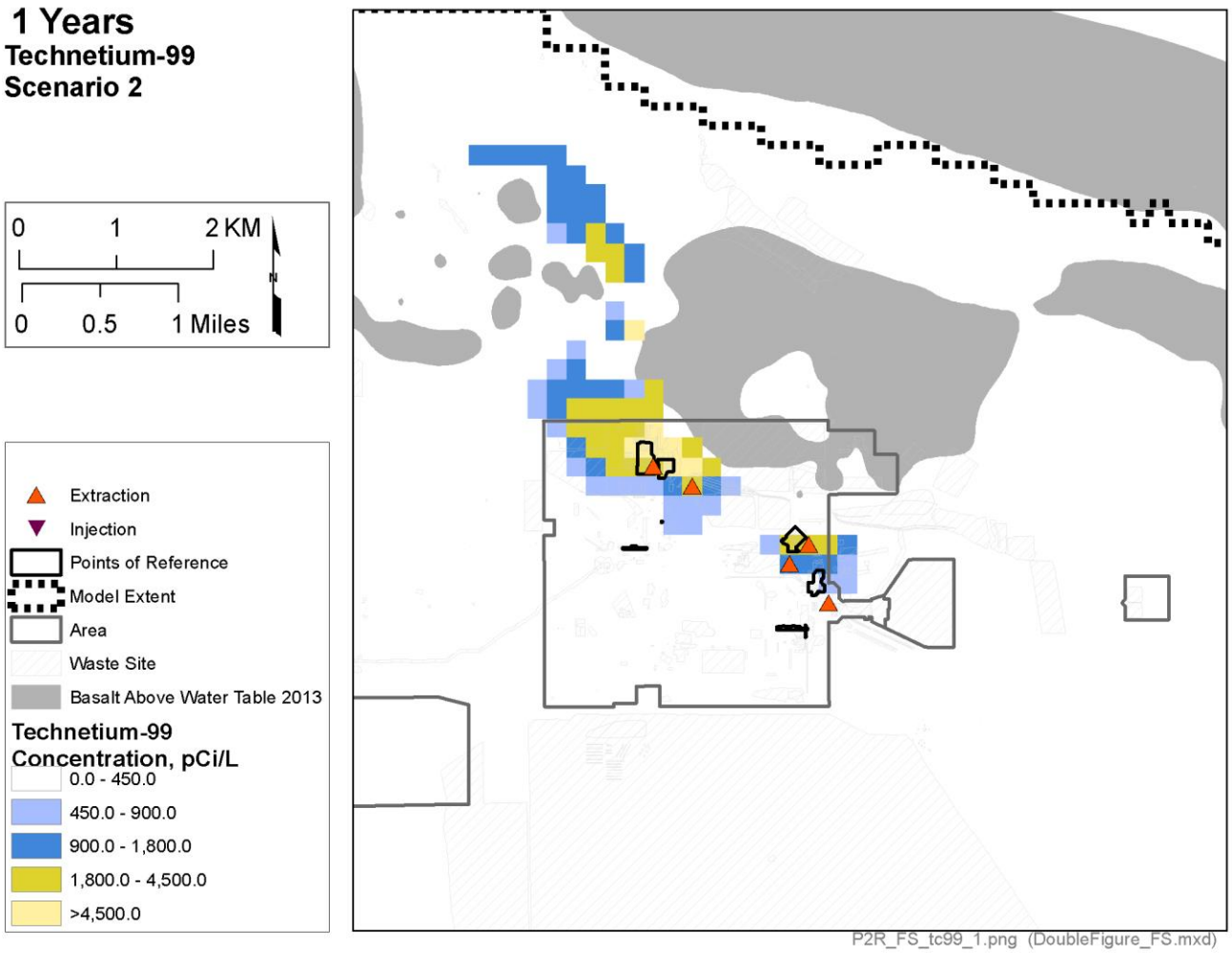

Figure B-58 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 2 simulation.

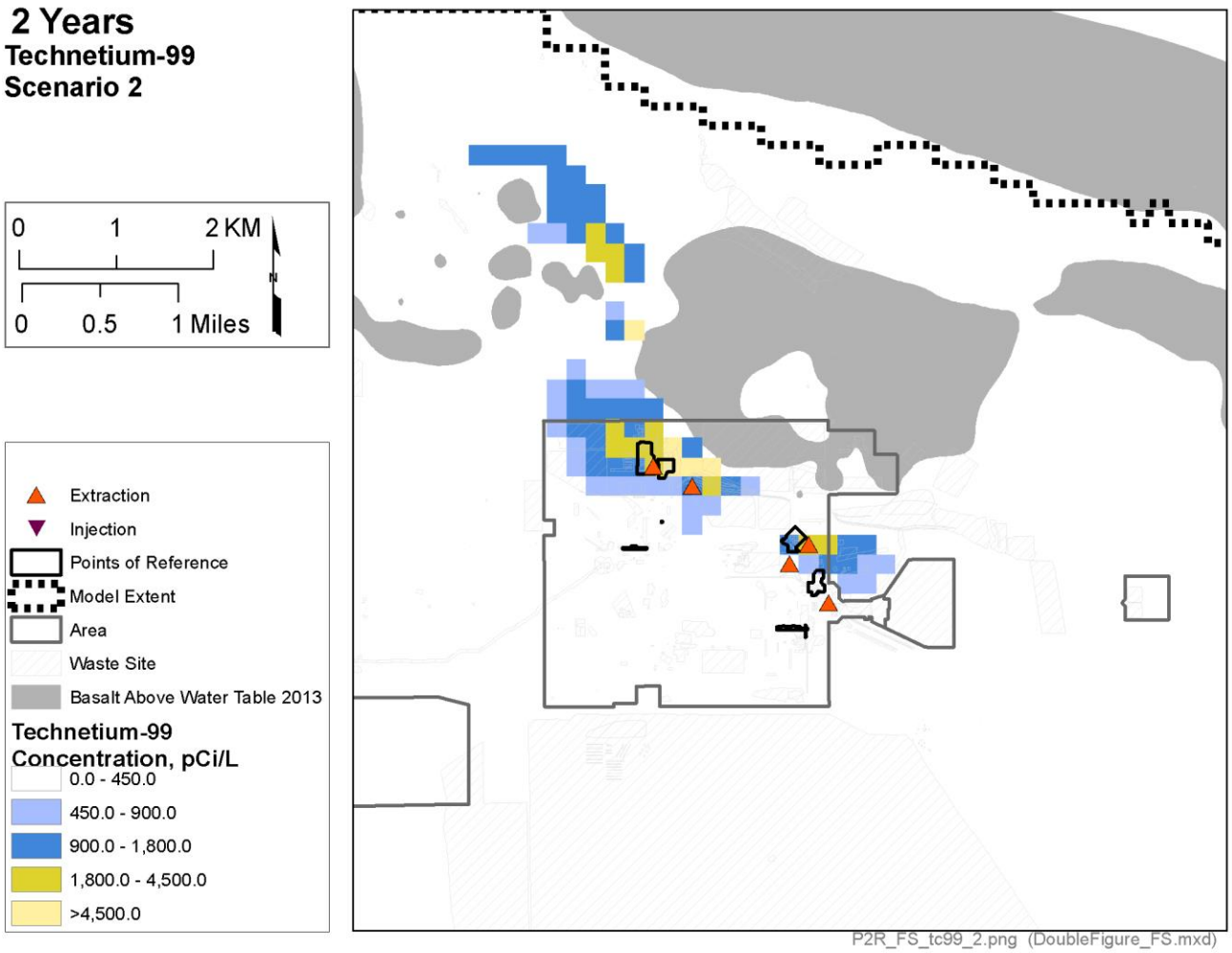

Figure B-59 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 2 simulation.

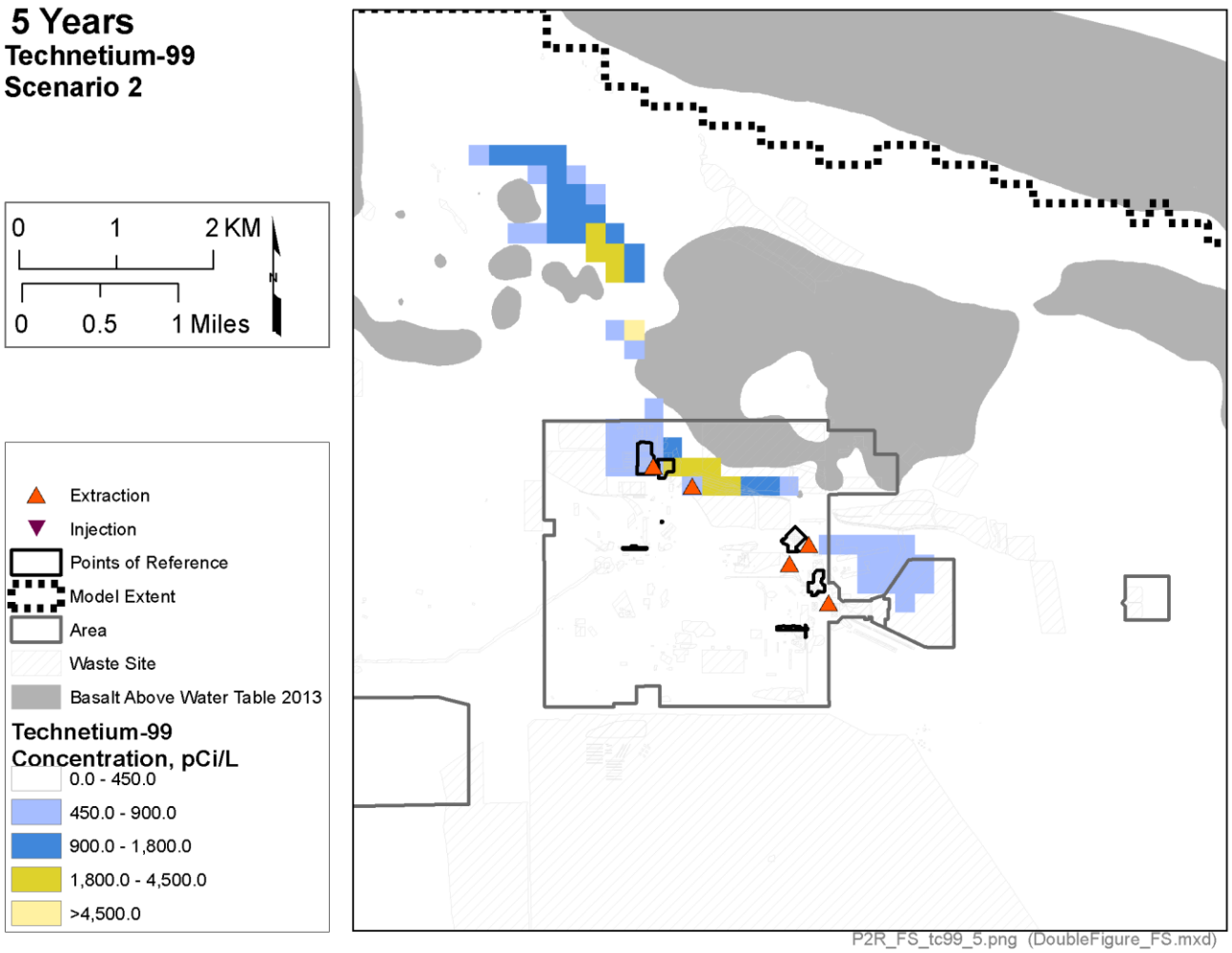

Figure B-60 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 2 simulation.

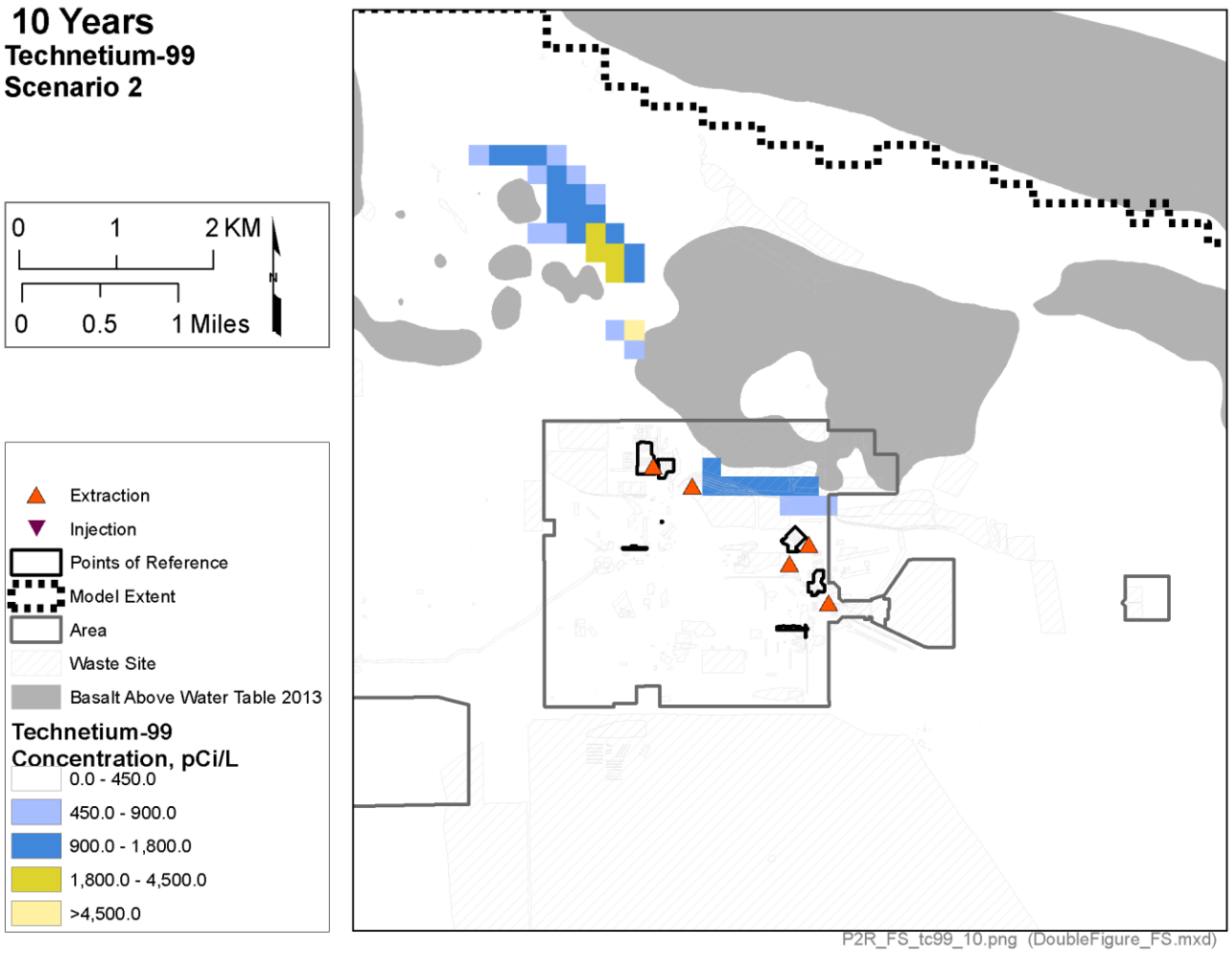

Figure B-61 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 2 simulation.

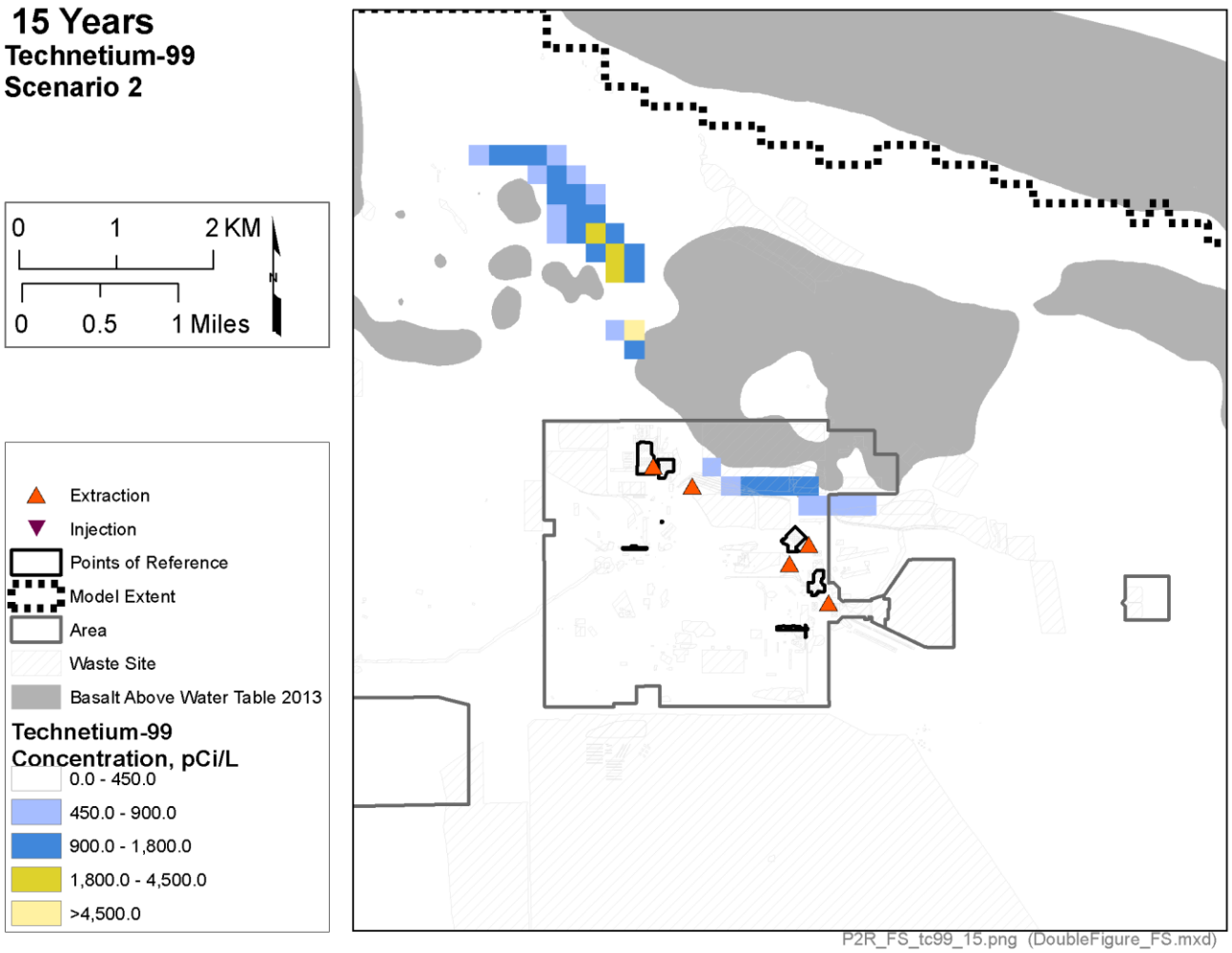

Figure B-62 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 2 simulation.

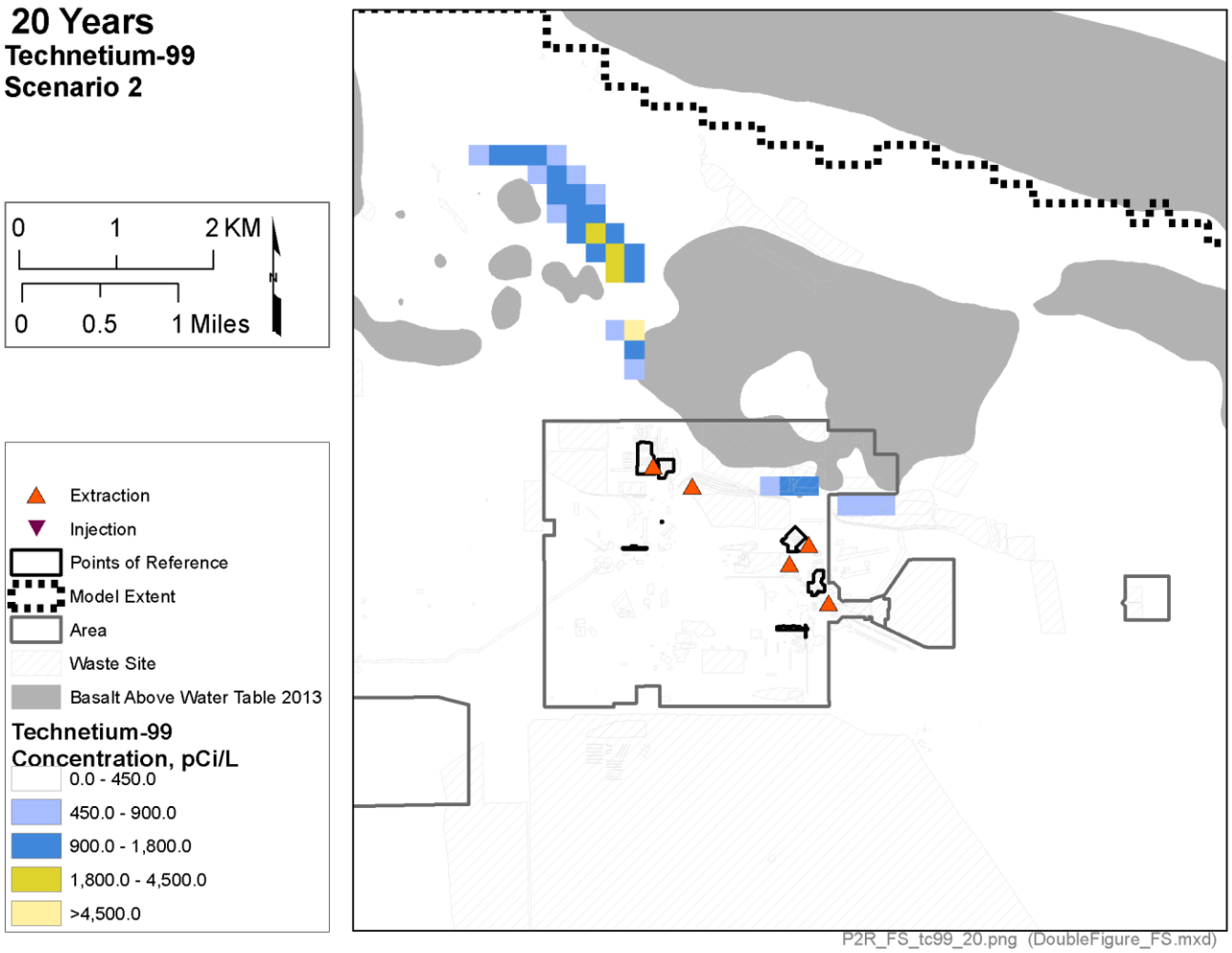

Figure B-63 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 2 simulation.

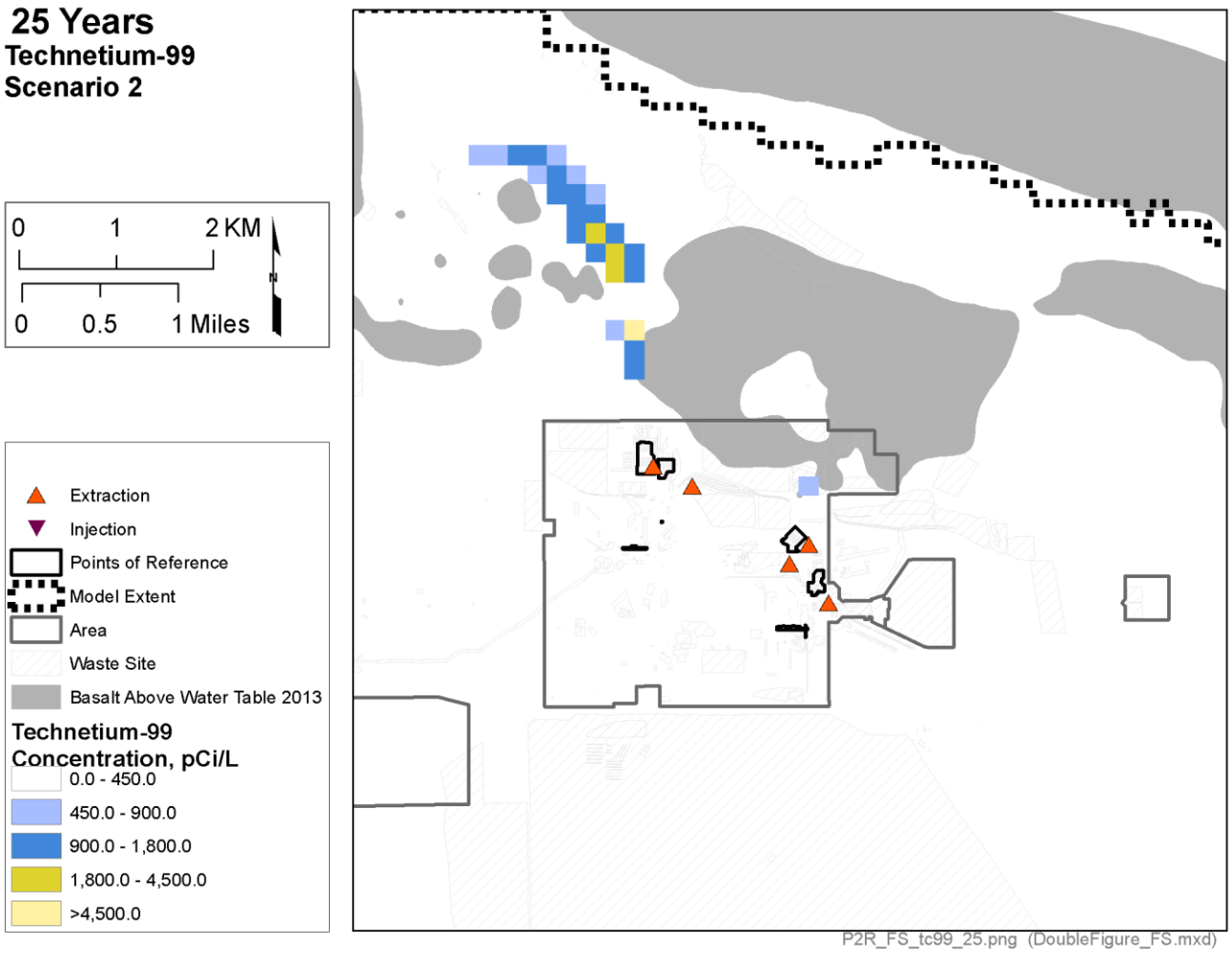

Figure B-64 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 2 simulation.

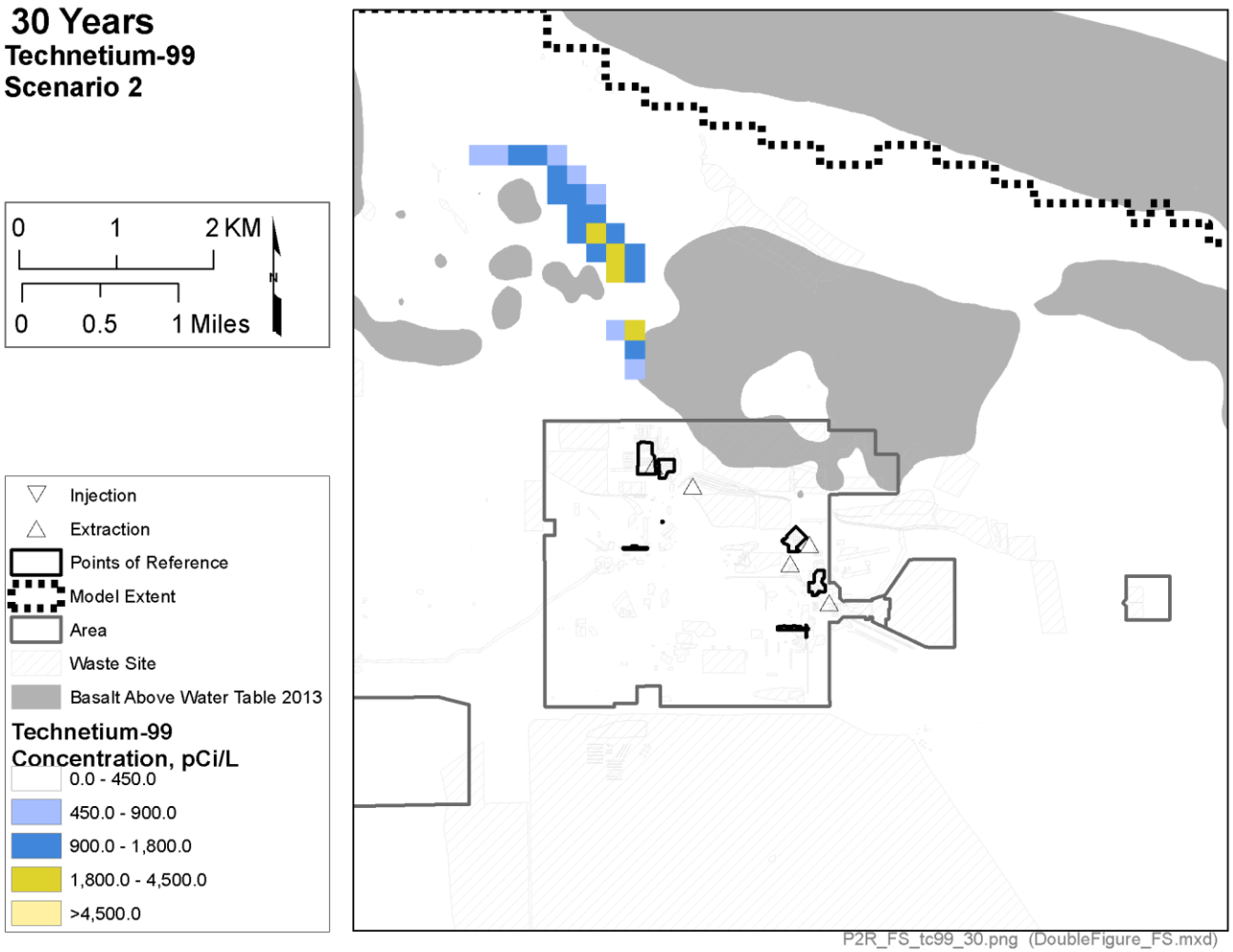

Figure B-65 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 2 simulation.

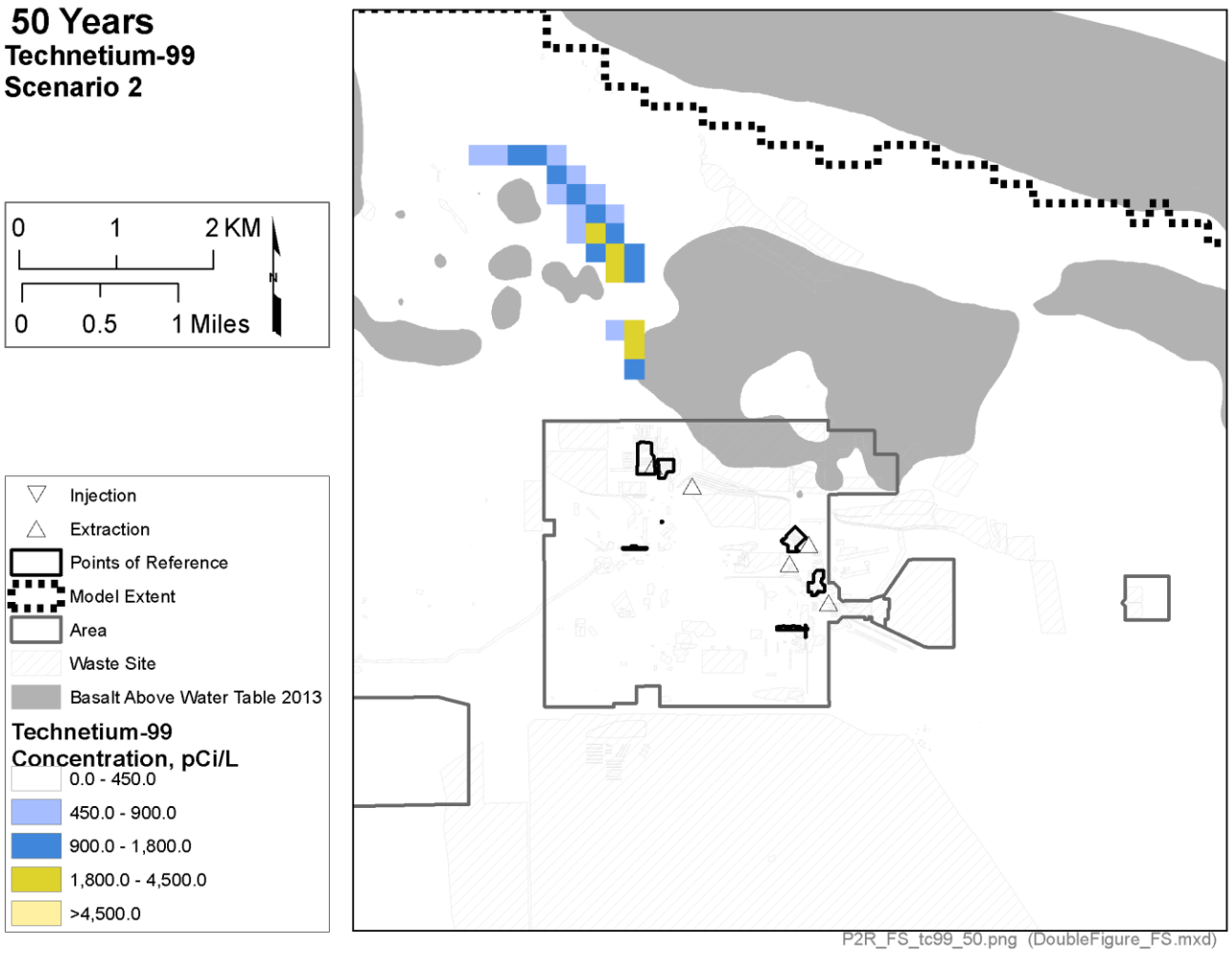

Figure B-66 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 2 simulation.

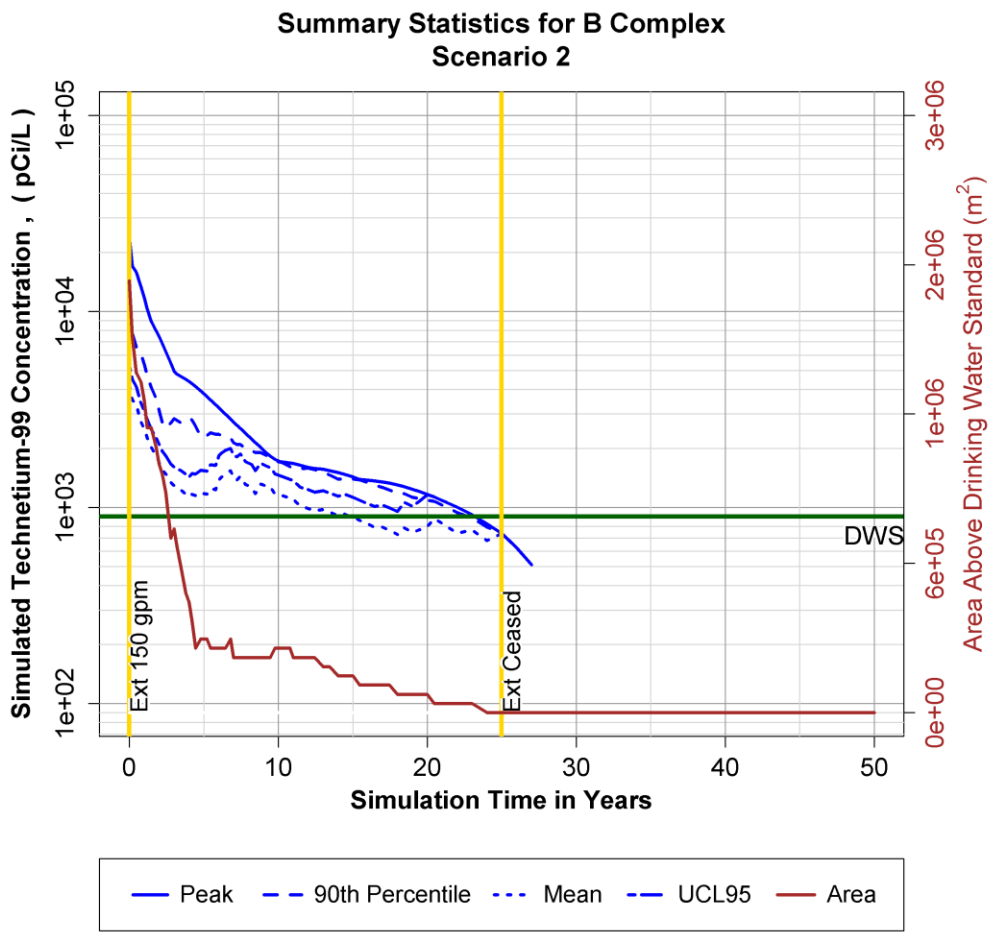

Figure B-67 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

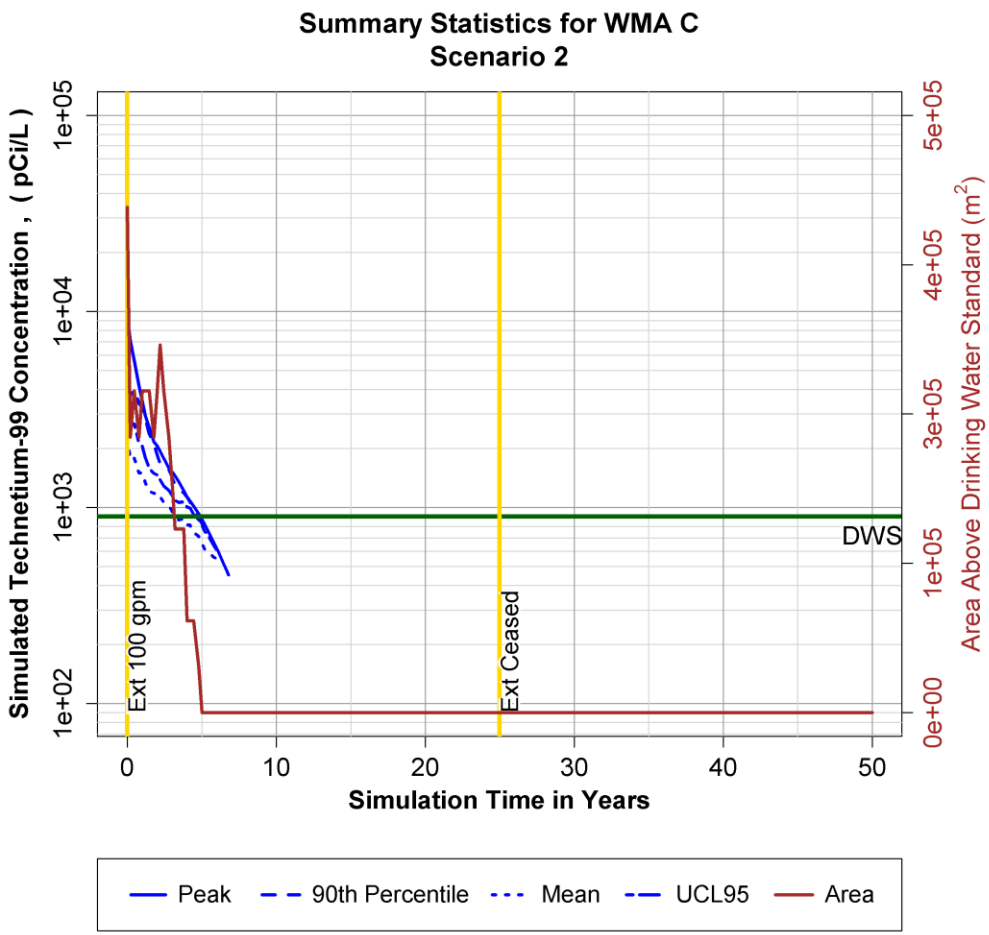

Figure B-68 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

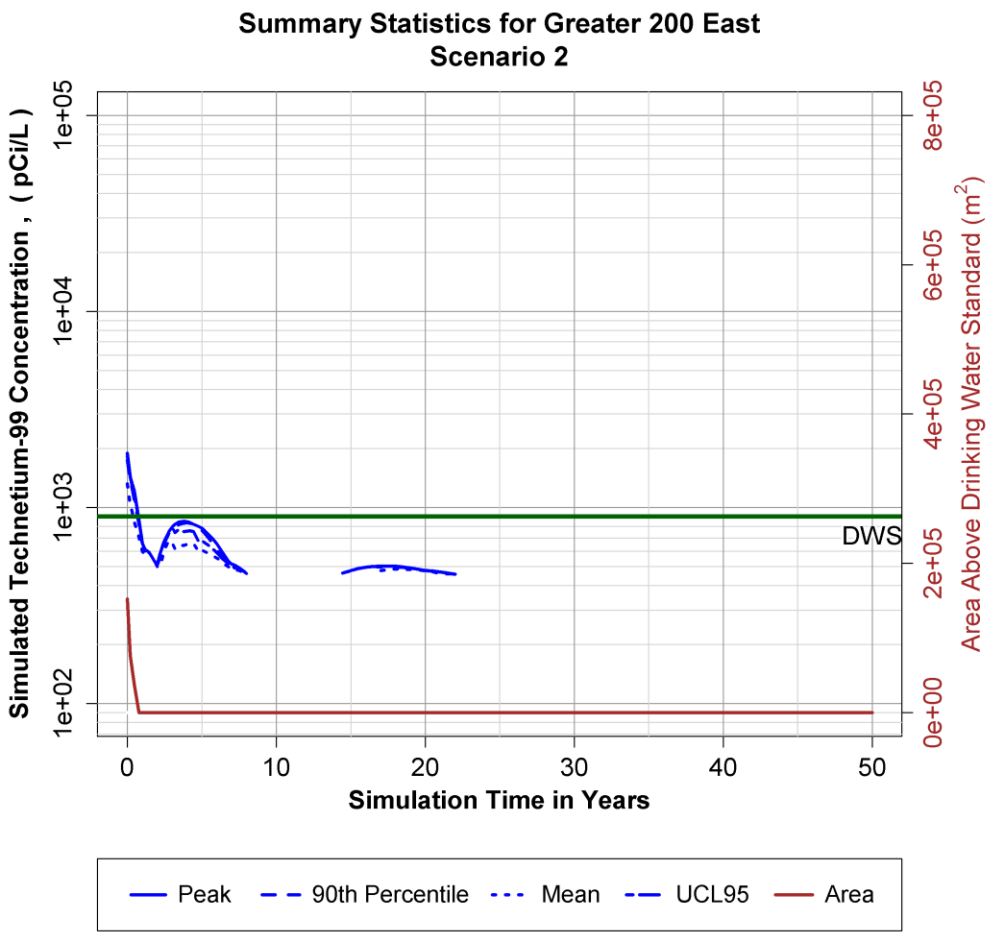

Figure B-69 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

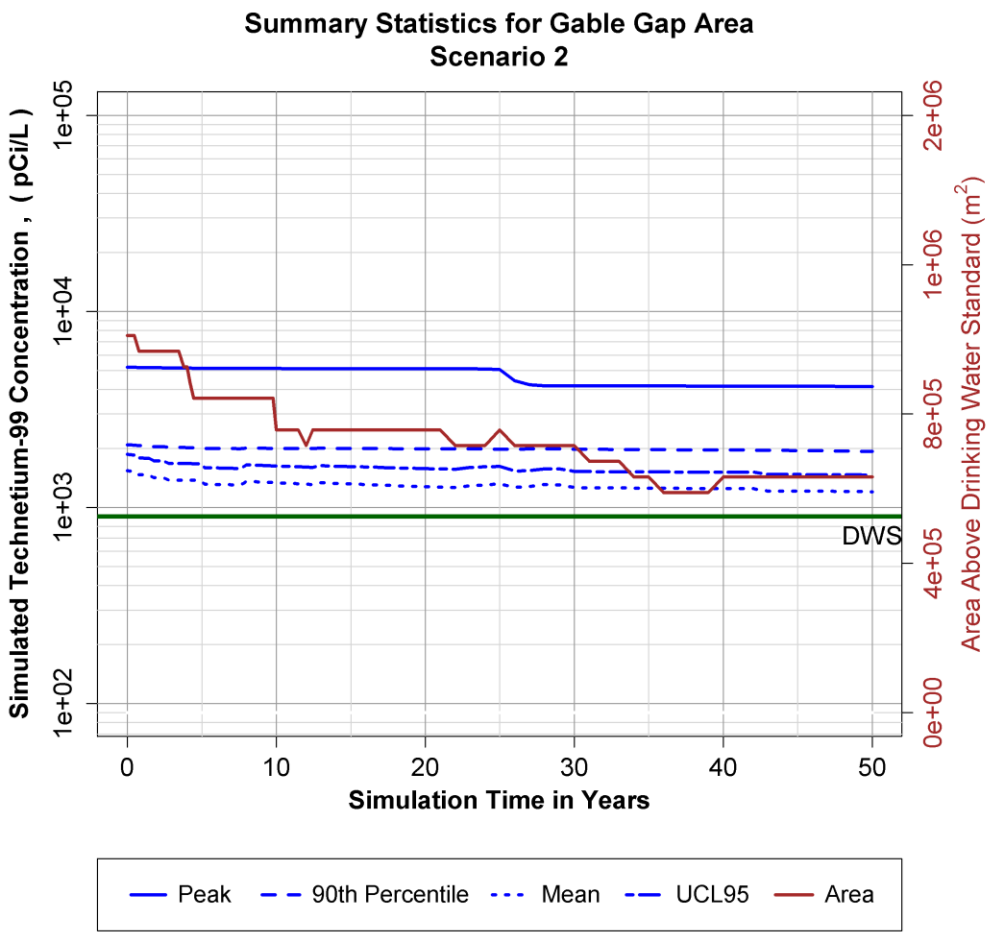

Figure B-70 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation.

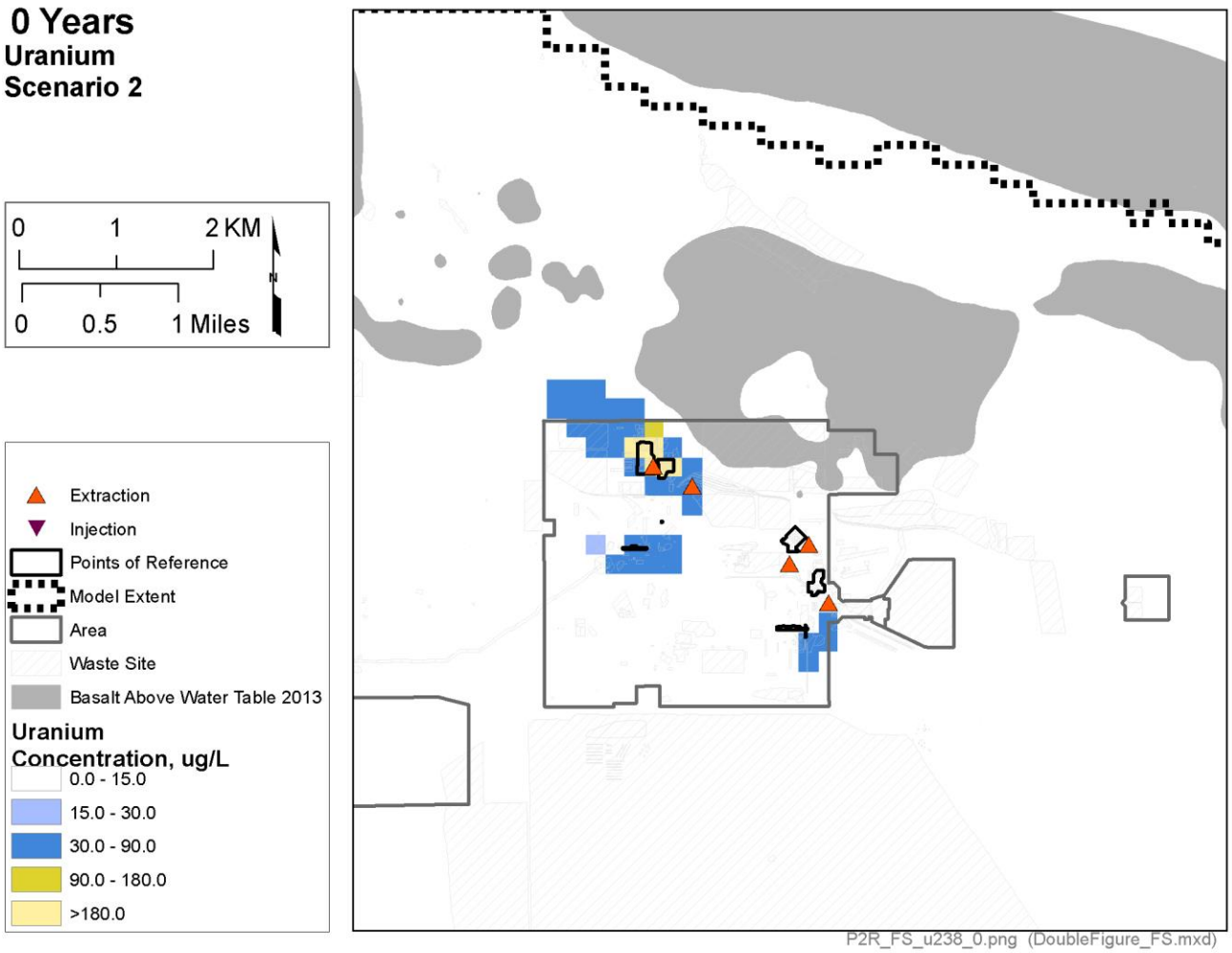

Figure B-71 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 2 simulation.

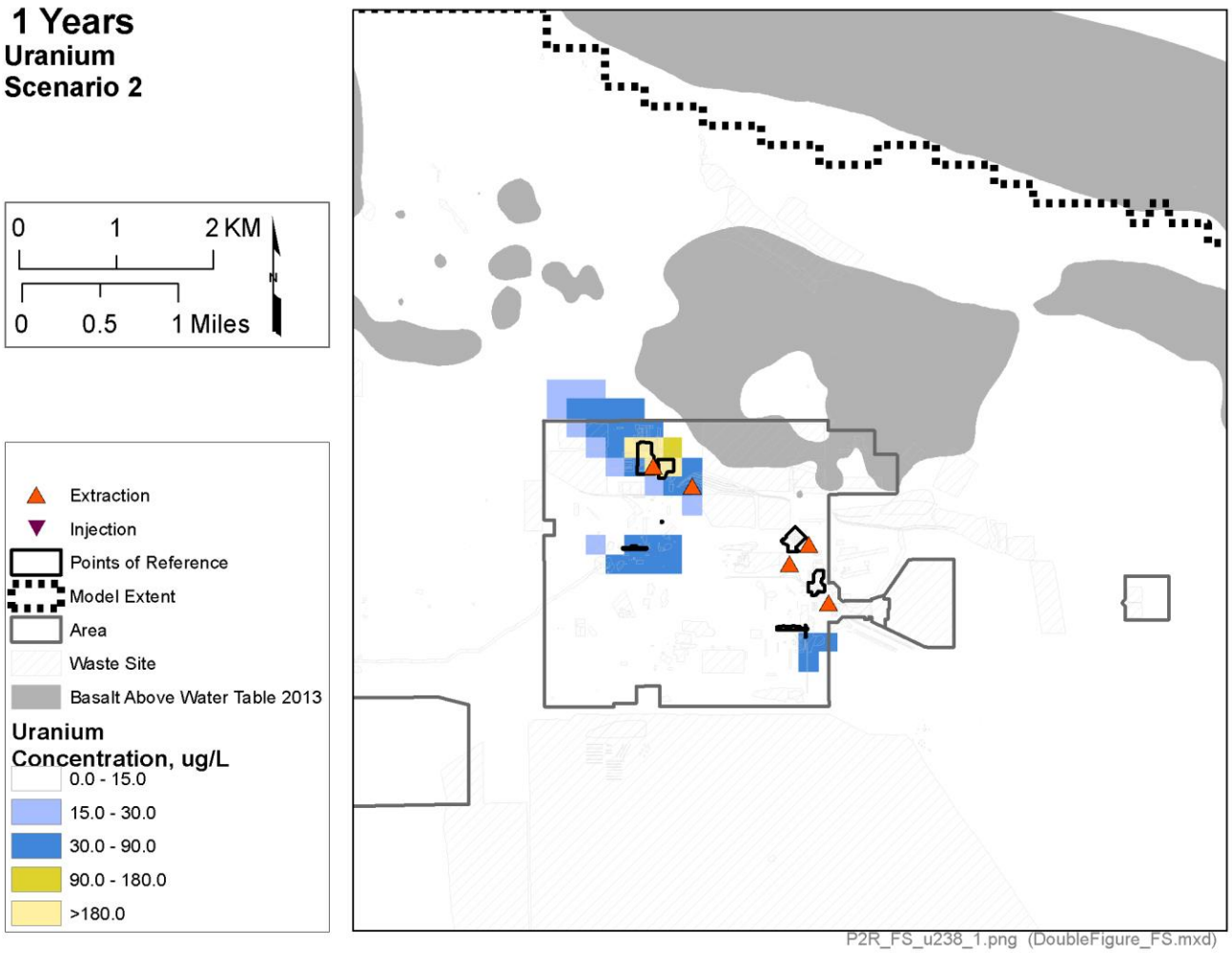

Figure B-72 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 2 simulation.

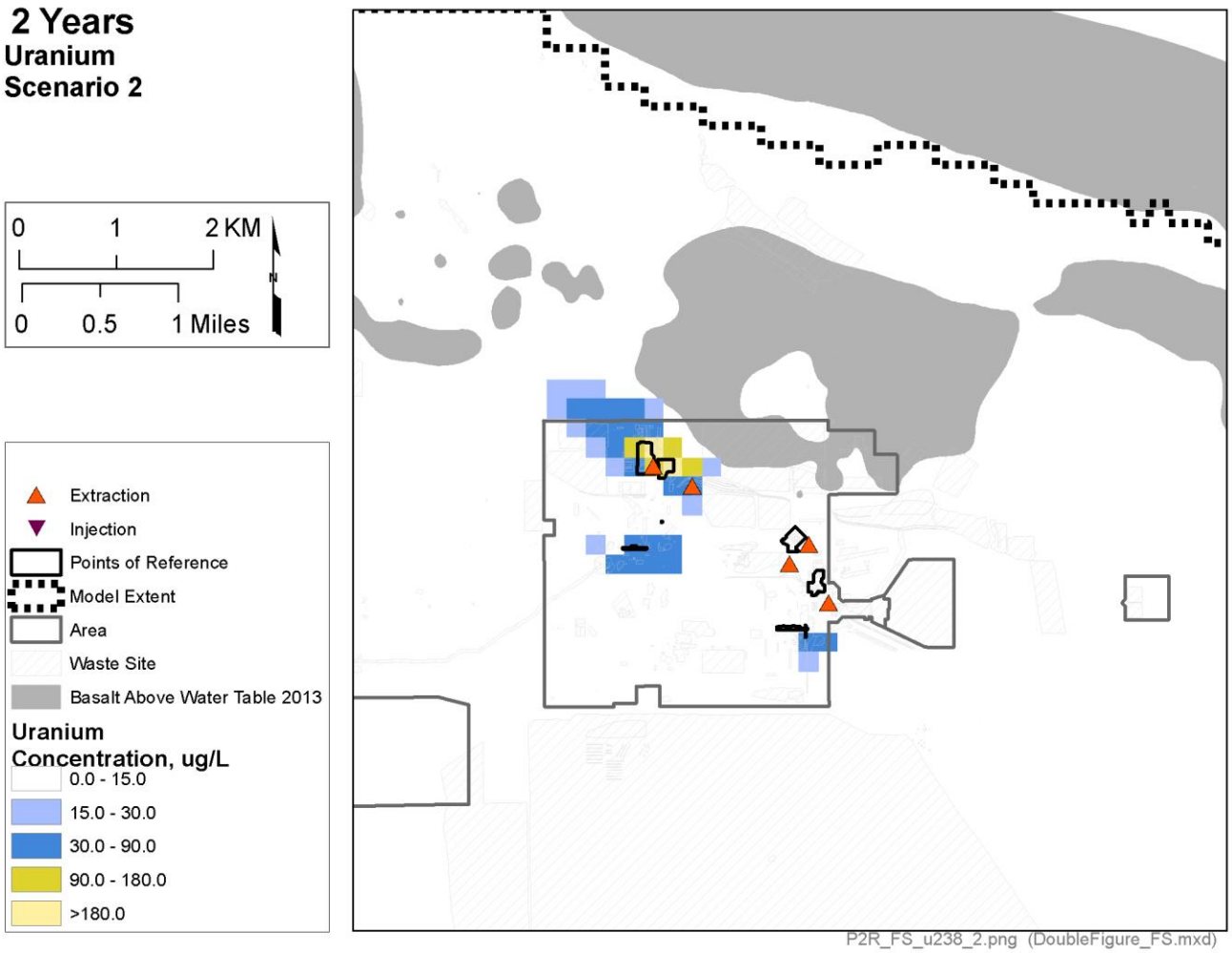

Figure B-73 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 2 simulation.

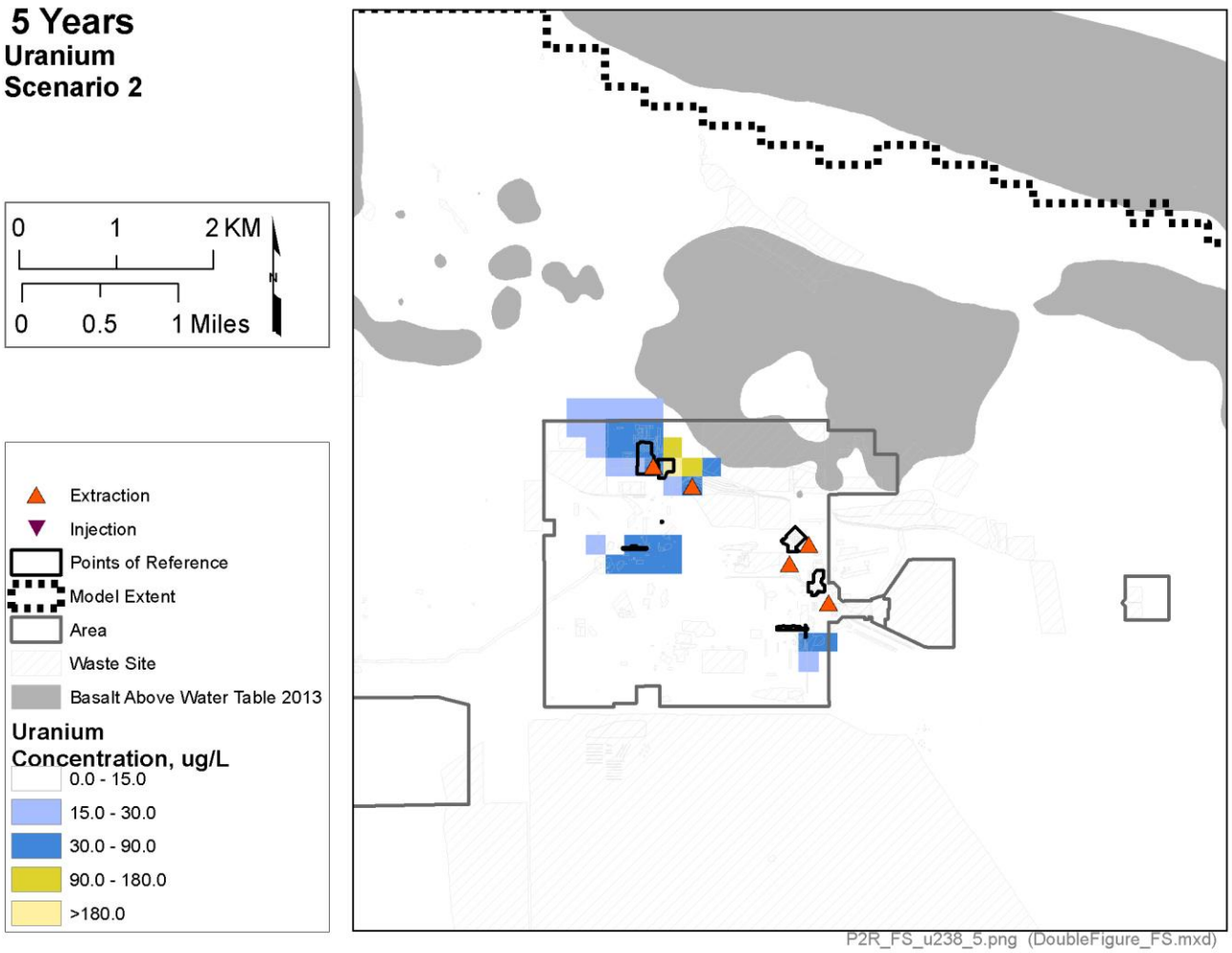

Figure B-74 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 2 simulation.

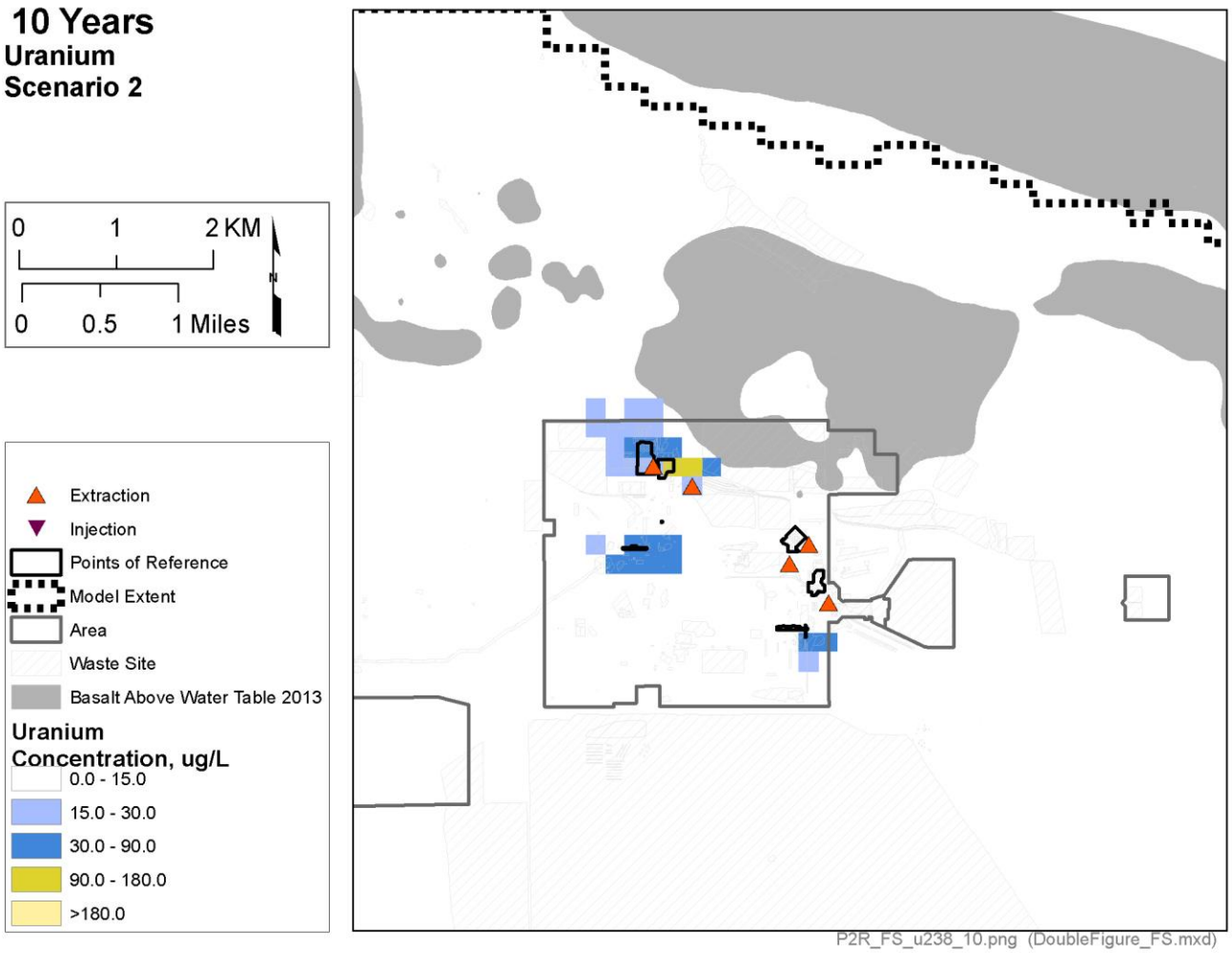

Figure B-75 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 2 simulation.

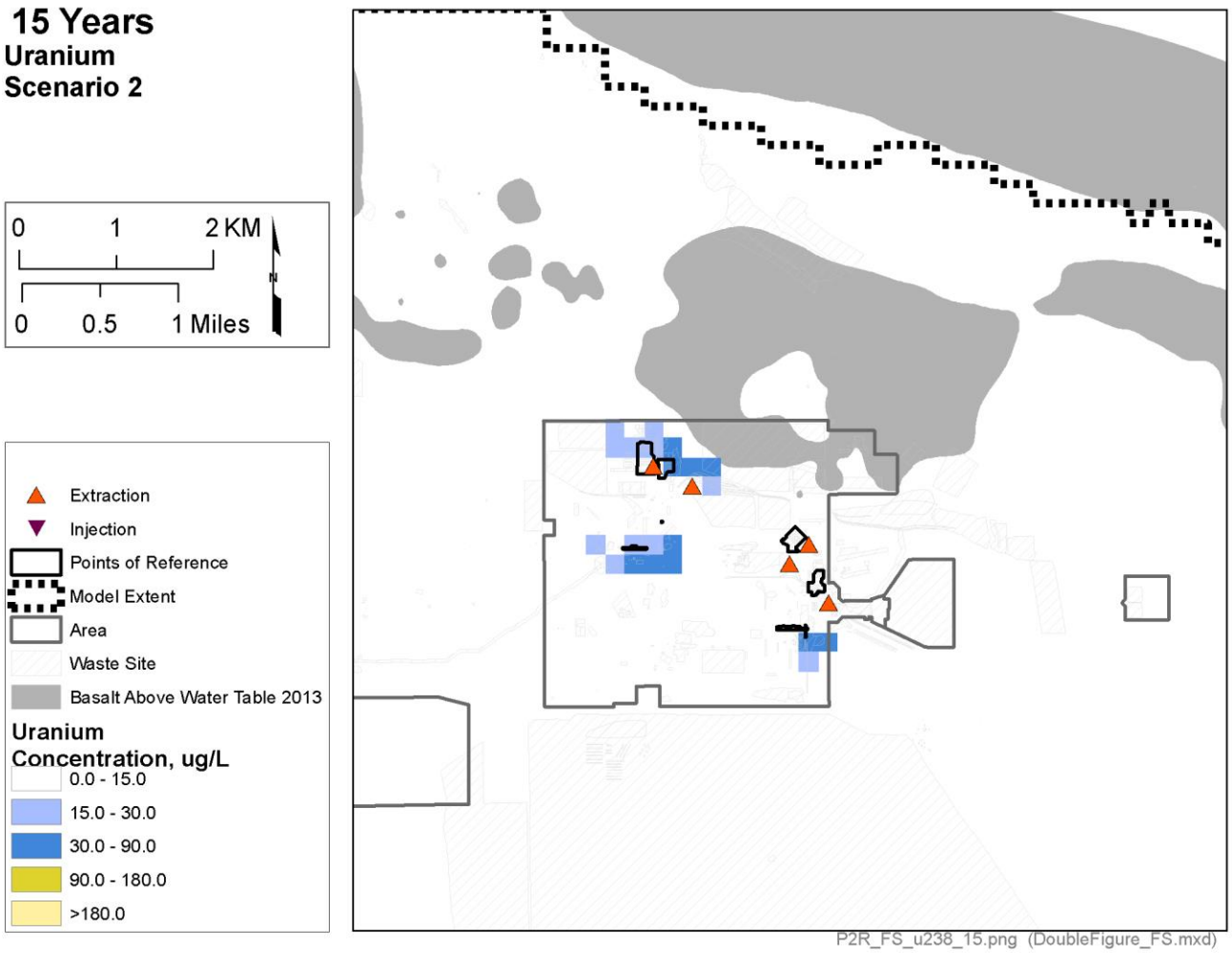

Figure B-76 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 2 simulation.

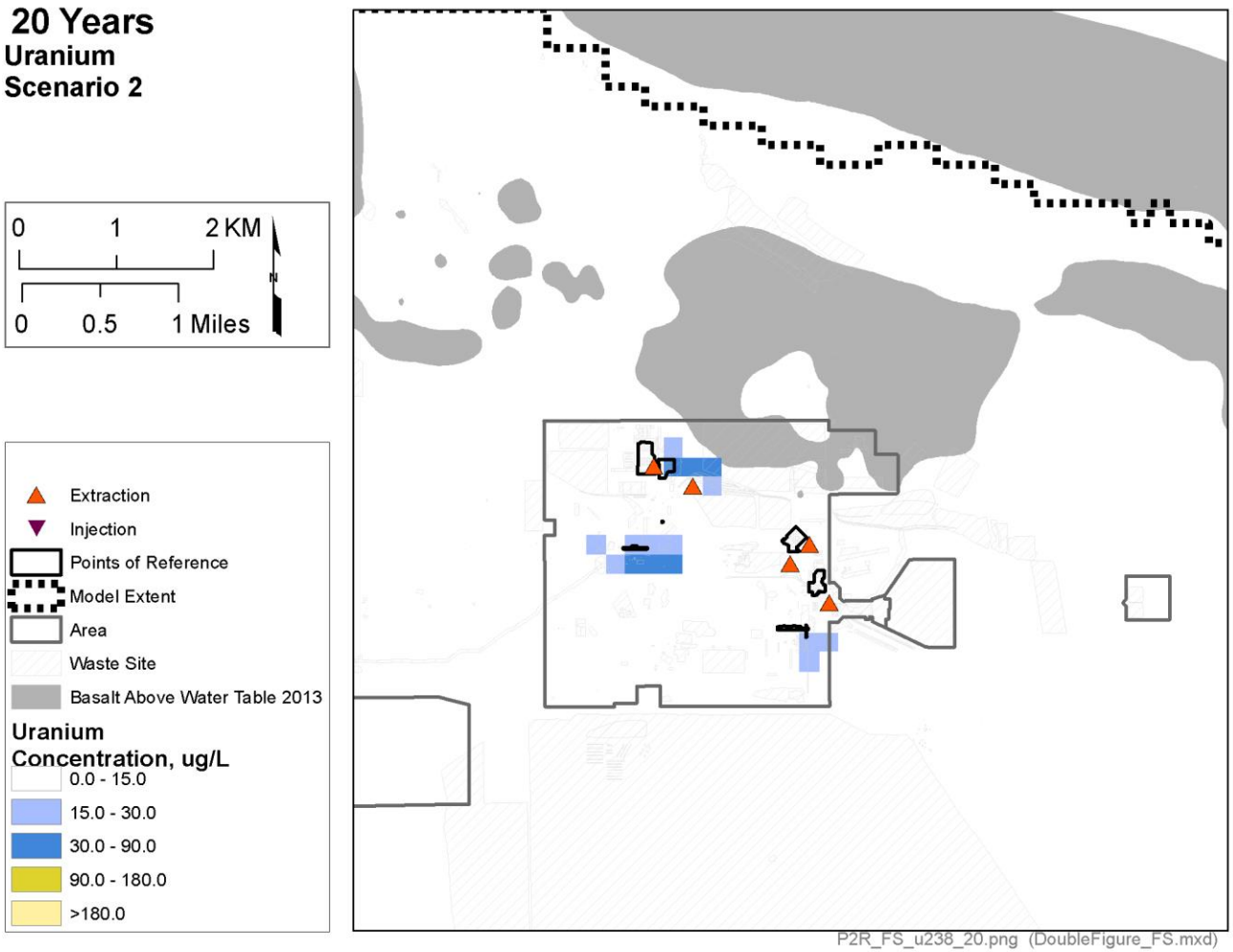

Figure B-77 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 2 simulation.

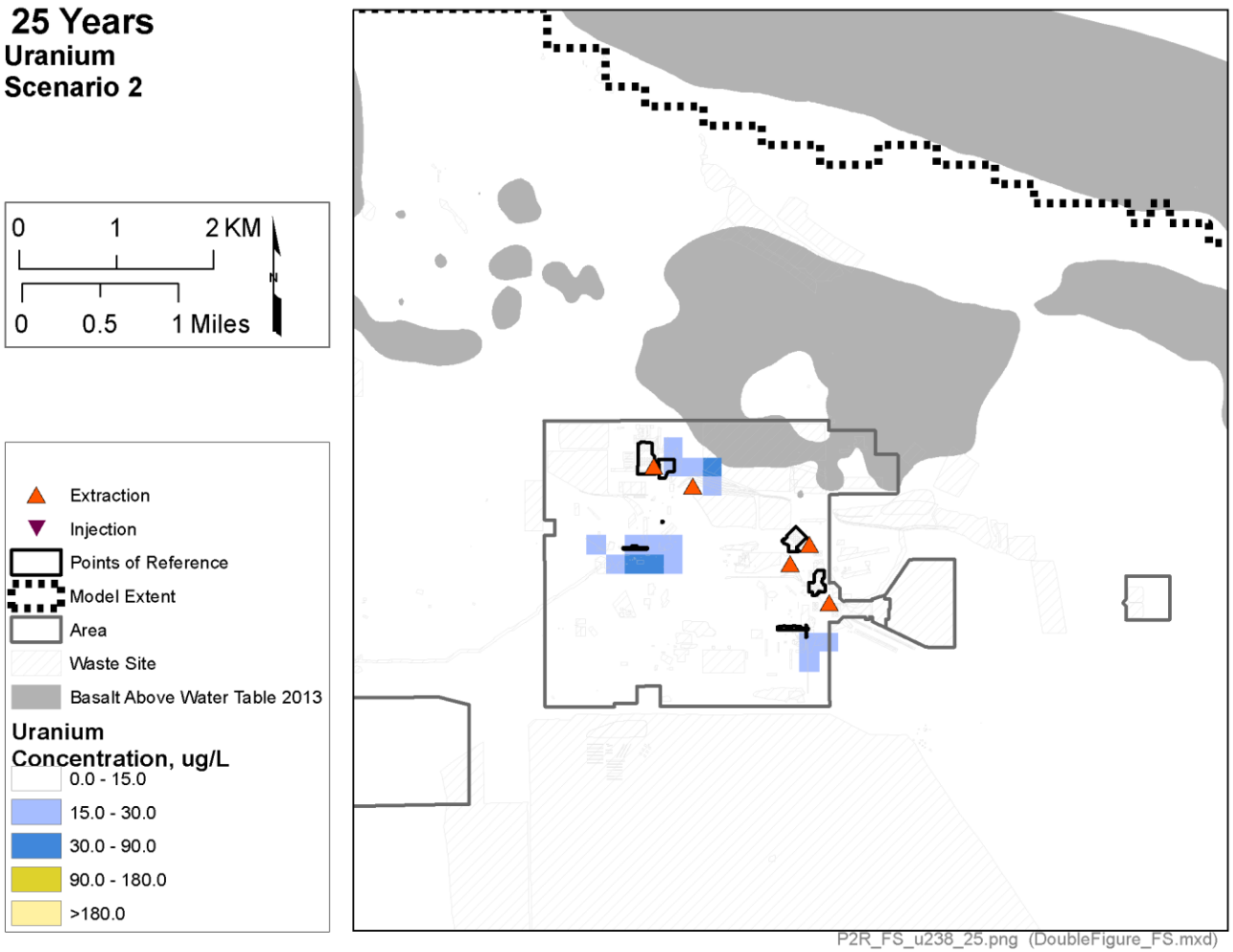

Figure B-78 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 2 simulation.

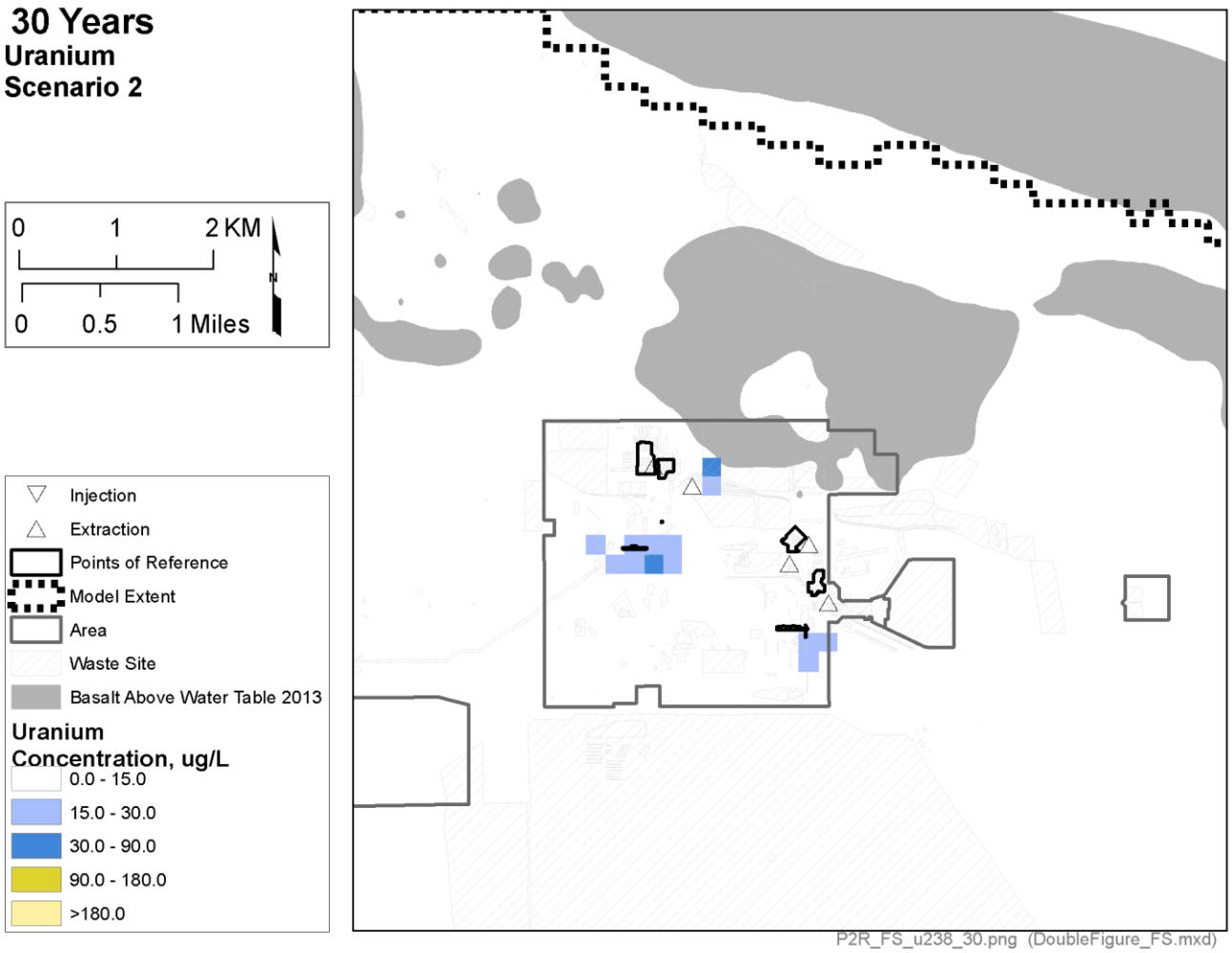

Figure B-79 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 2 simulation.

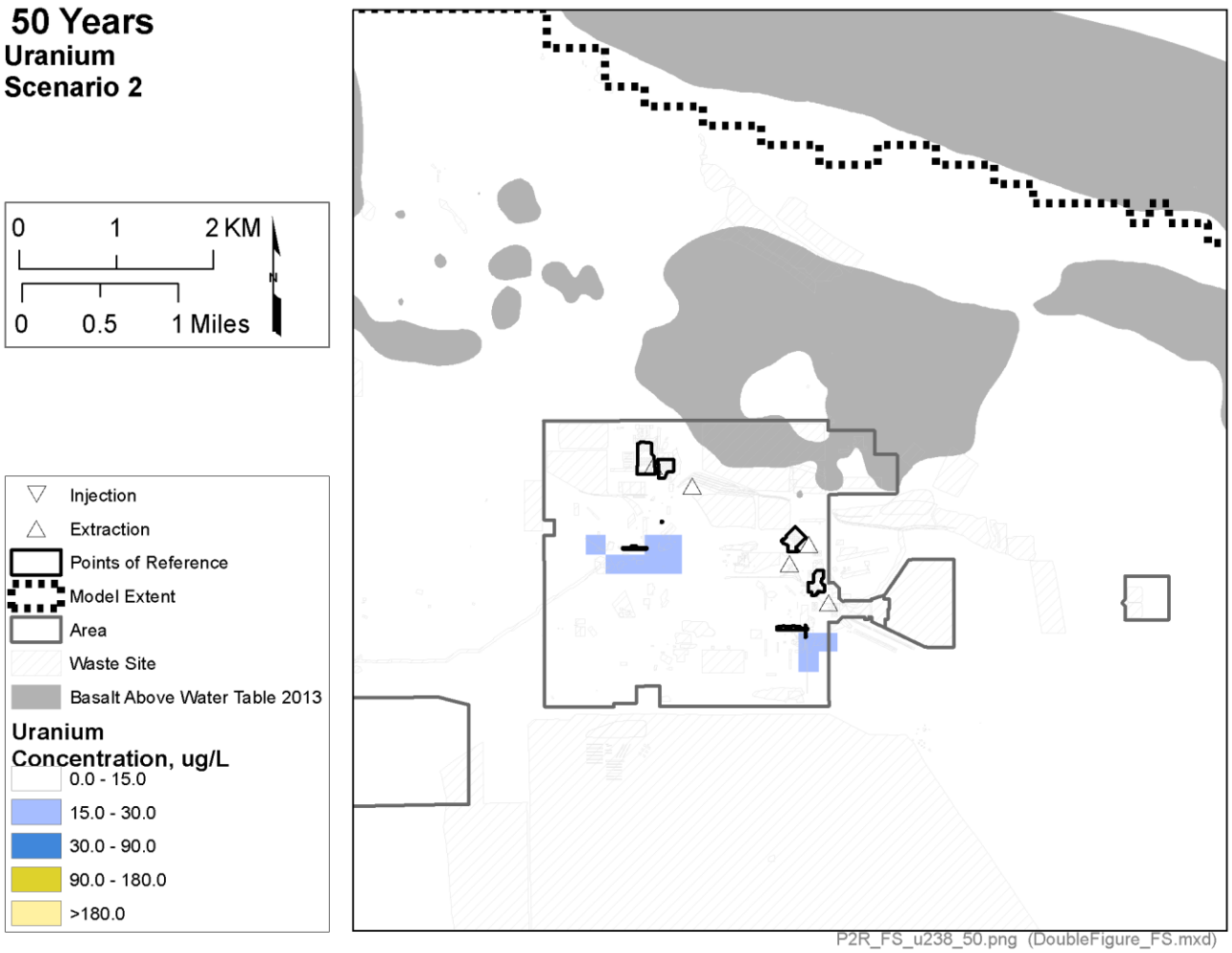

Figure B-80 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 2 simulation.

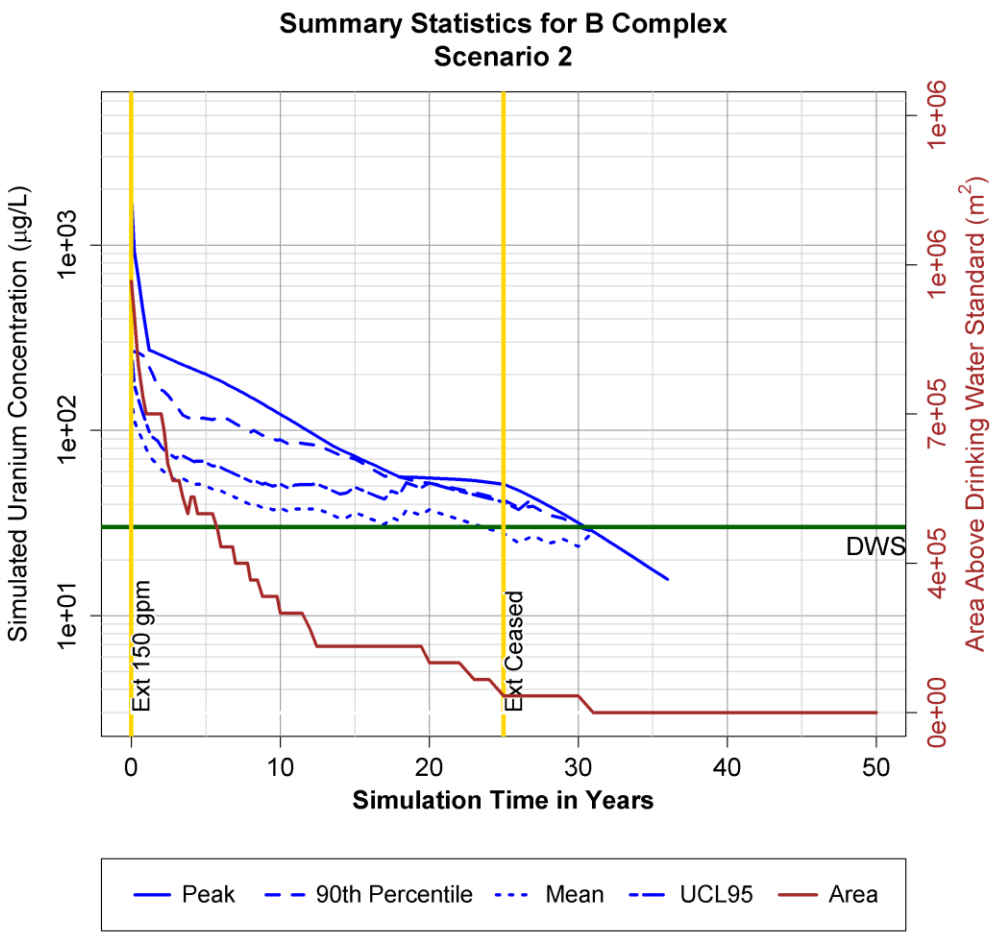

Figure B-81 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

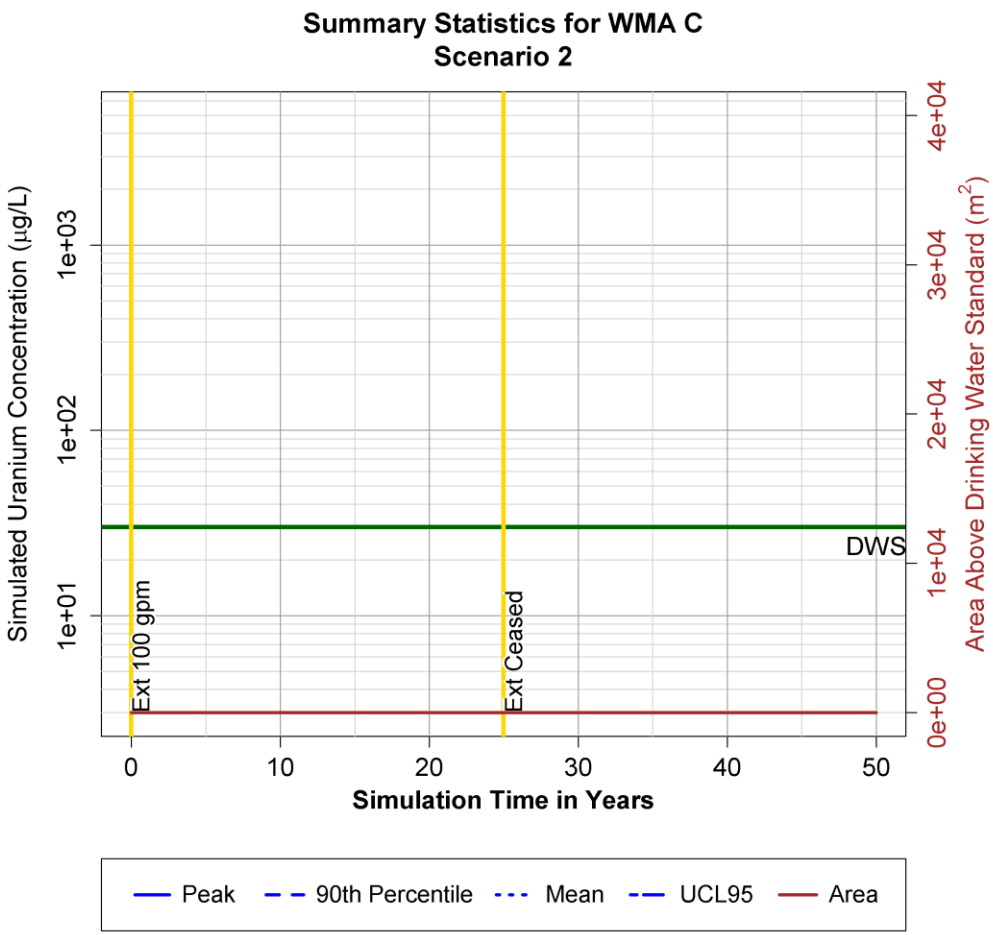

Figure B-82 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

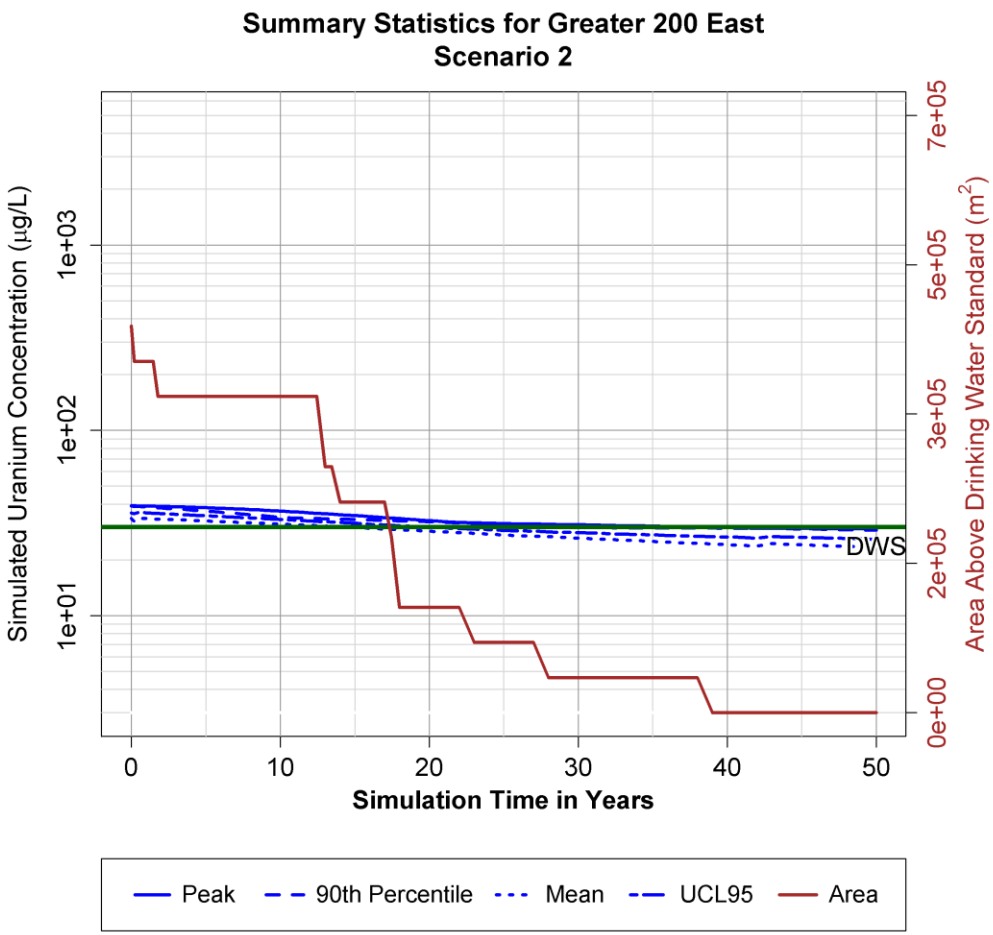

Figure B-83 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

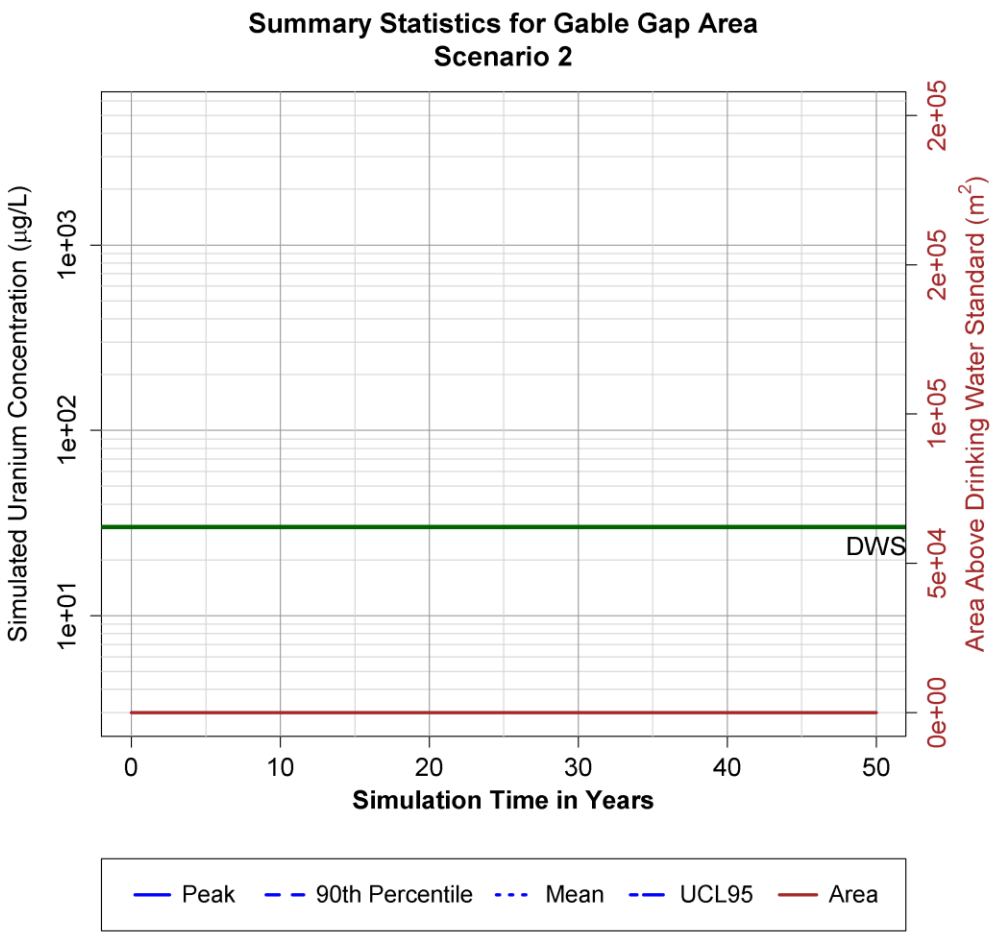

Figure B-84 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation.

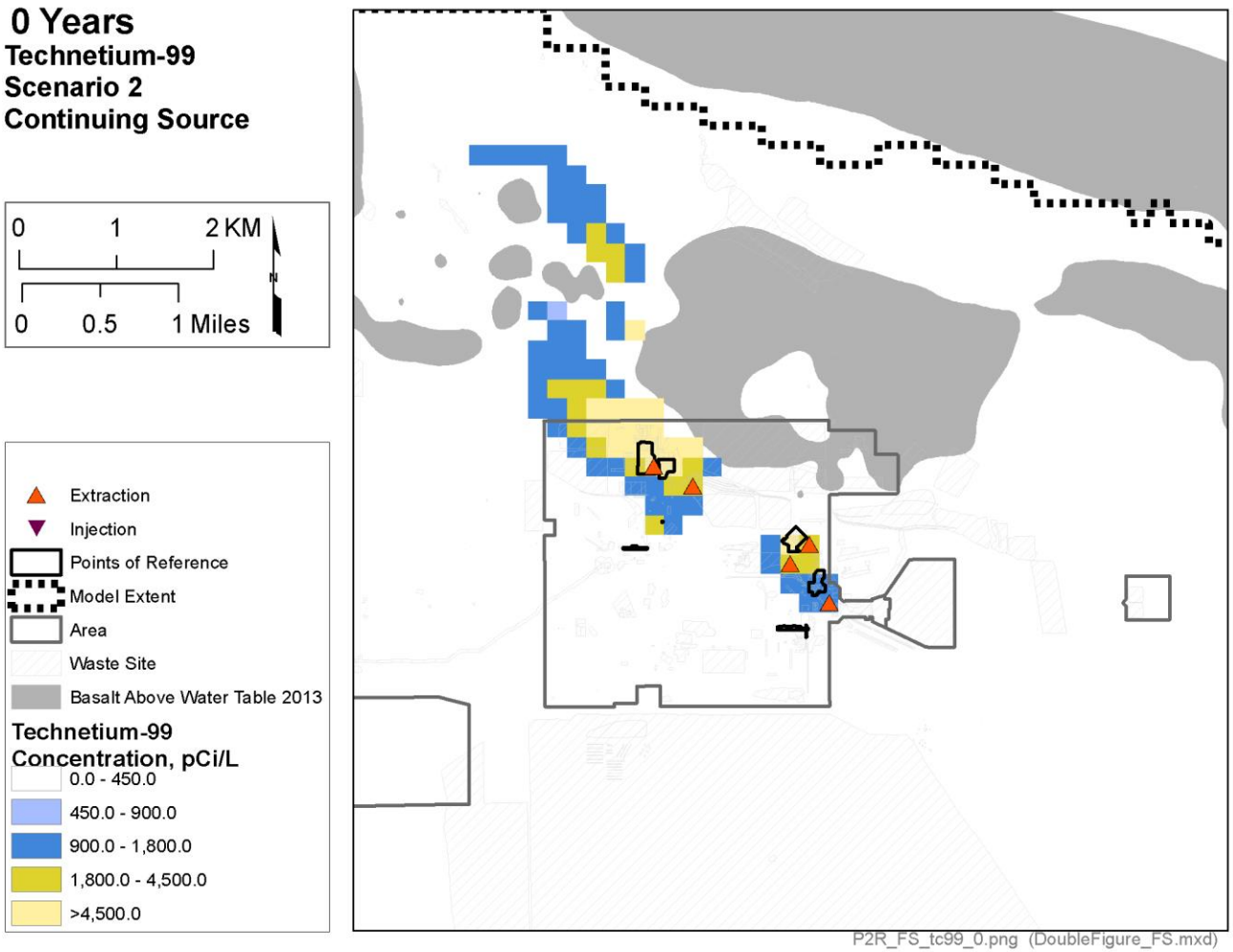

Figure B-85 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 2 simulation with a continuing source term.

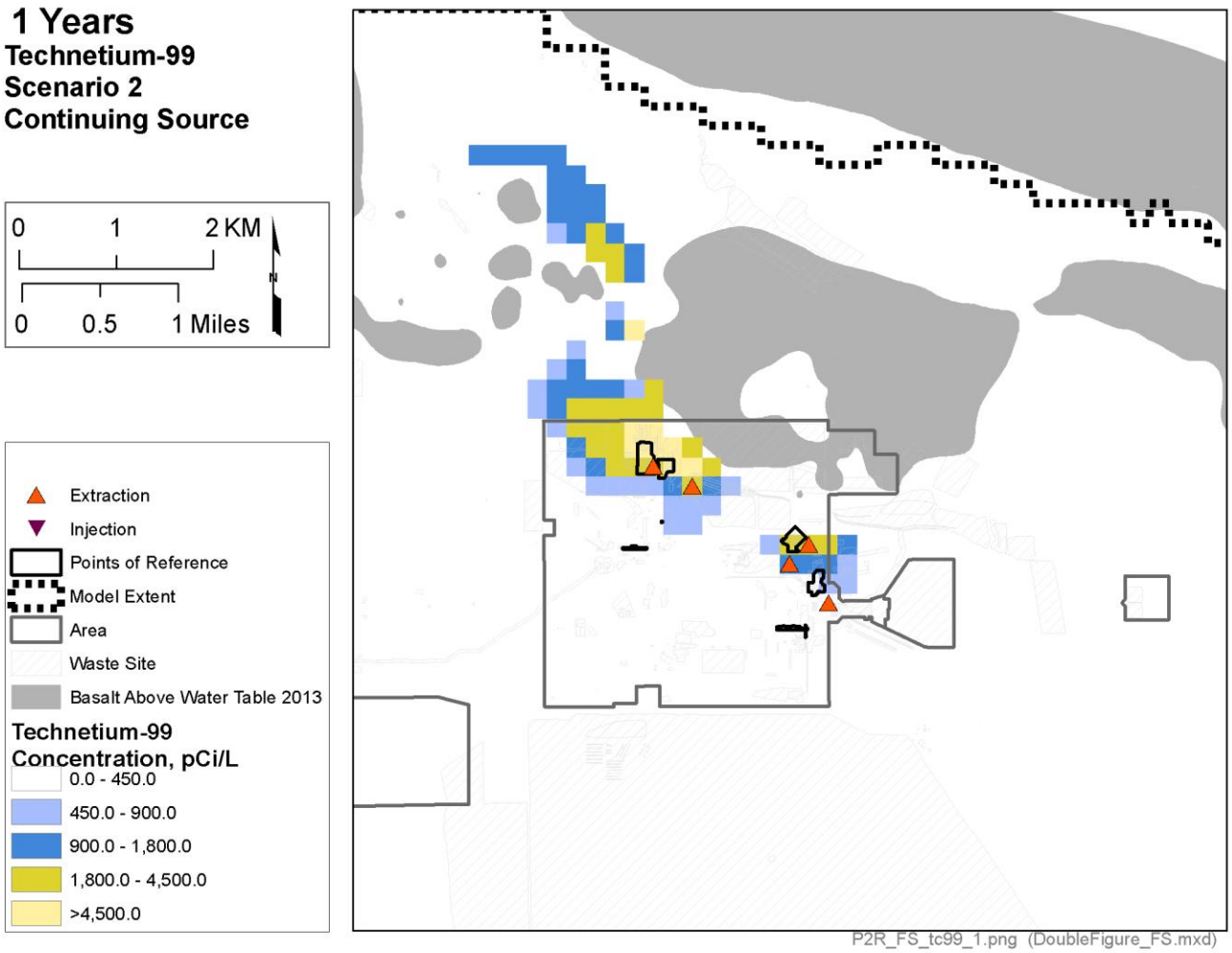

Figure B-86 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 2 simulation with a continuing source term.

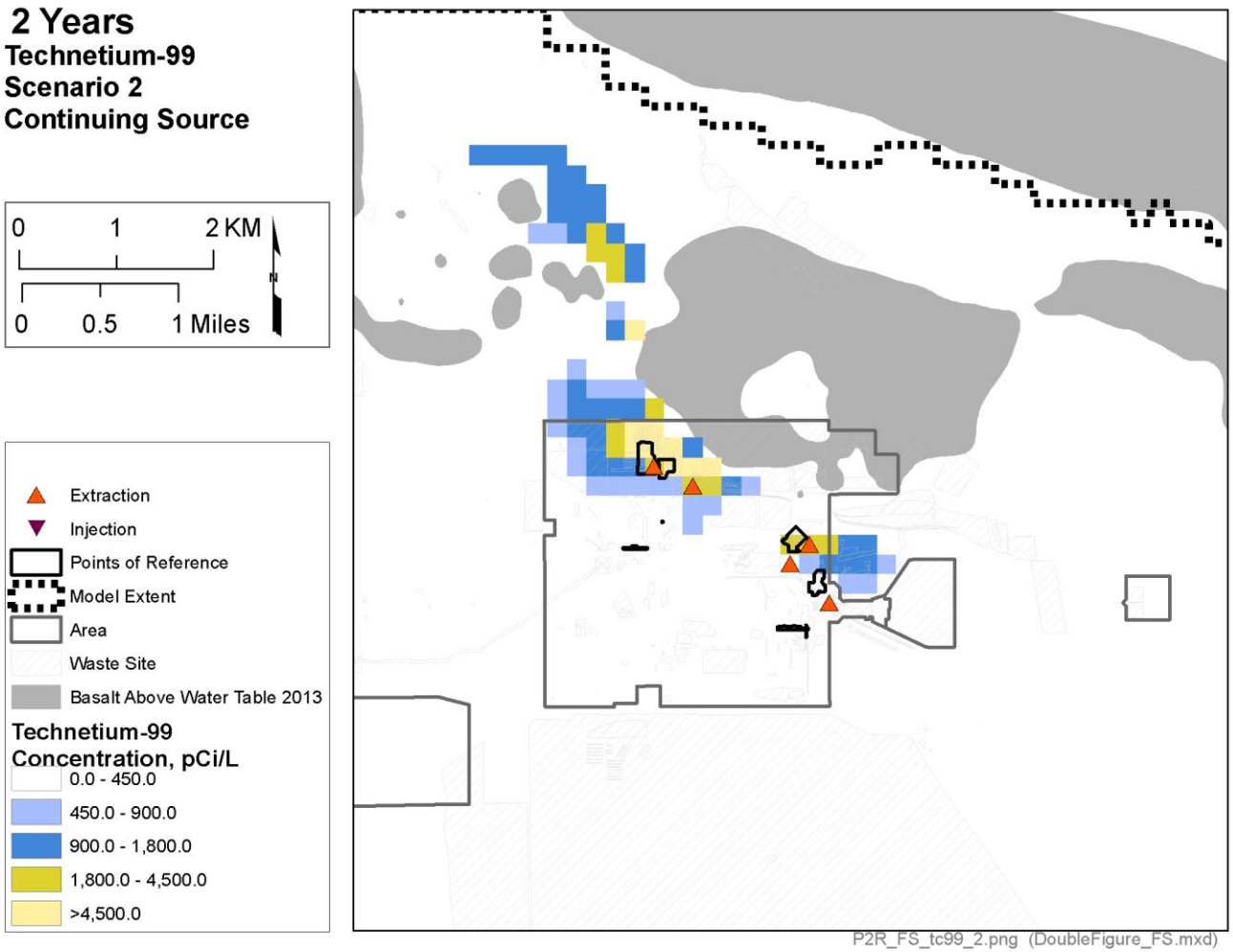

Figure B-87 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 2 simulation with a continuing source term.

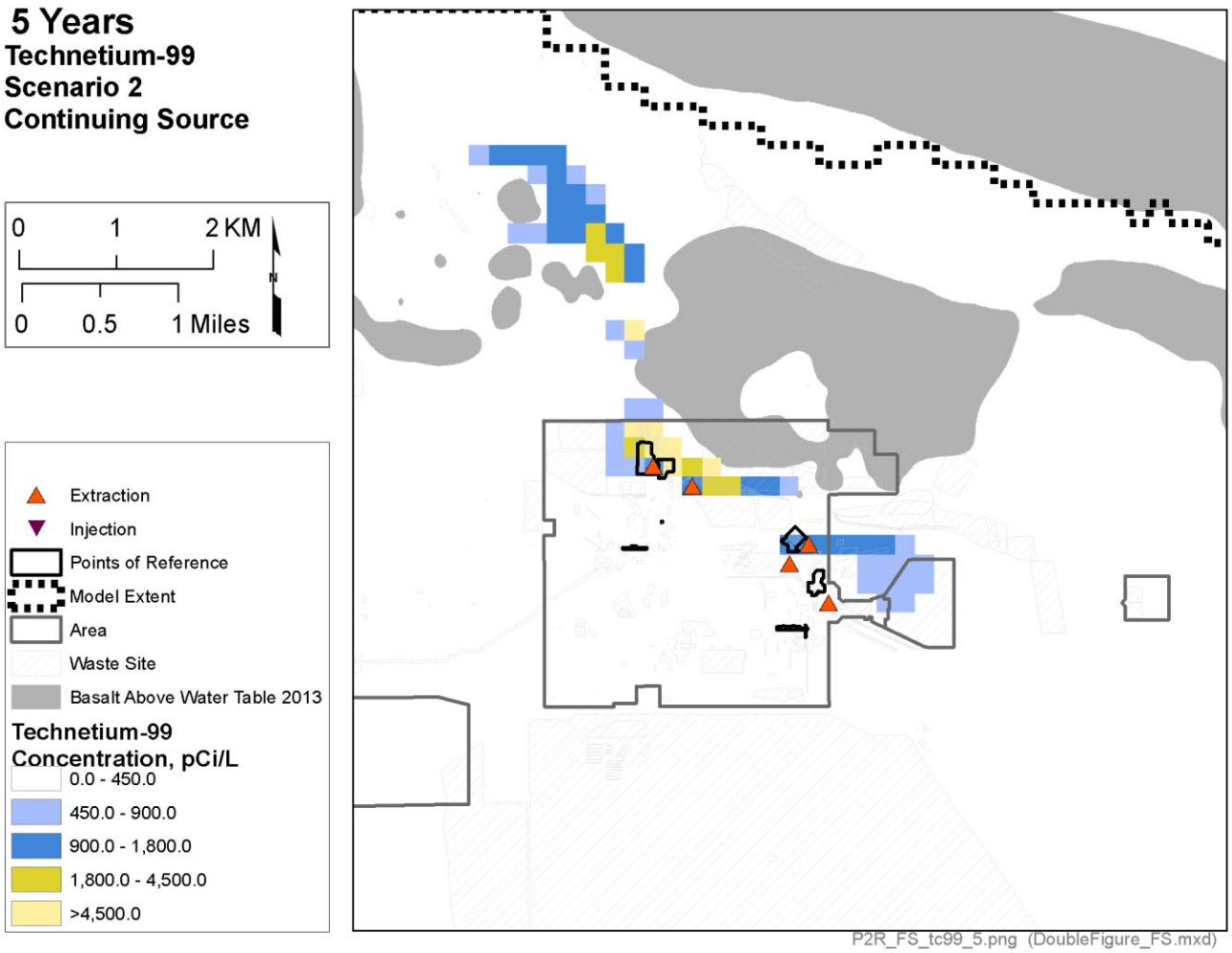

Figure B-88 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 2 simulation with a continuing source term.

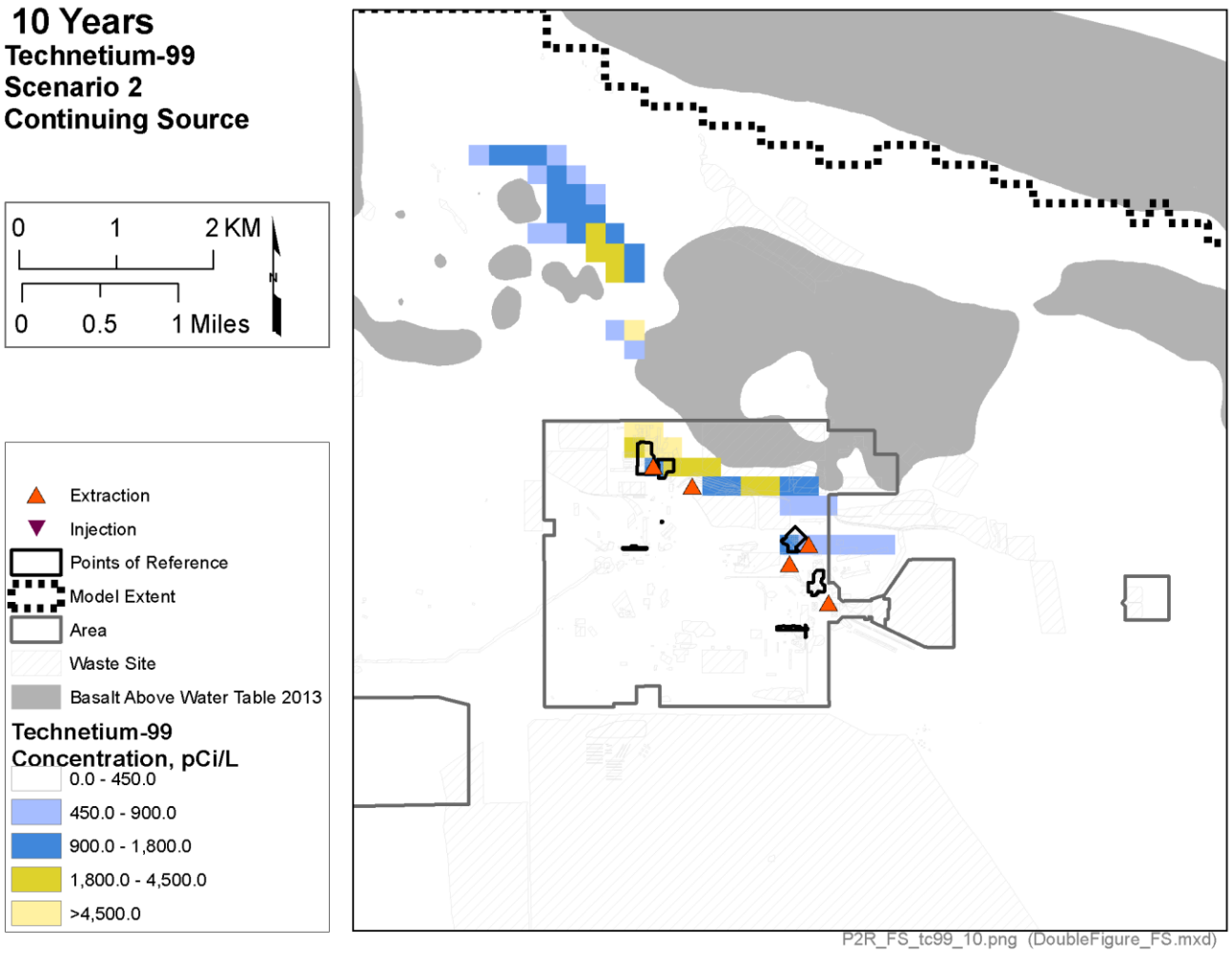

Figure B-89 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 2 simulation with a continuing source term.

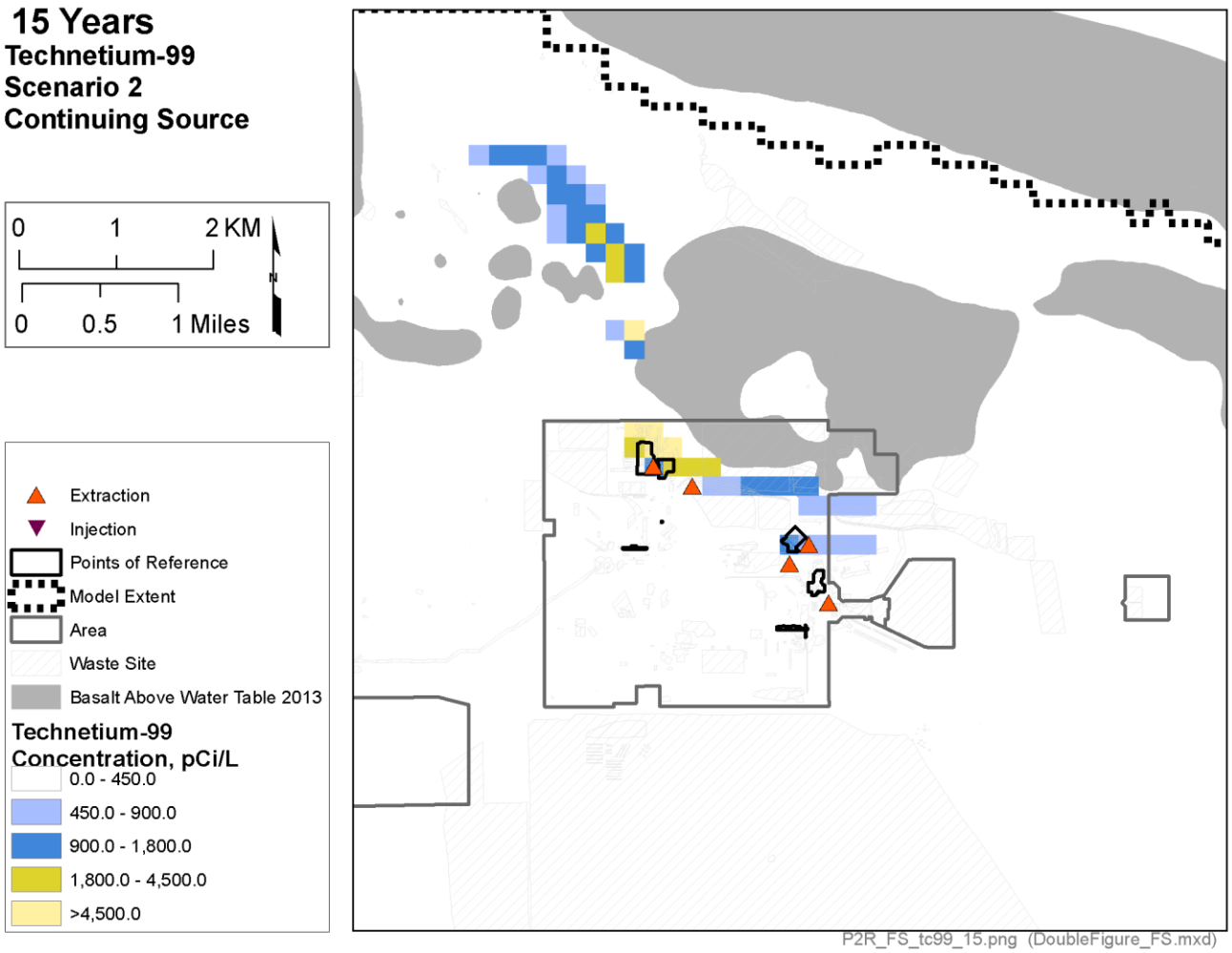

Figure B-90 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 2 simulation with a continuing source term.

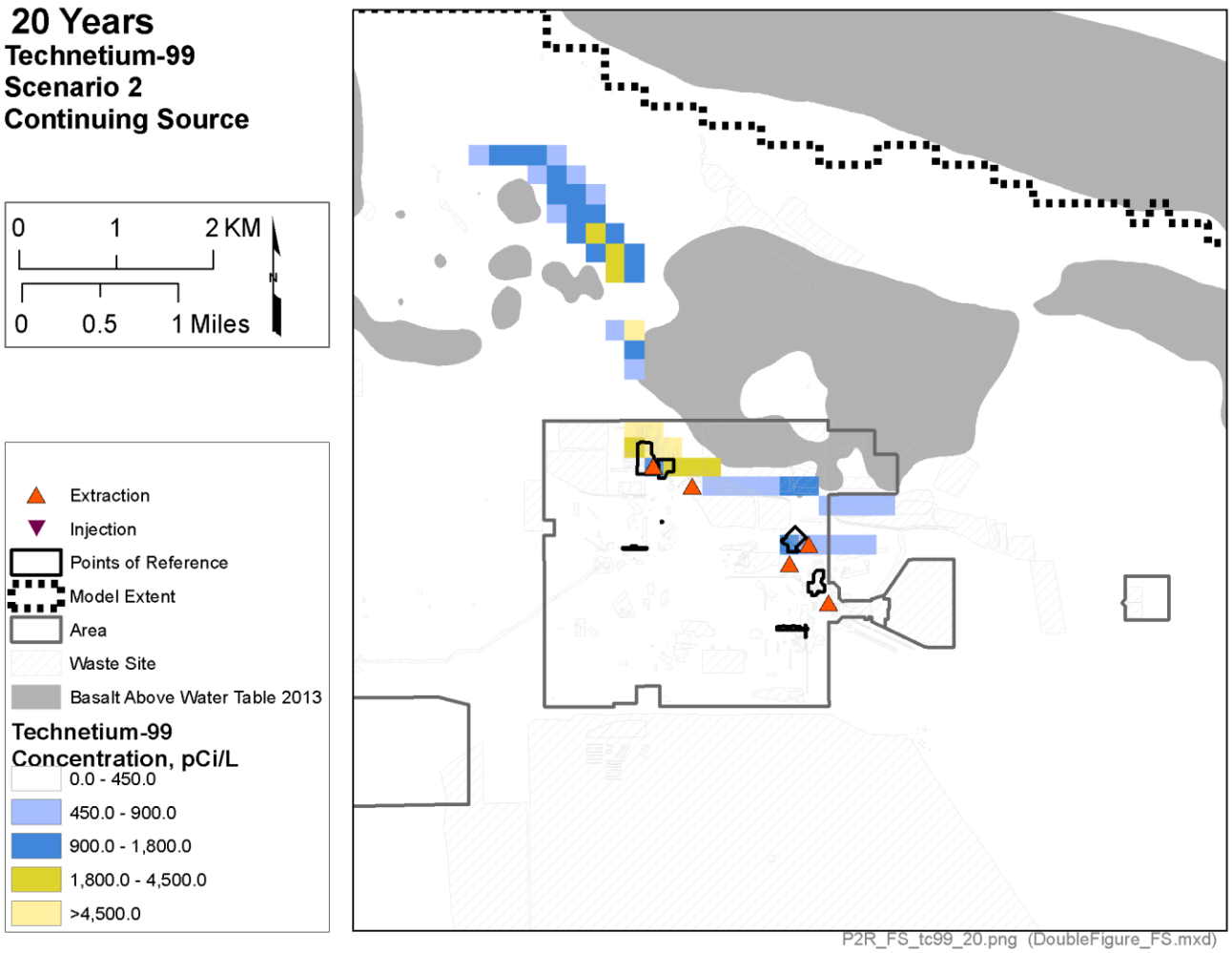

Figure B-91 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 2 simulation with a continuing source term.

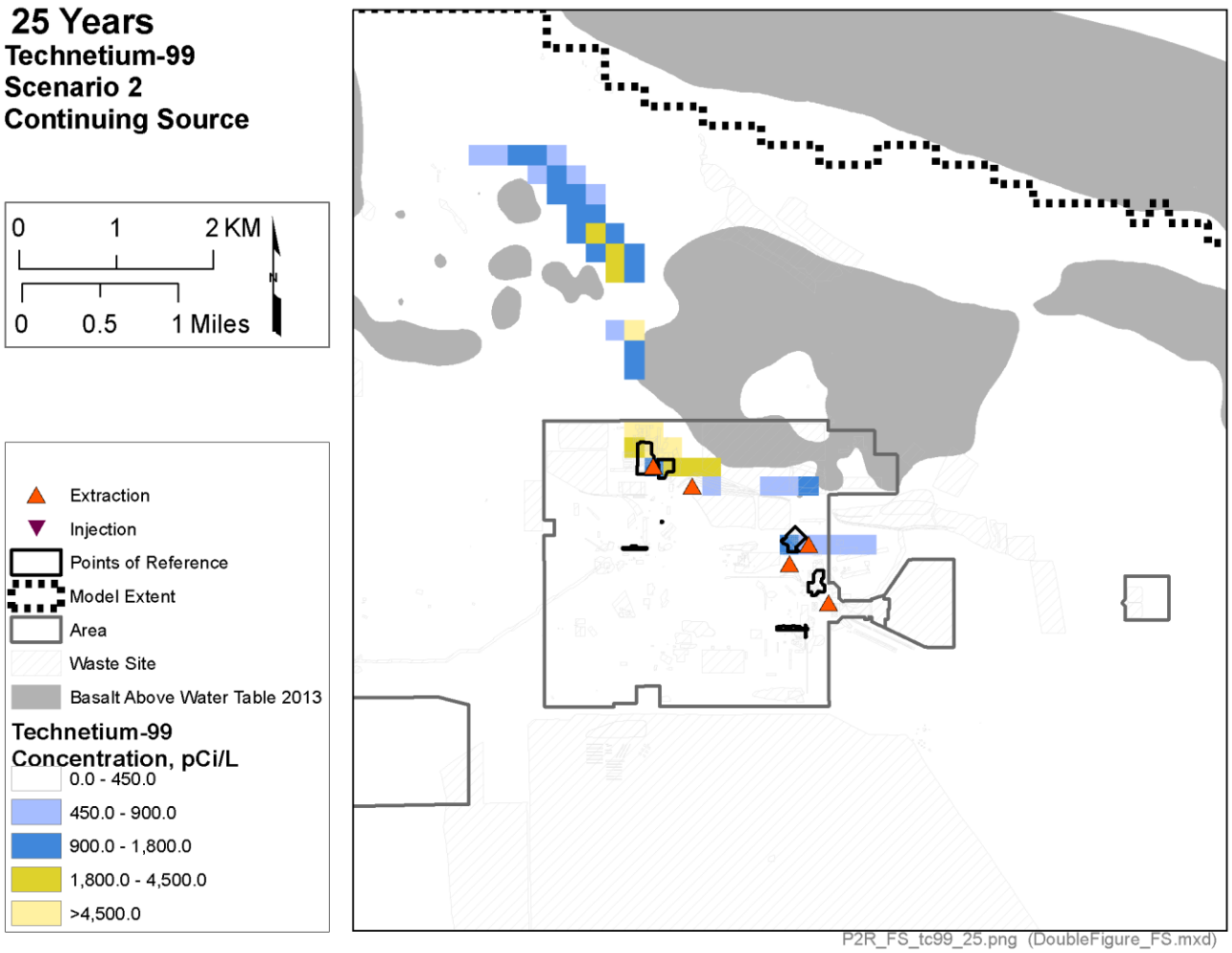

Figure B-92 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 2 simulation with a continuing source term.

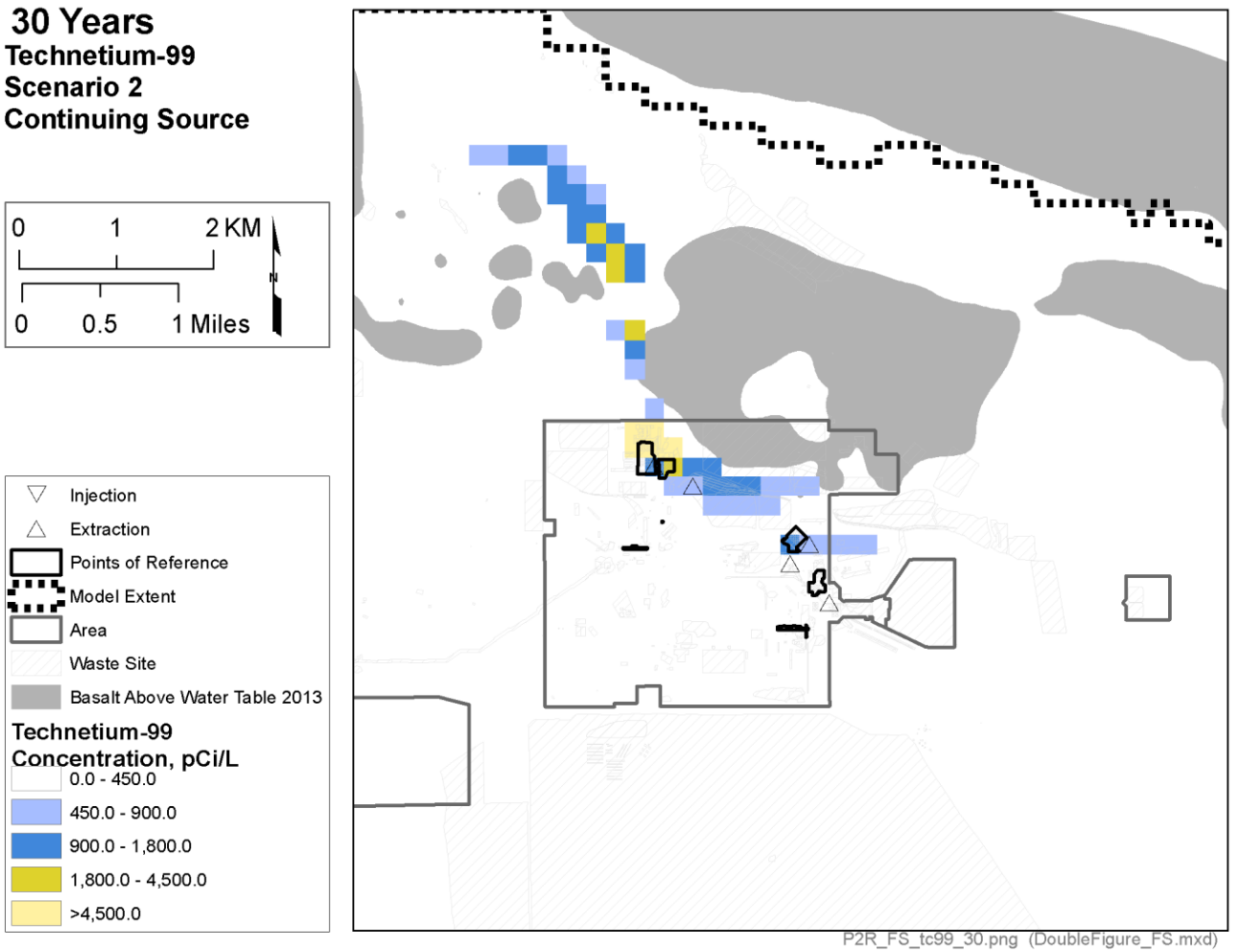

Figure B-93 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 2 simulation with a continuing source term.

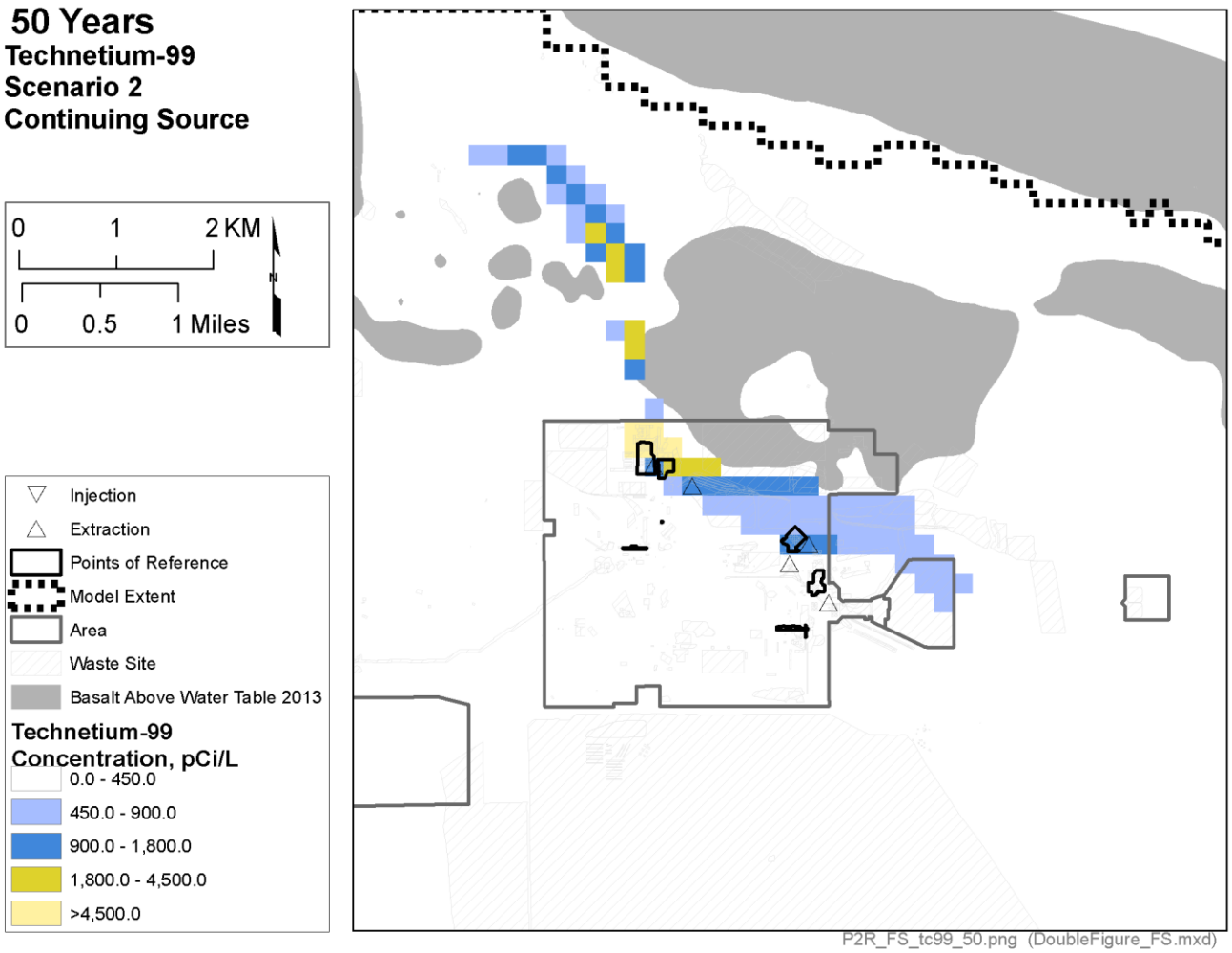

Figure B-94 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 2 simulation with a continuing source term.

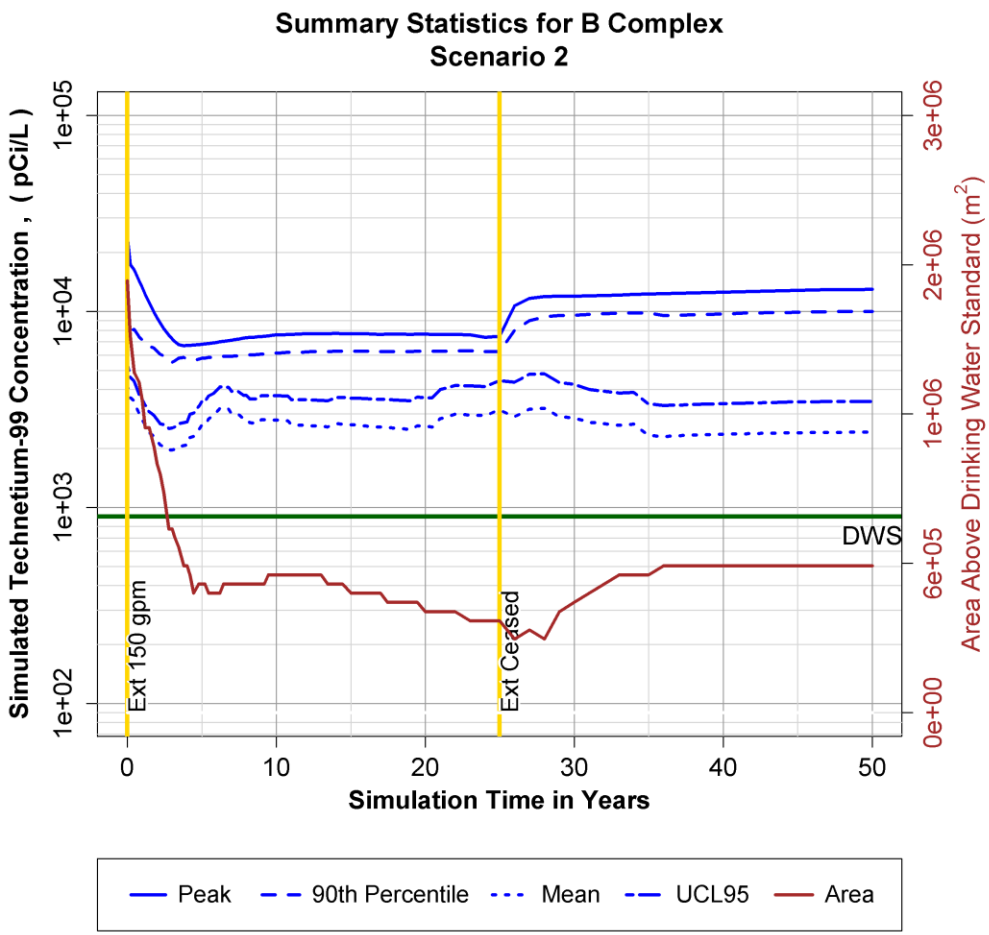

Figure B-95 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

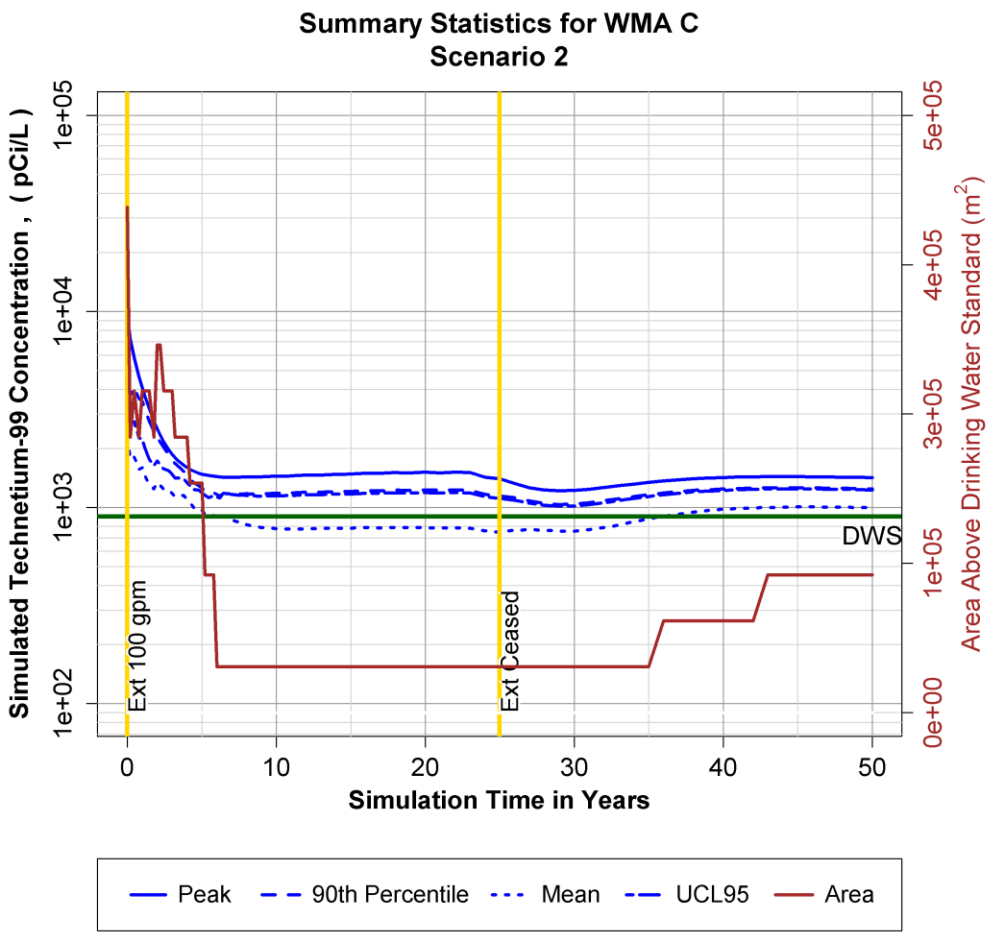

Figure B-96 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

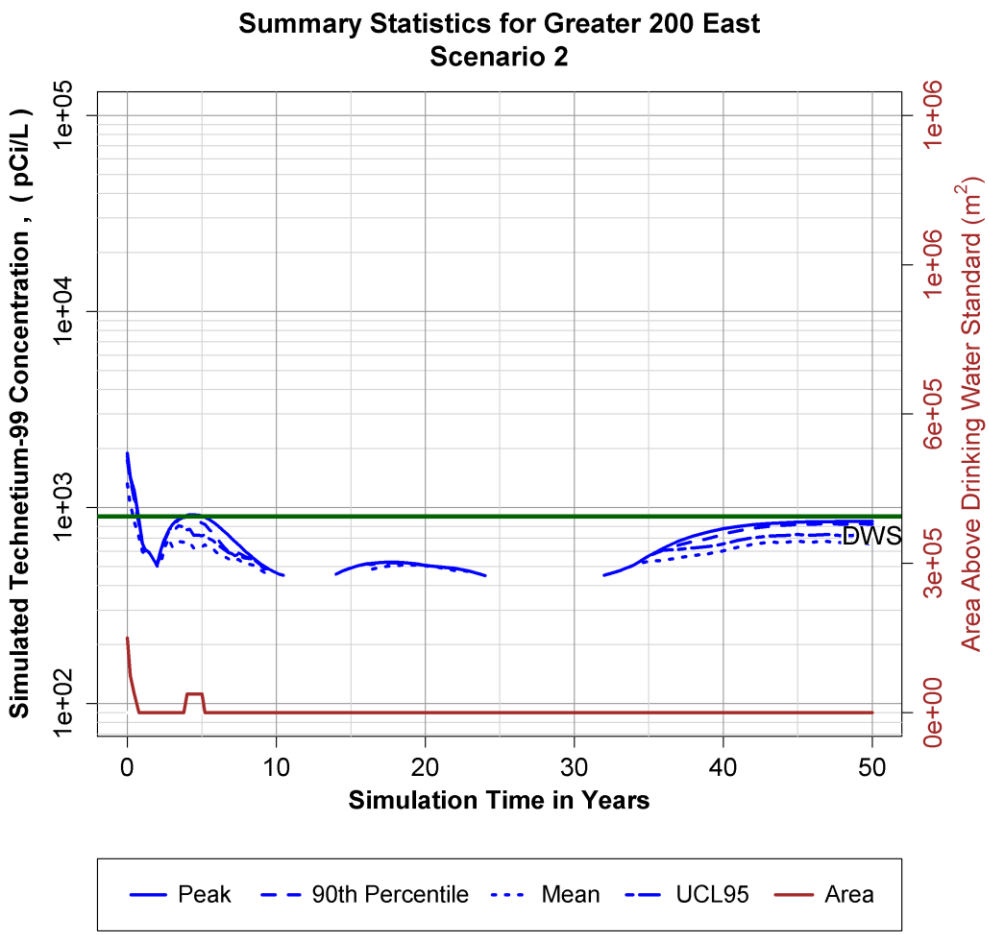

Figure B-97 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

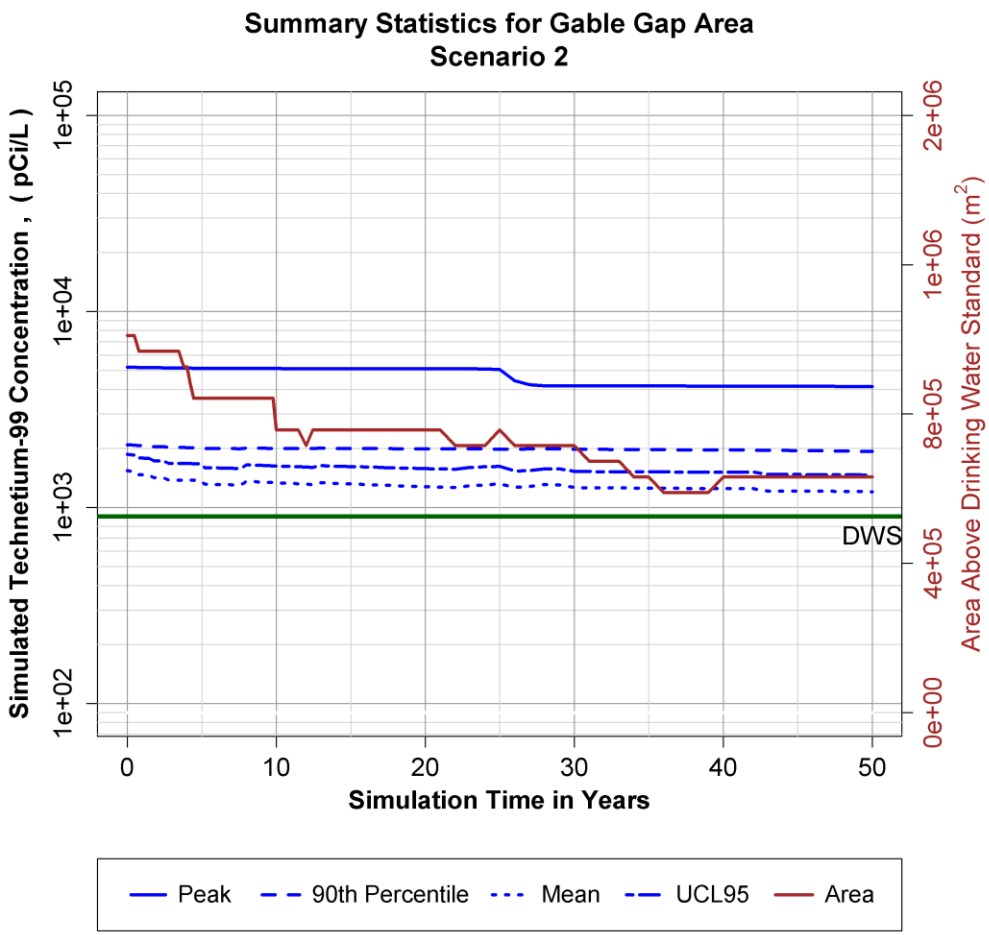

Figure B-98 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 2 simulation with a continuing source term.

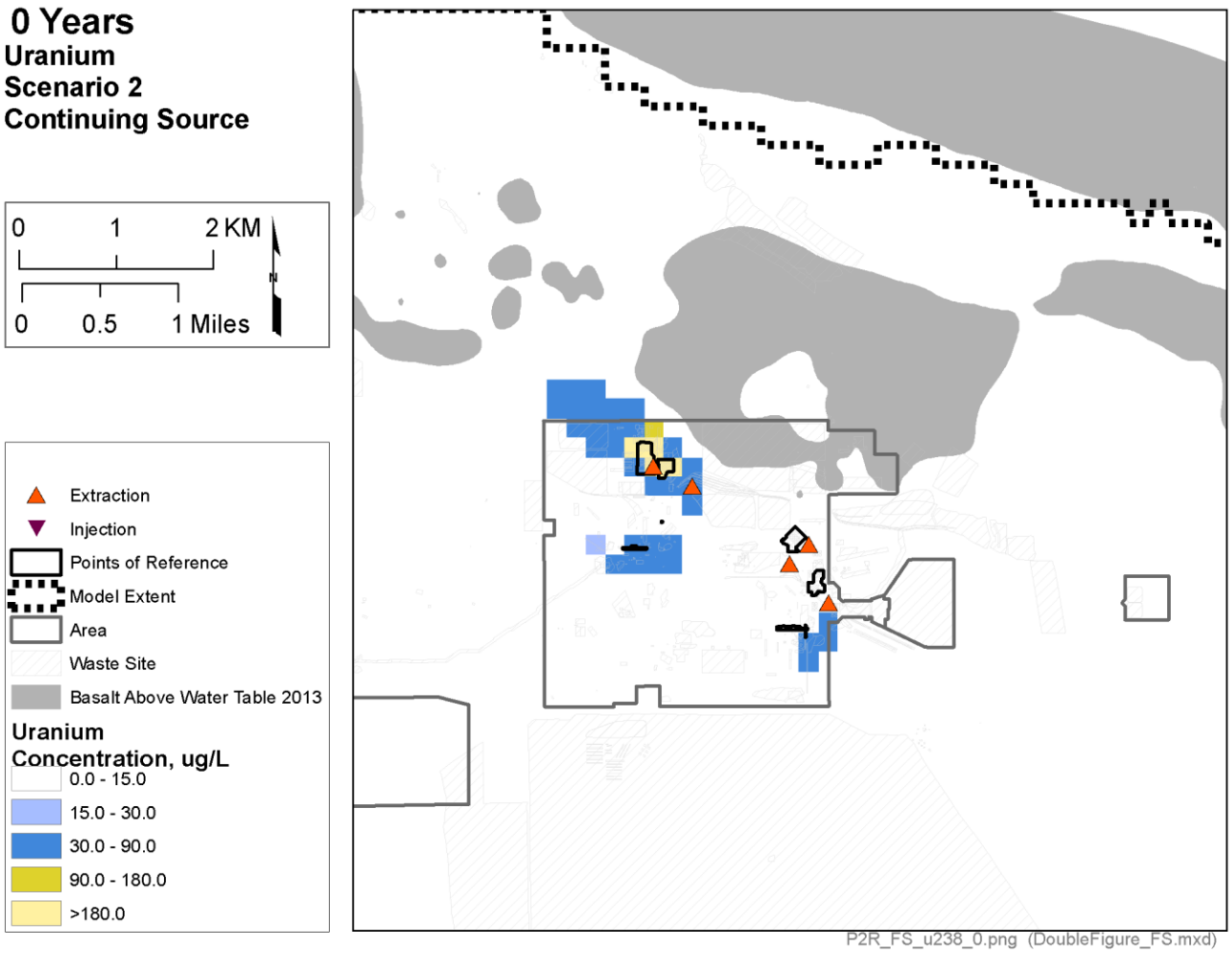

Figure B-99 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 2 simulation with a continuing source term.

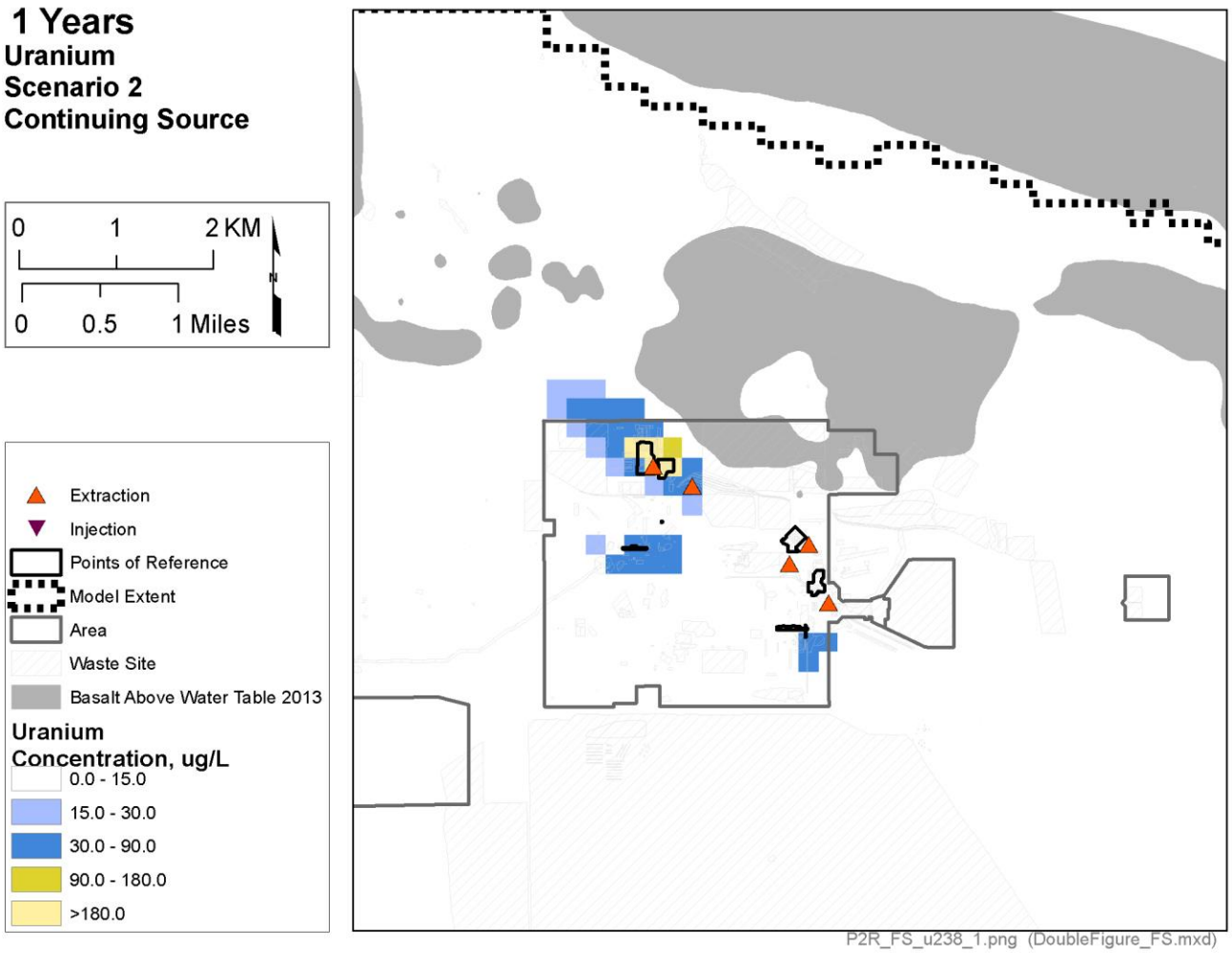

Figure B-100 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 2 simulation with a continuing source term.

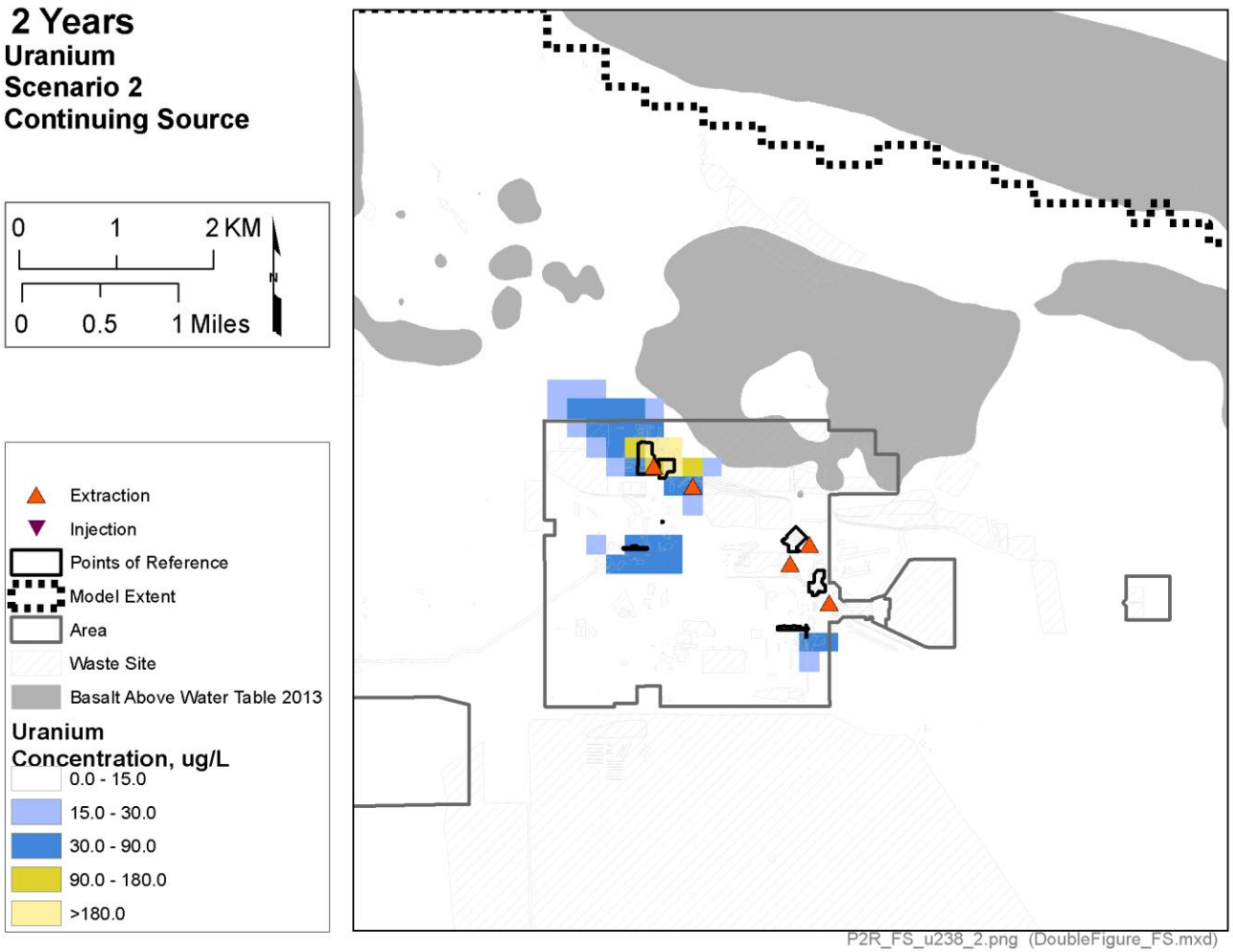

Figure B-101 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 2 simulation with a continuing source term.

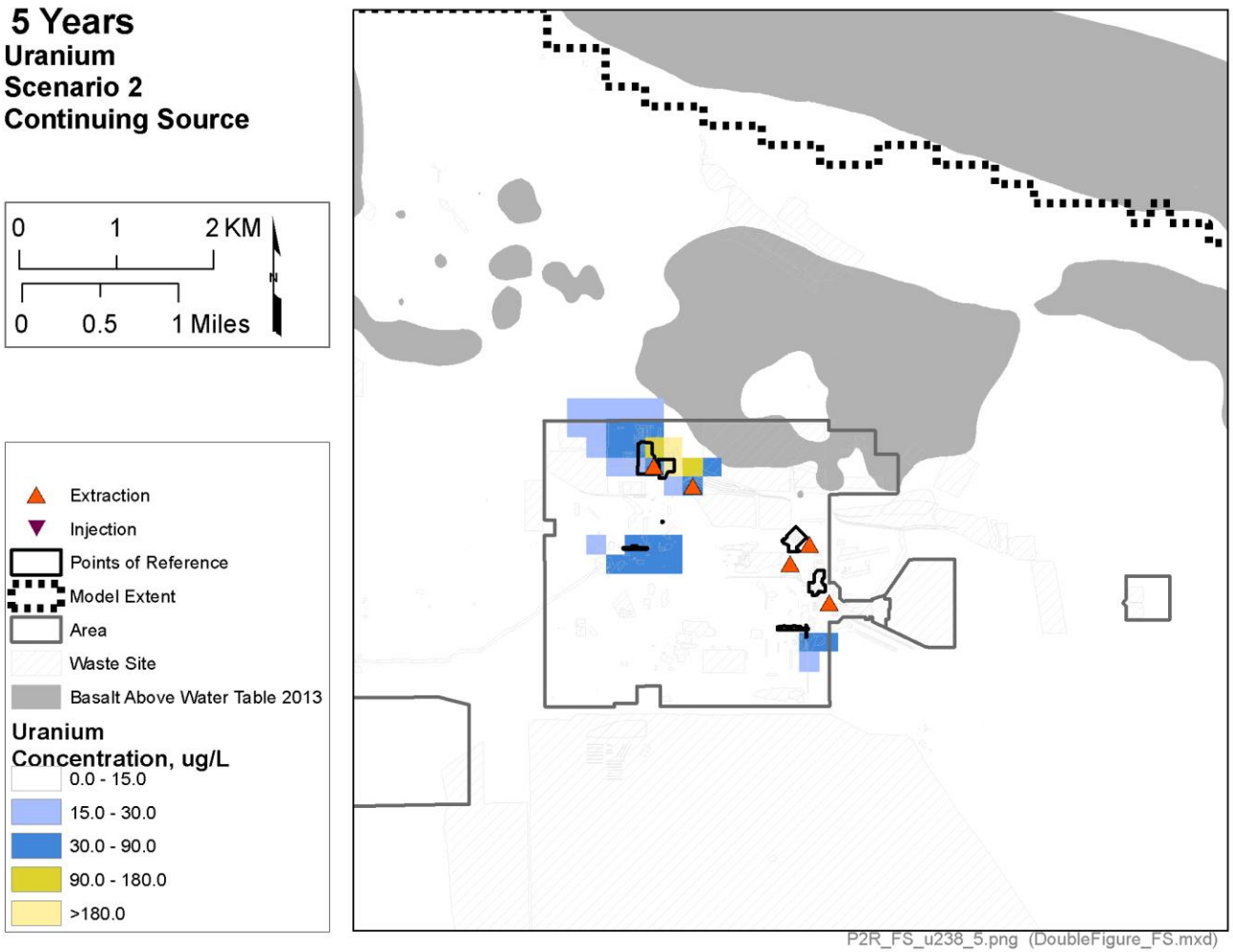

Figure B-102 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 2 simulation with a continuing source term.

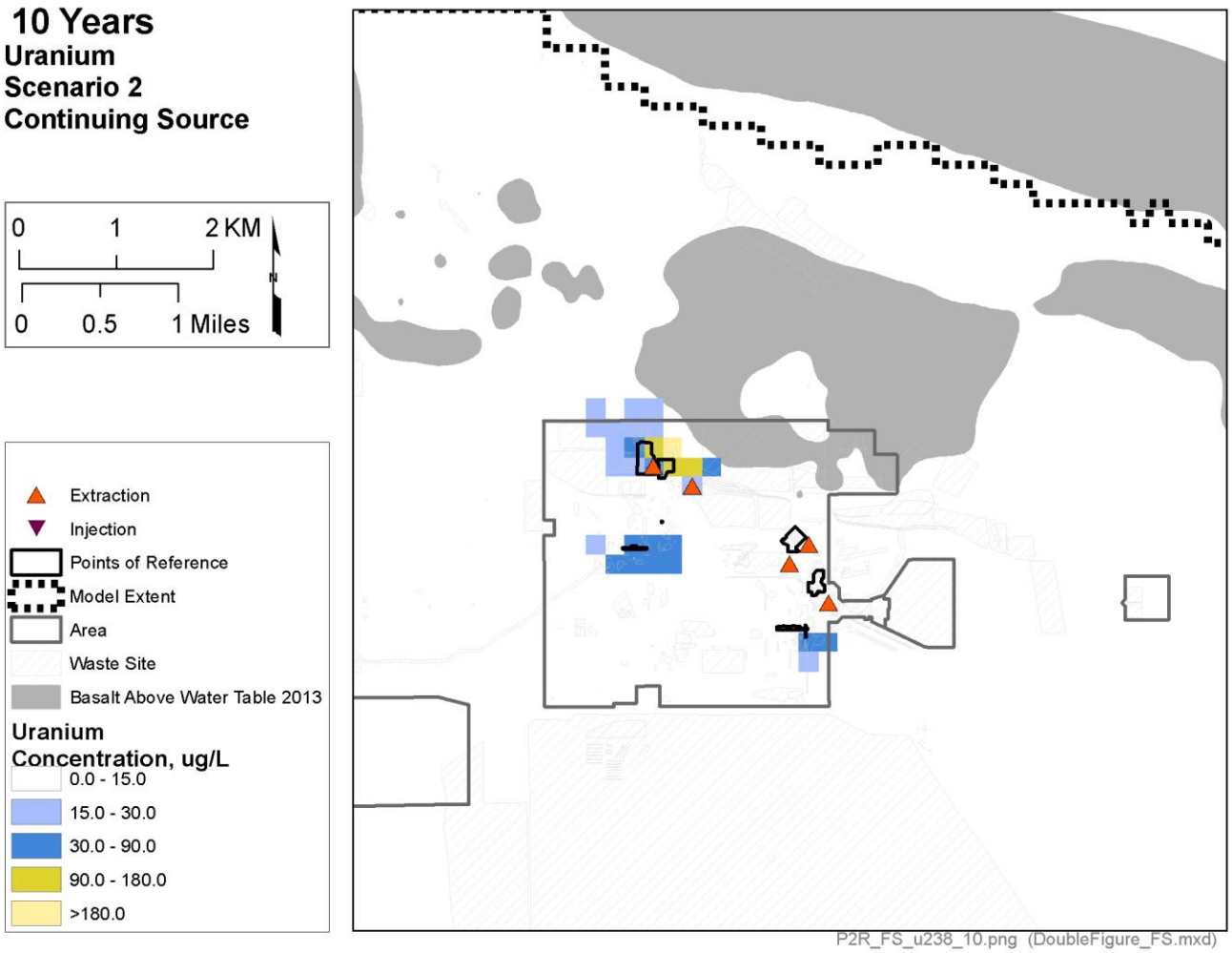

Figure B-103 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 2 simulation with a continuing source term.

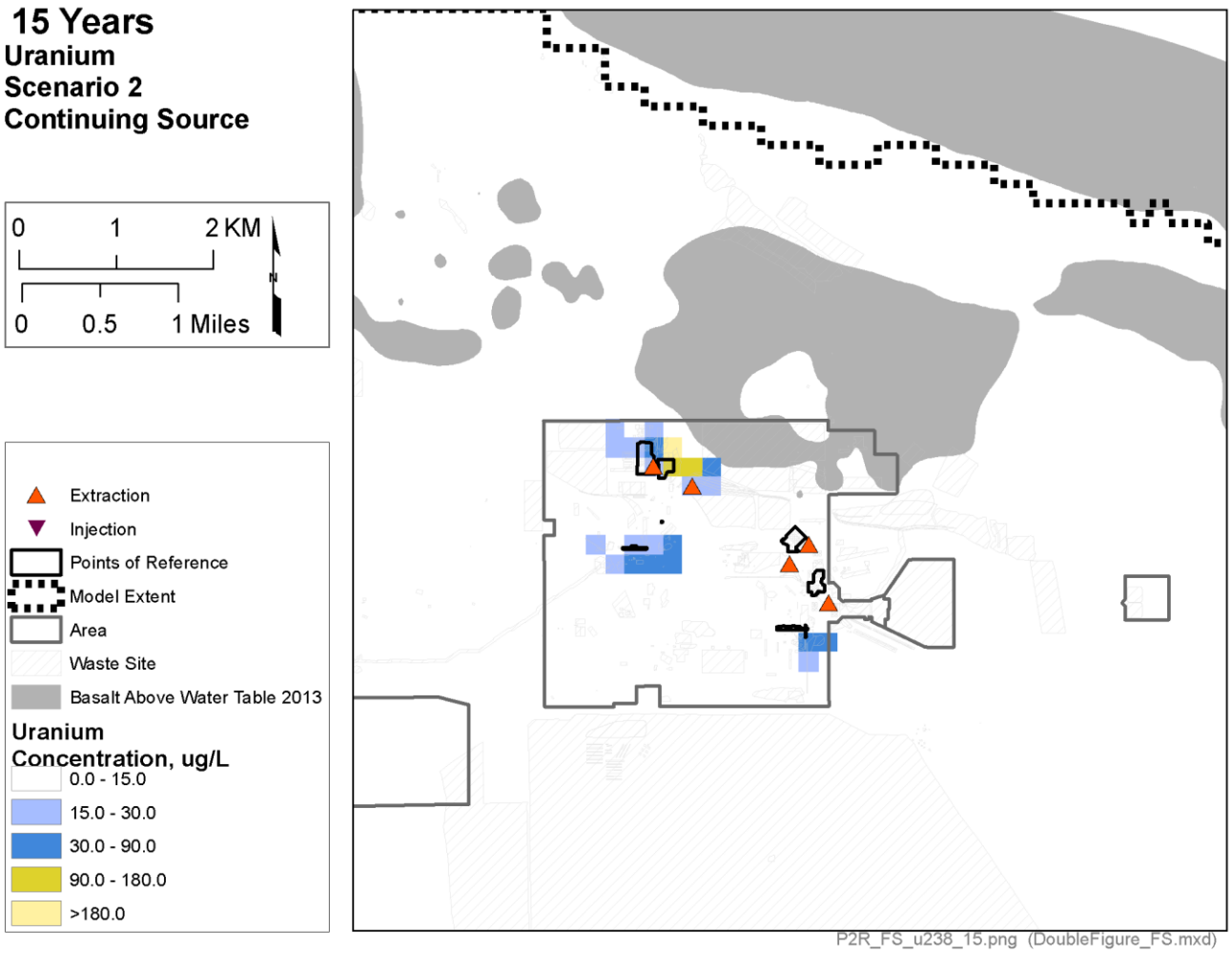

Figure B-104 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 2 simulation with a continuing source term.

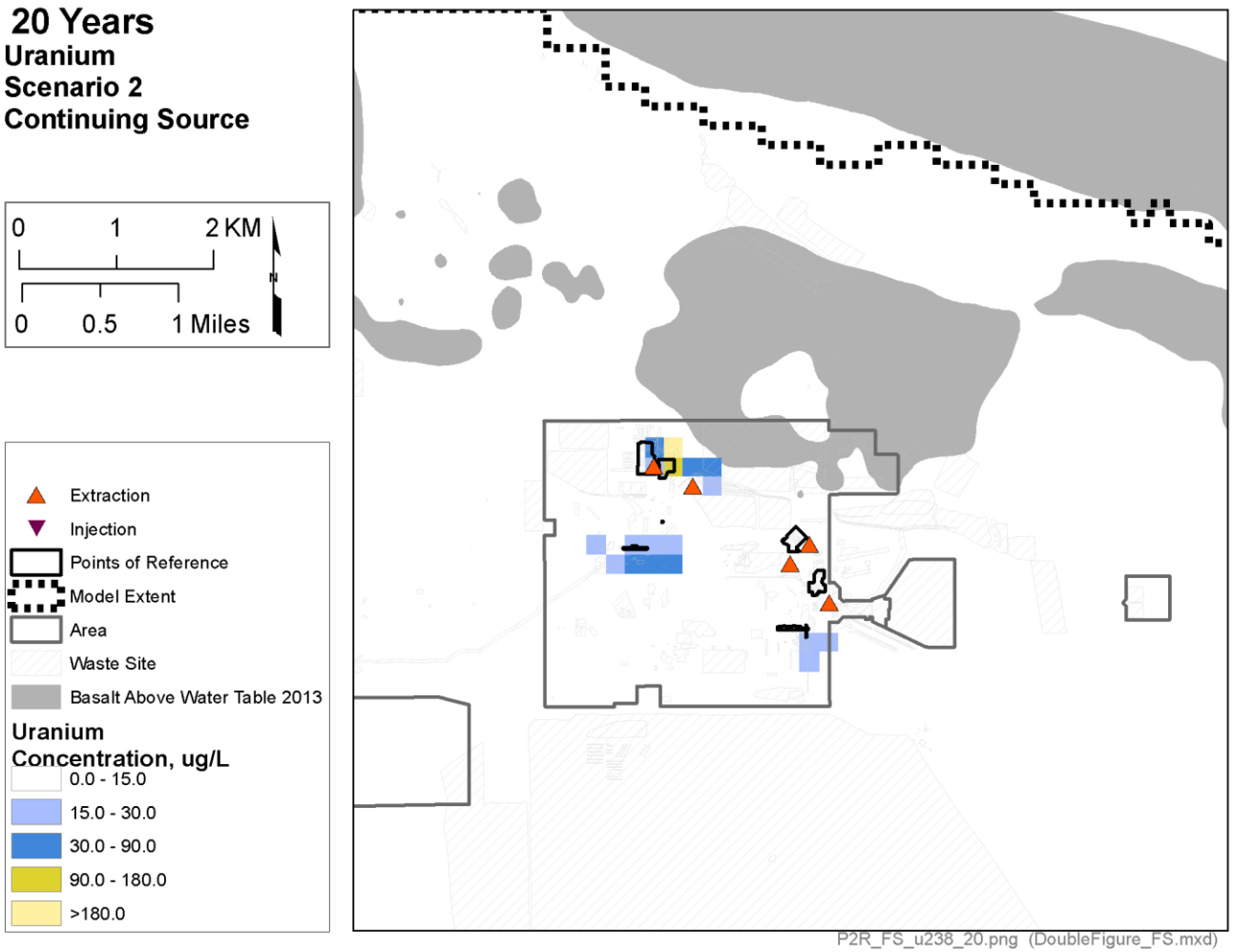

Figure B-105 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 2 simulation with a continuing source term.

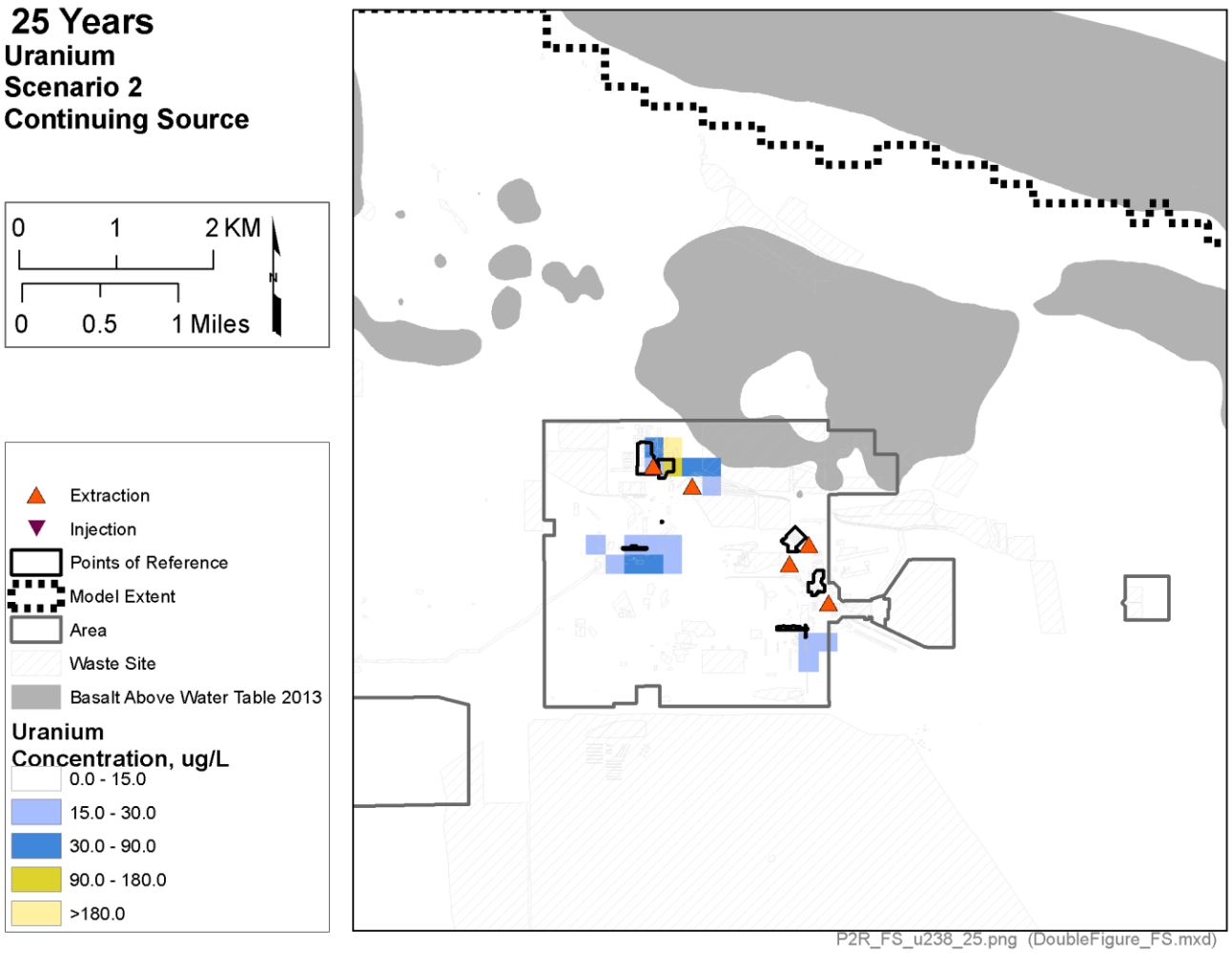

Figure B-106 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 2 simulation with a continuing source term.

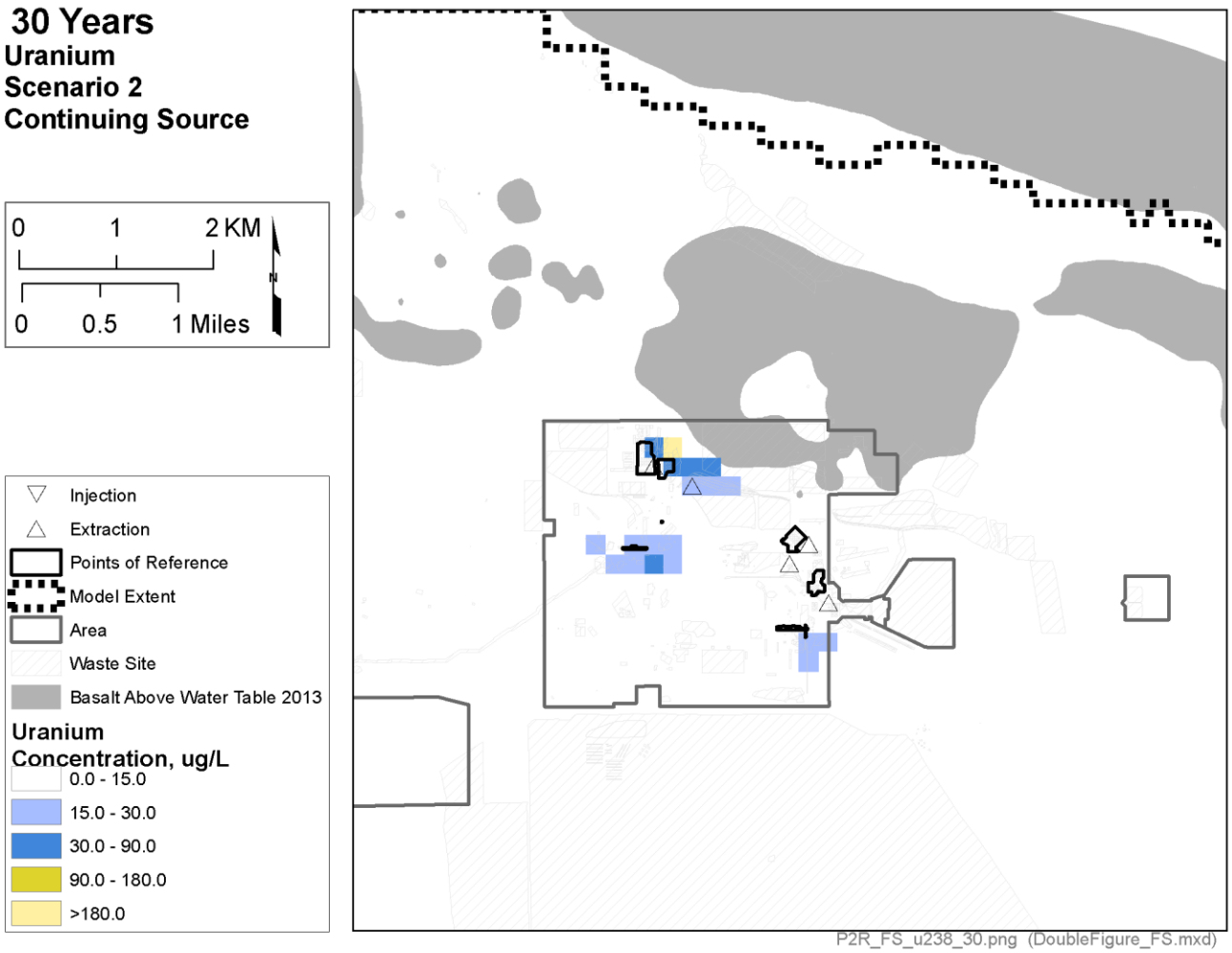

Figure B-107 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 2 simulation with a continuing source term.

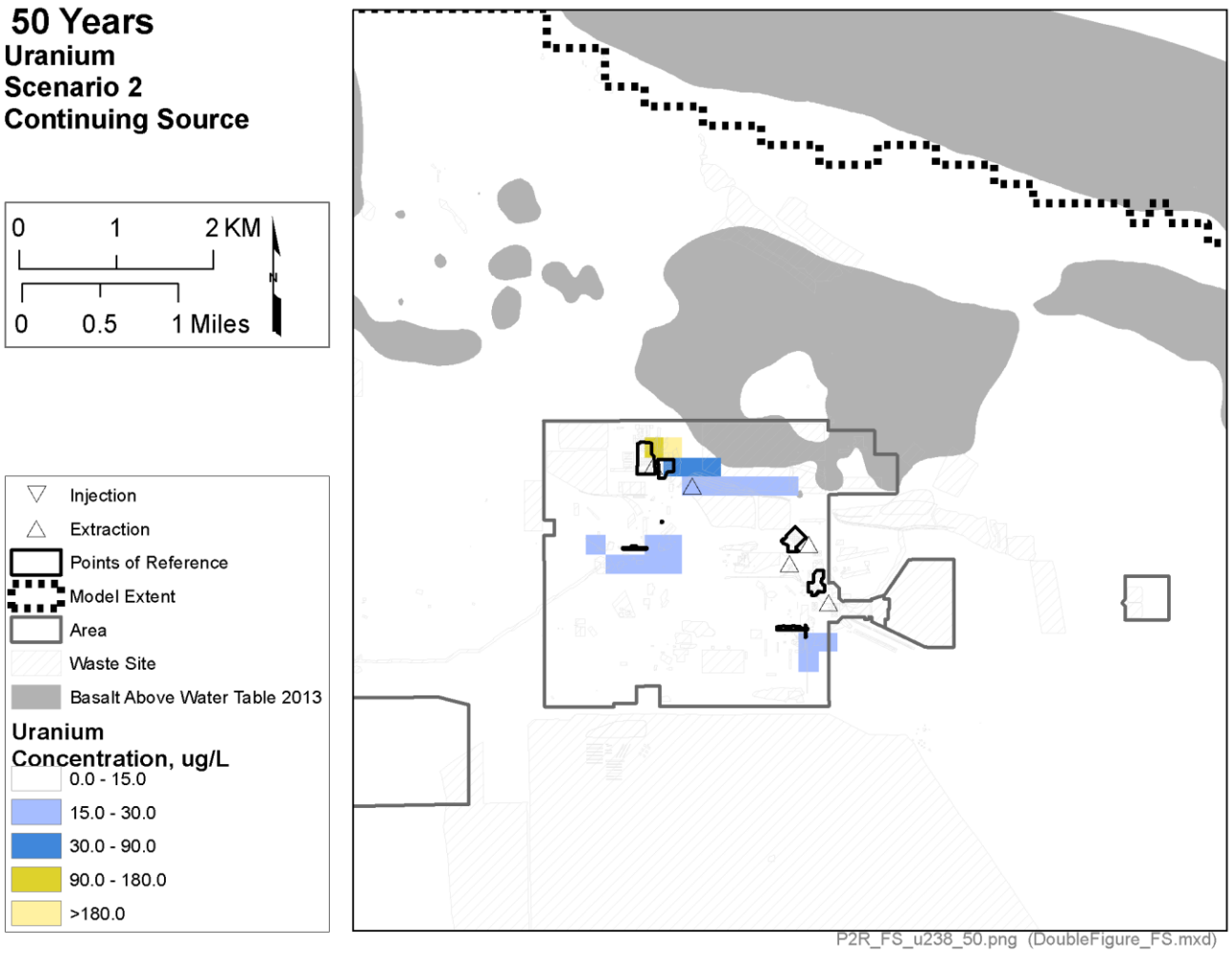

Figure B-108 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 2 simulation with a continuing source term.

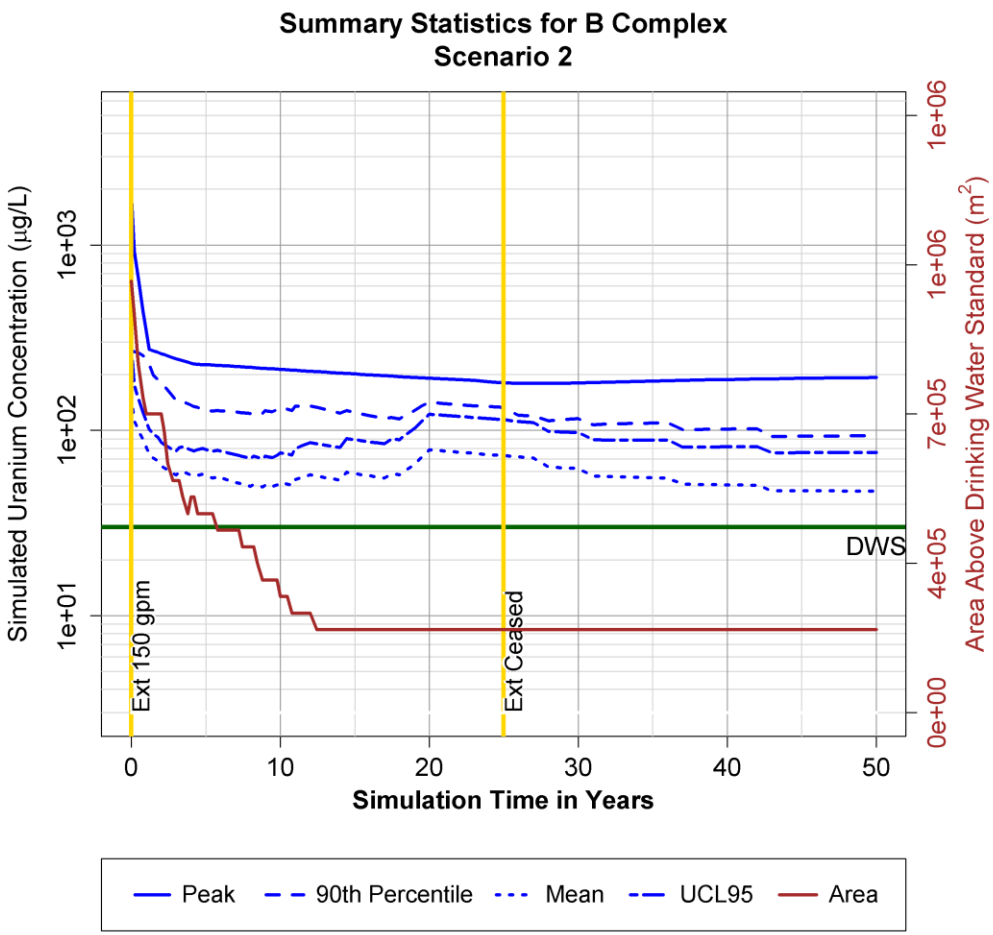

Figure B-109 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

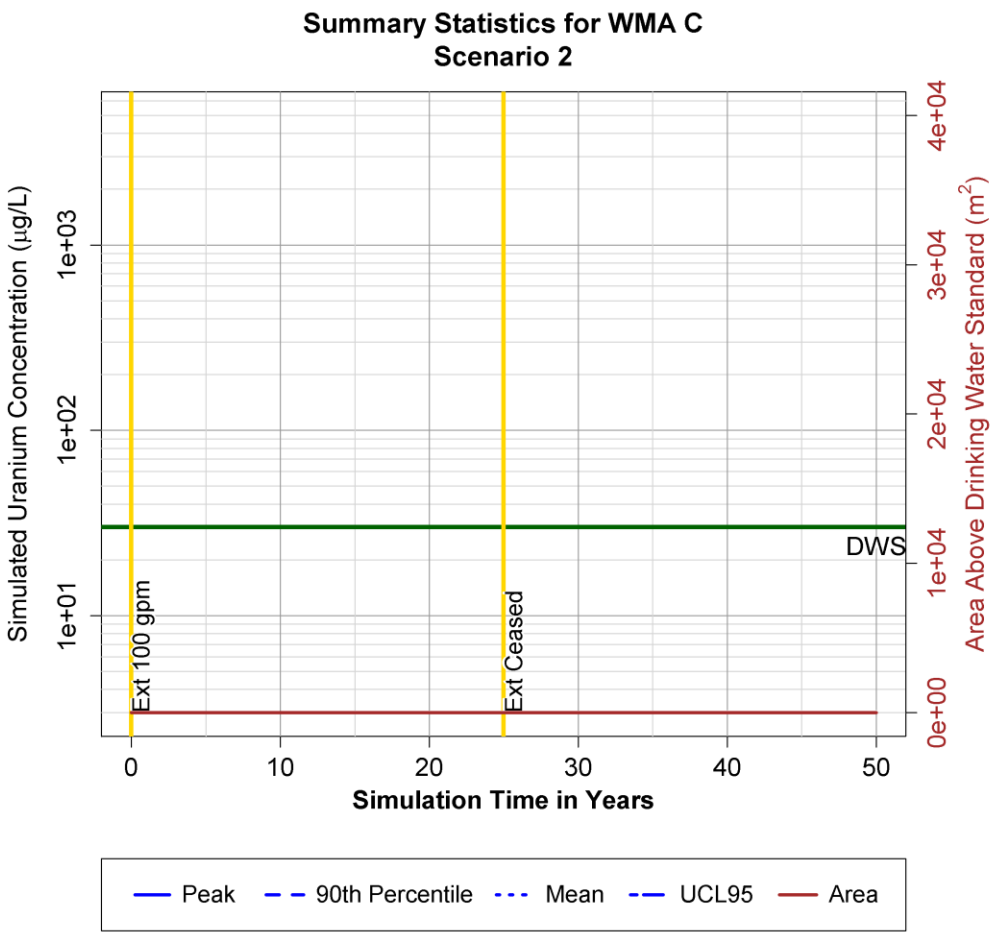

Figure B-110 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

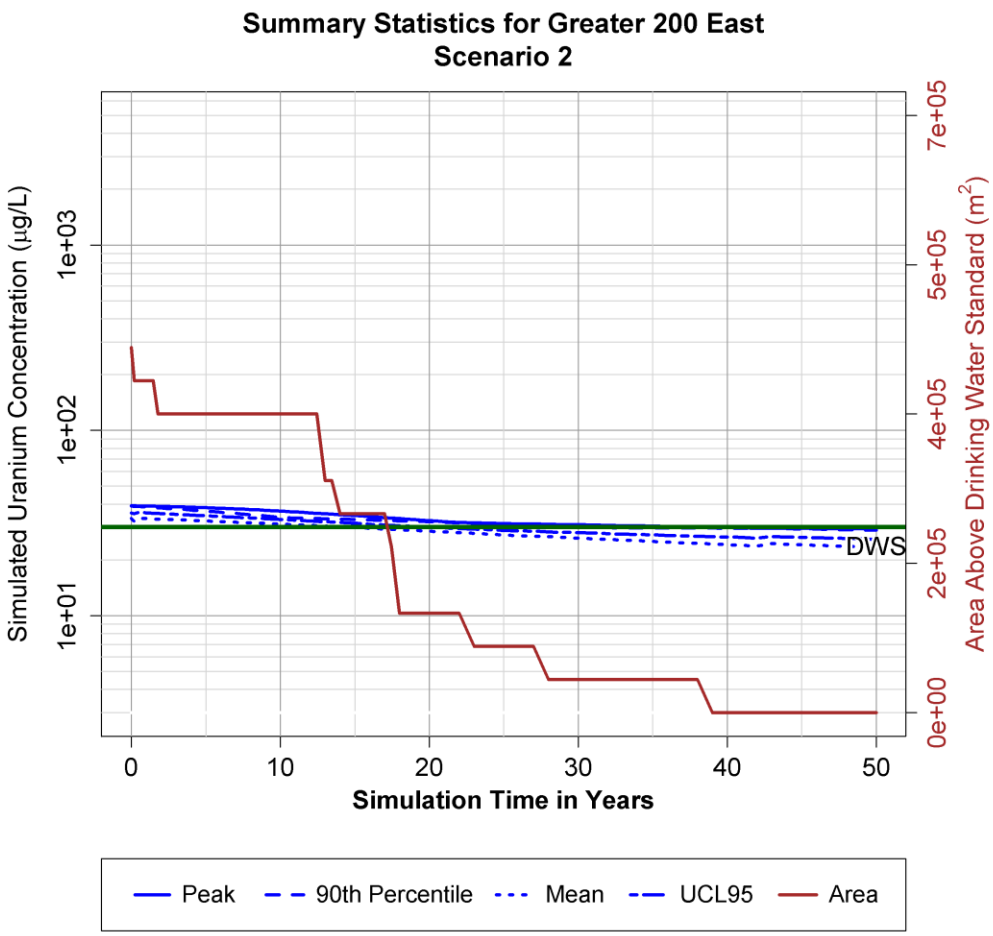

Figure B-111 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

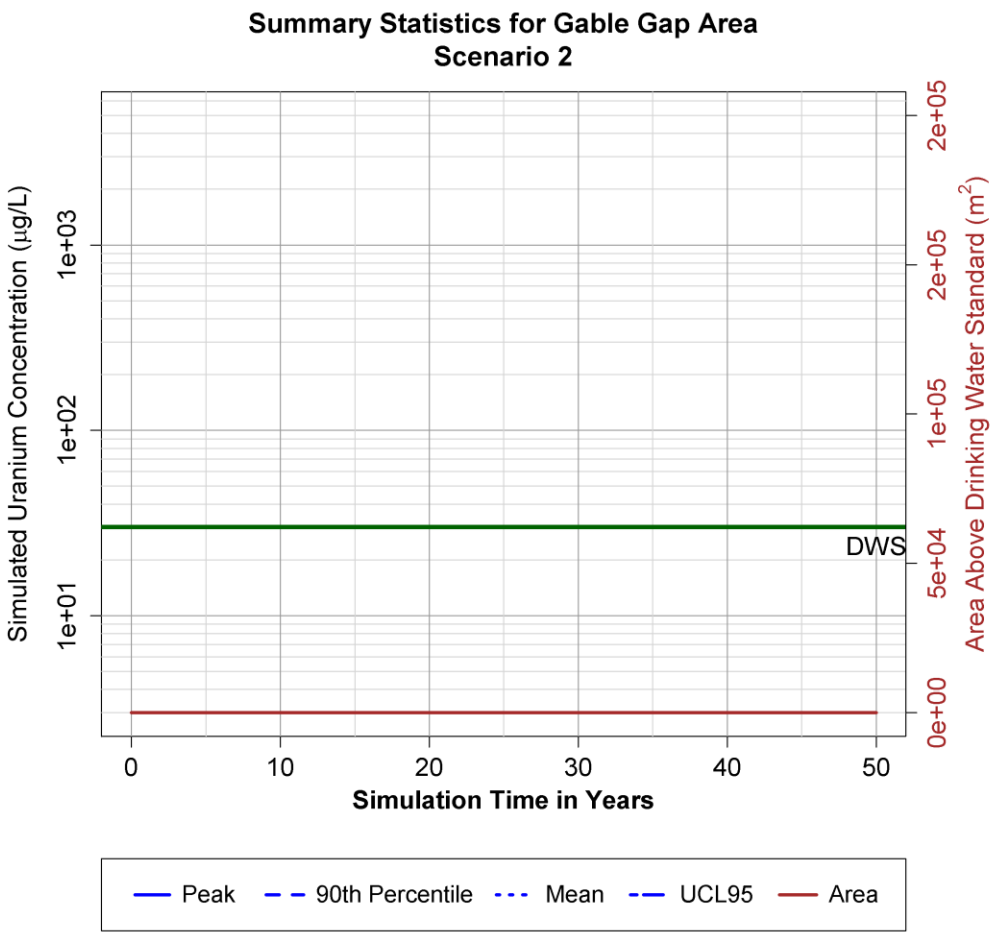

Figure B-112 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 2 simulation with a continuing source term.

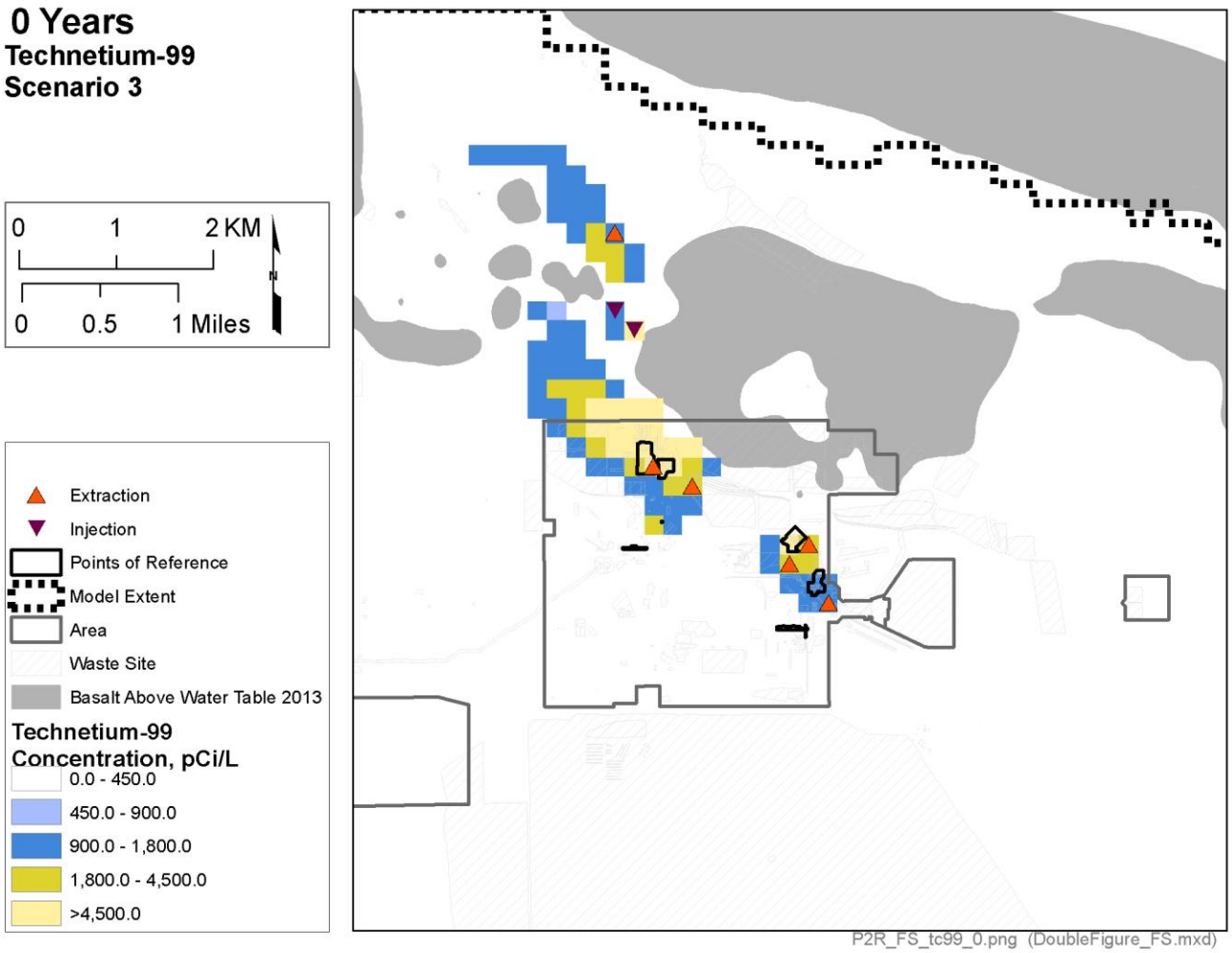

Figure B-113 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 3 simulation.

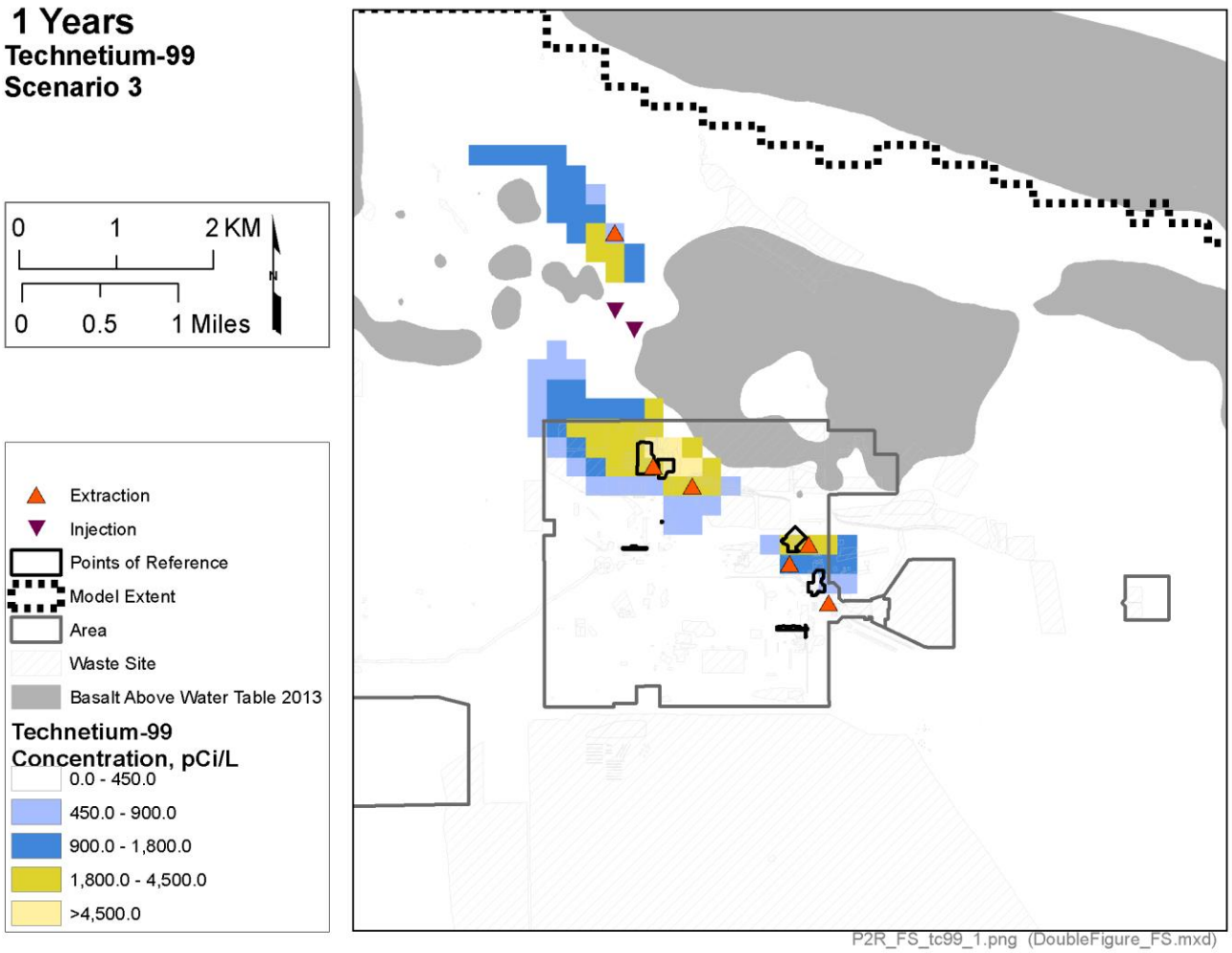

Figure B-114 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 3 simulation.

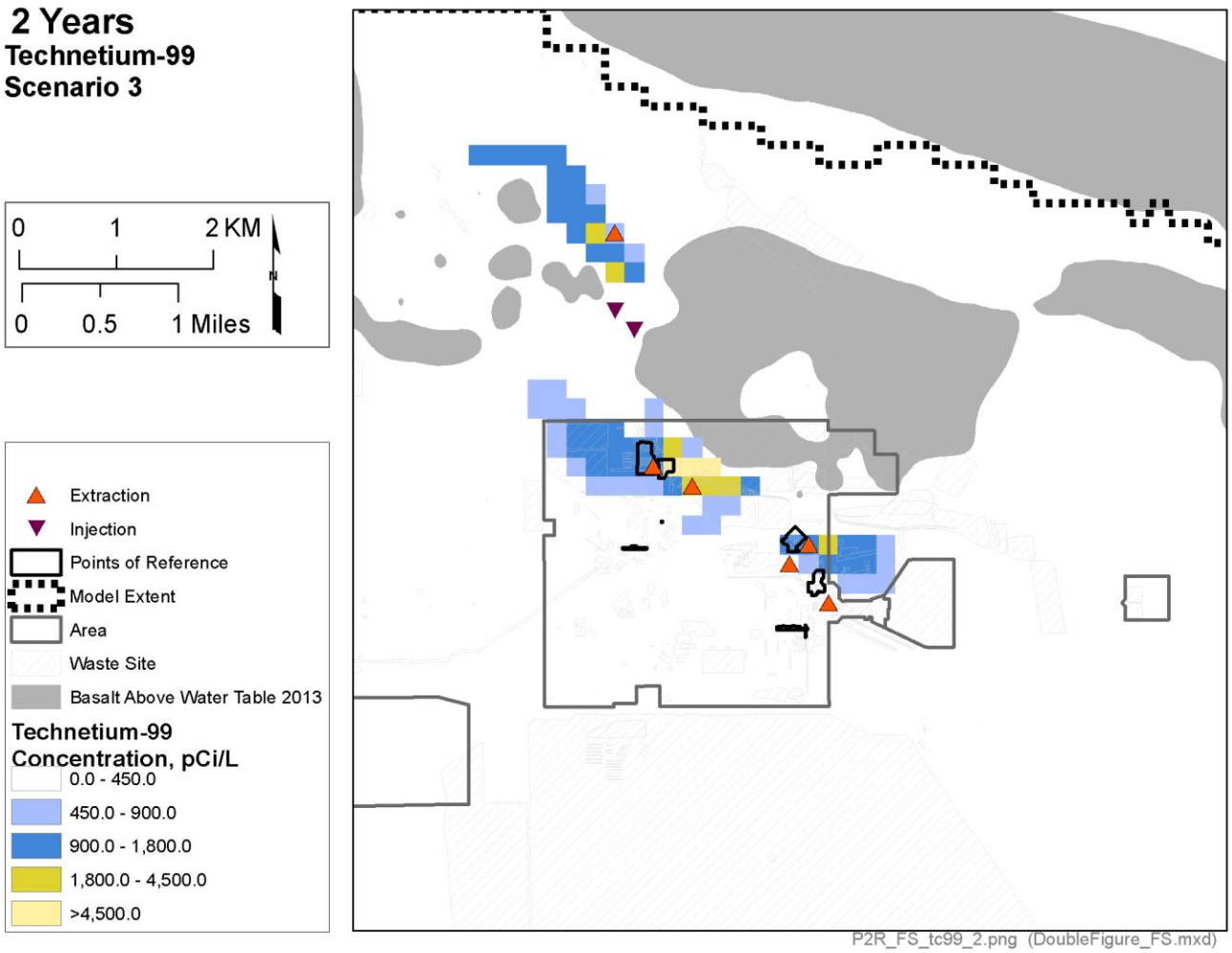

Figure B-115 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 3 simulation.

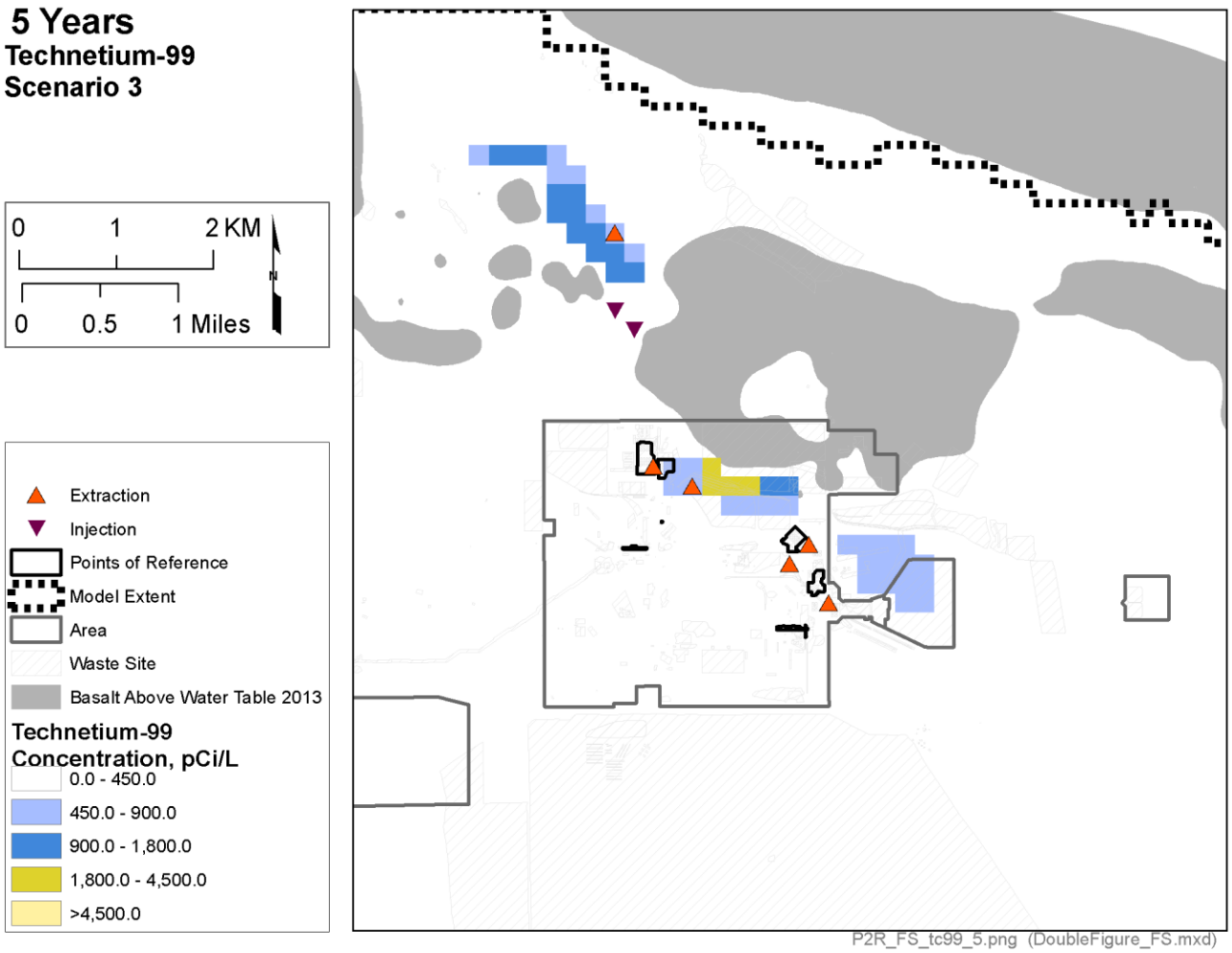

Figure B-116 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 3 simulation.

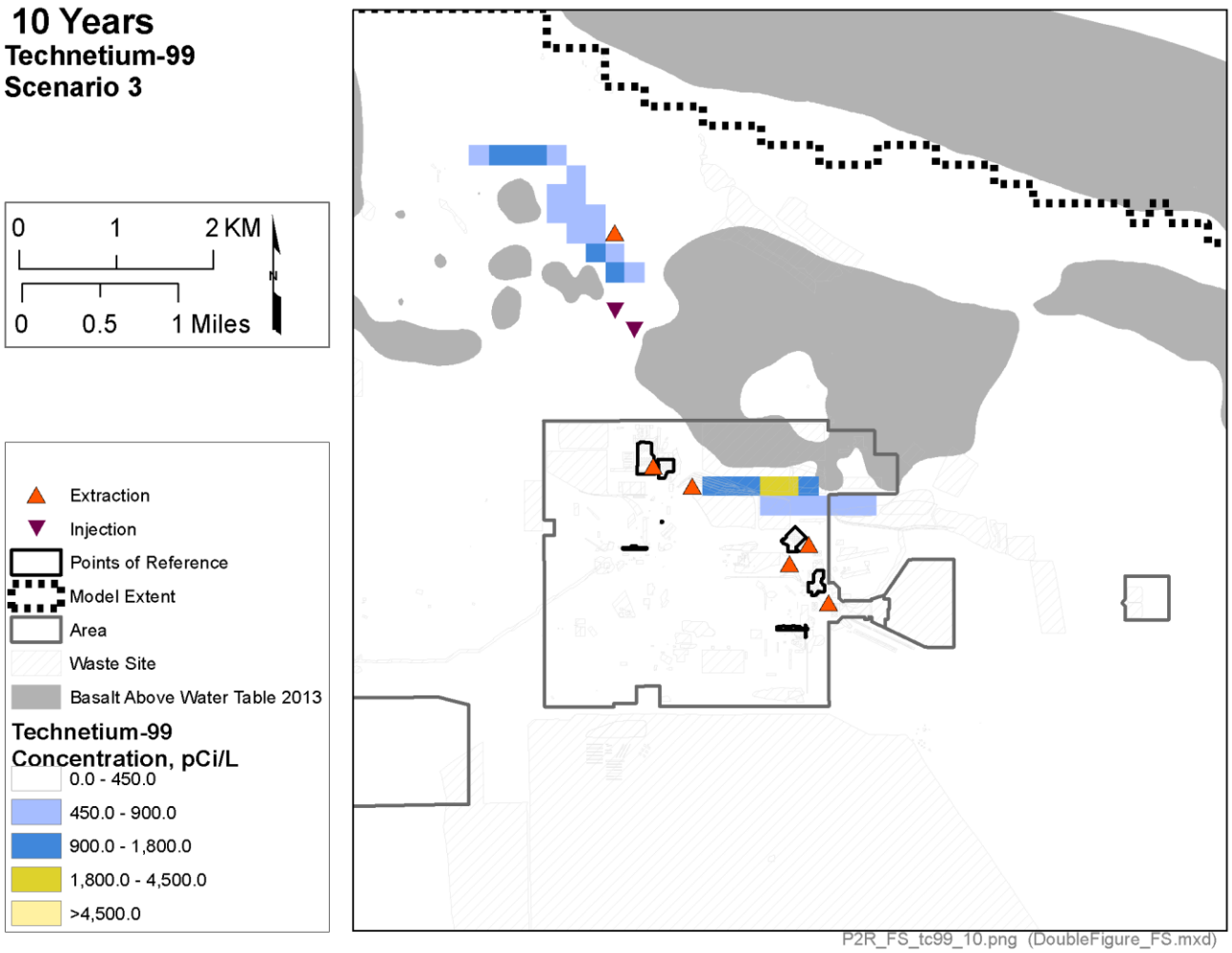

Figure B-117 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 3 simulation.

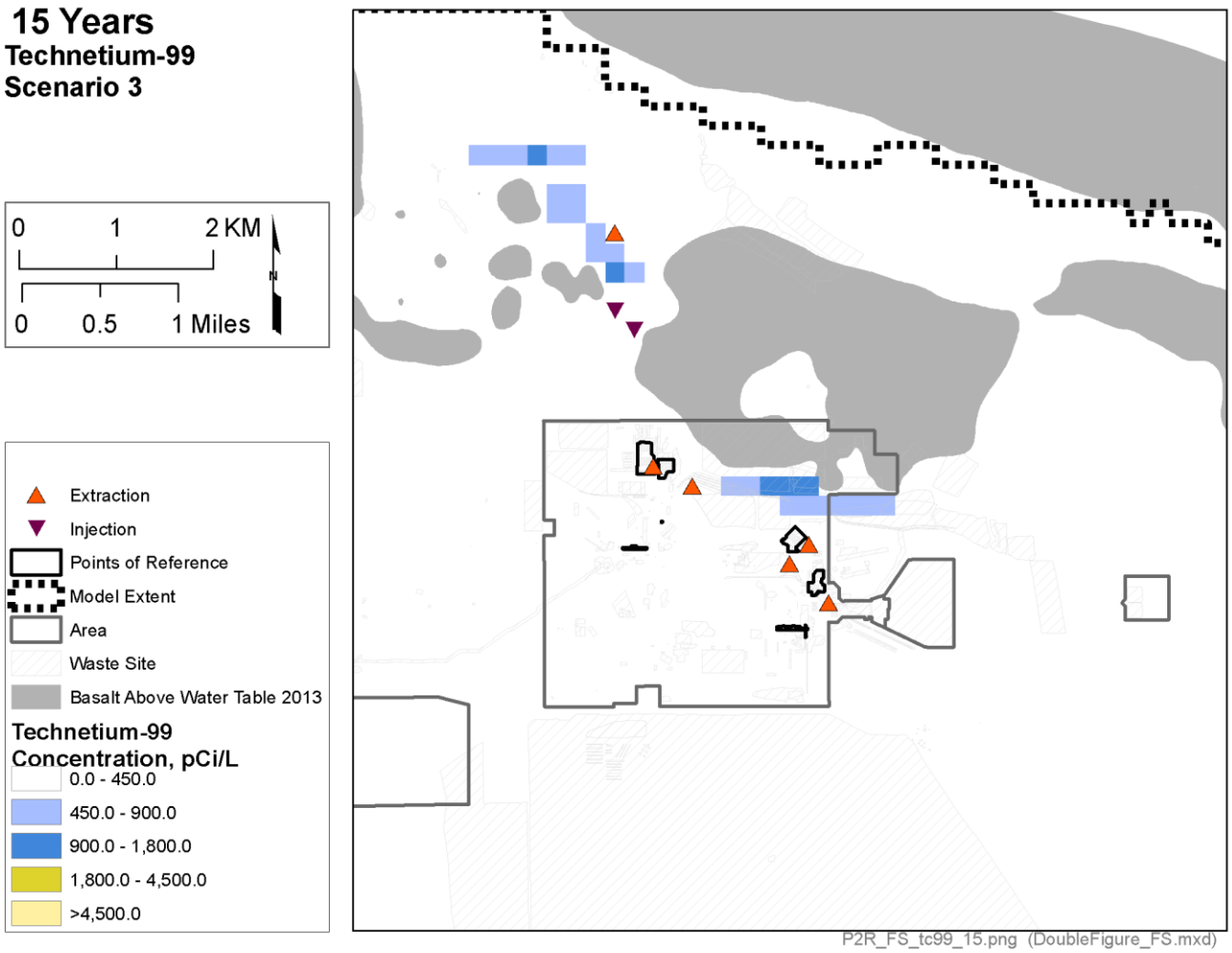

Figure B-118 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 3 simulation.

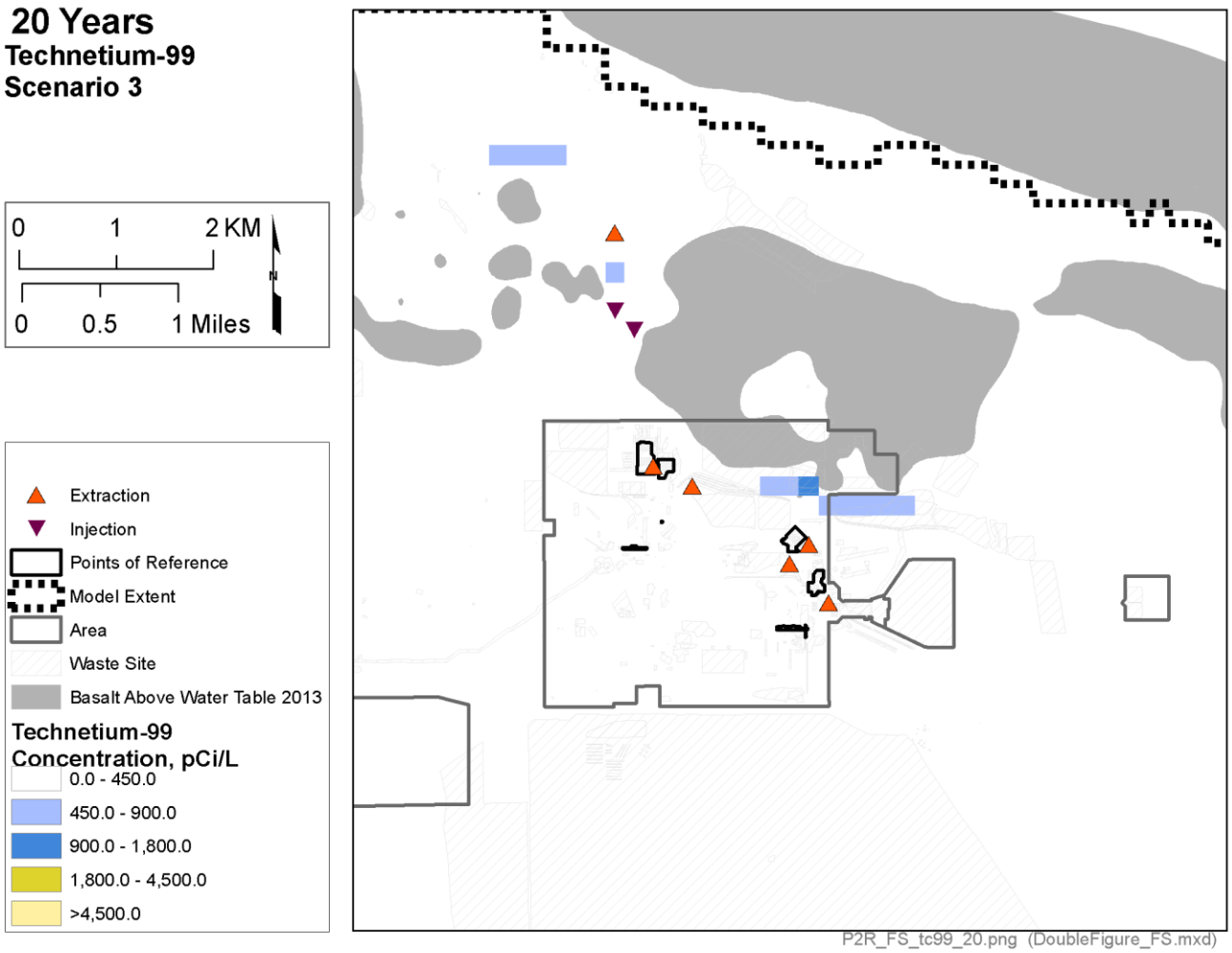

Figure B-119 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 3 simulation.

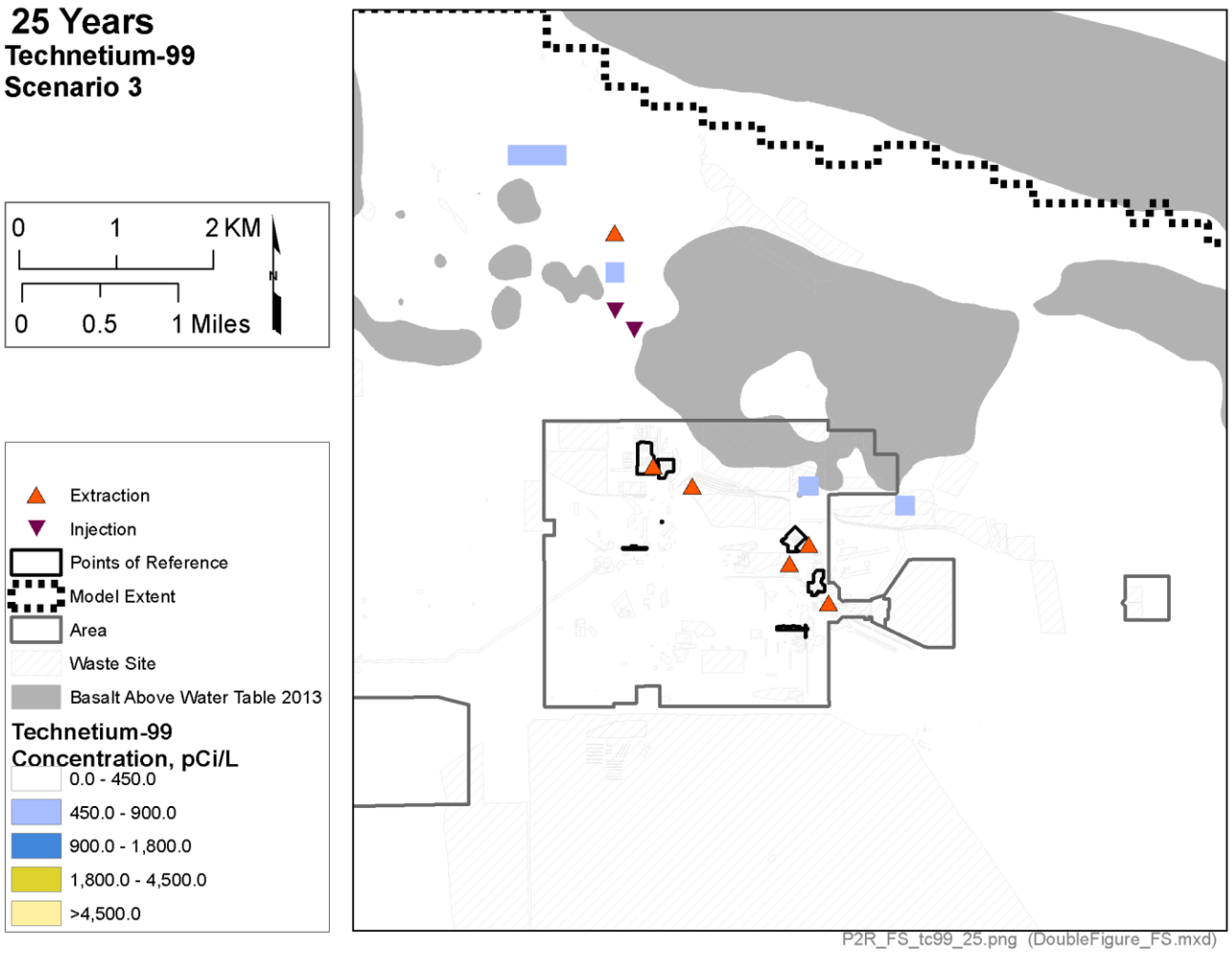

Figure B-120 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 3 simulation.

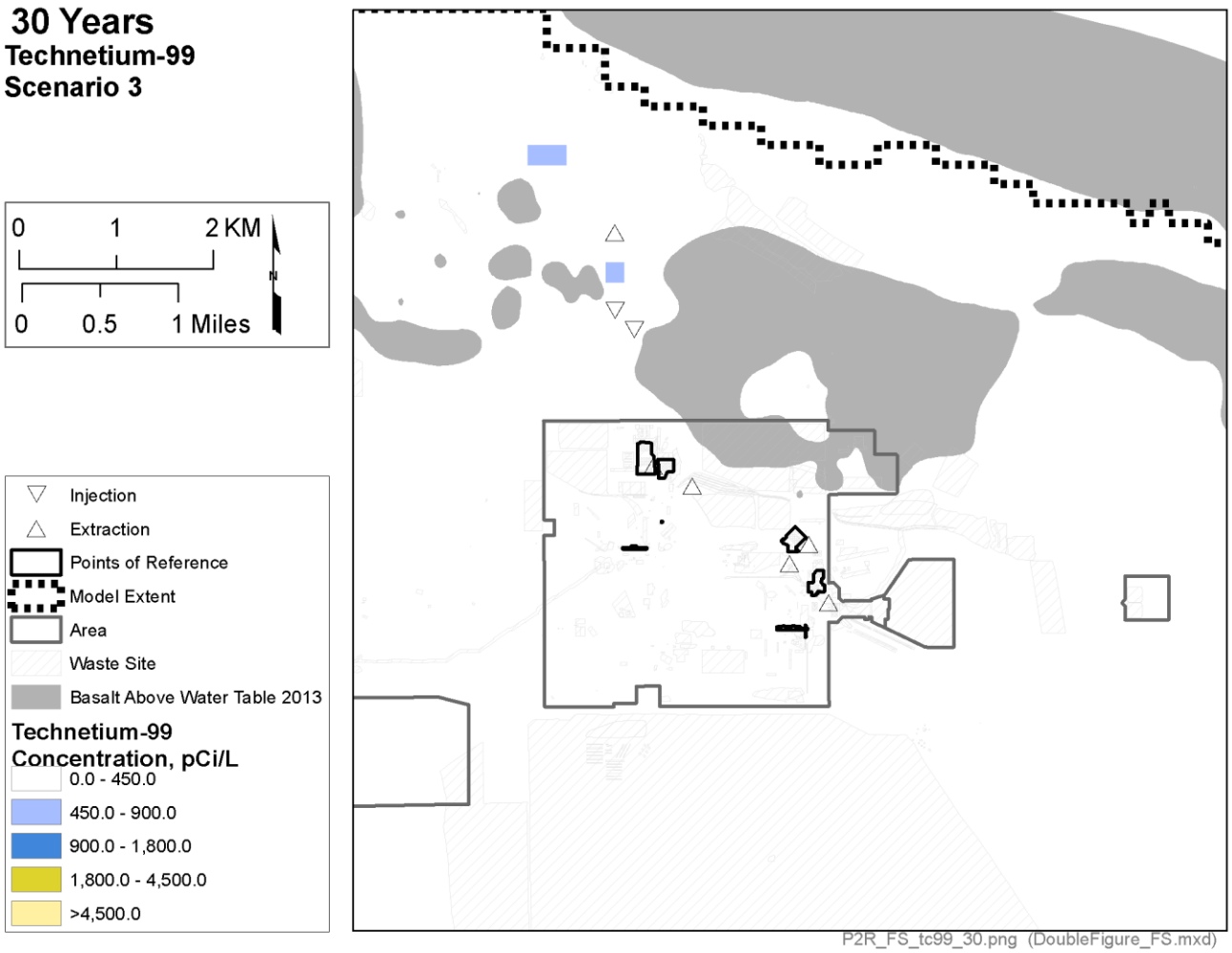

Figure B-121 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 3 simulation.

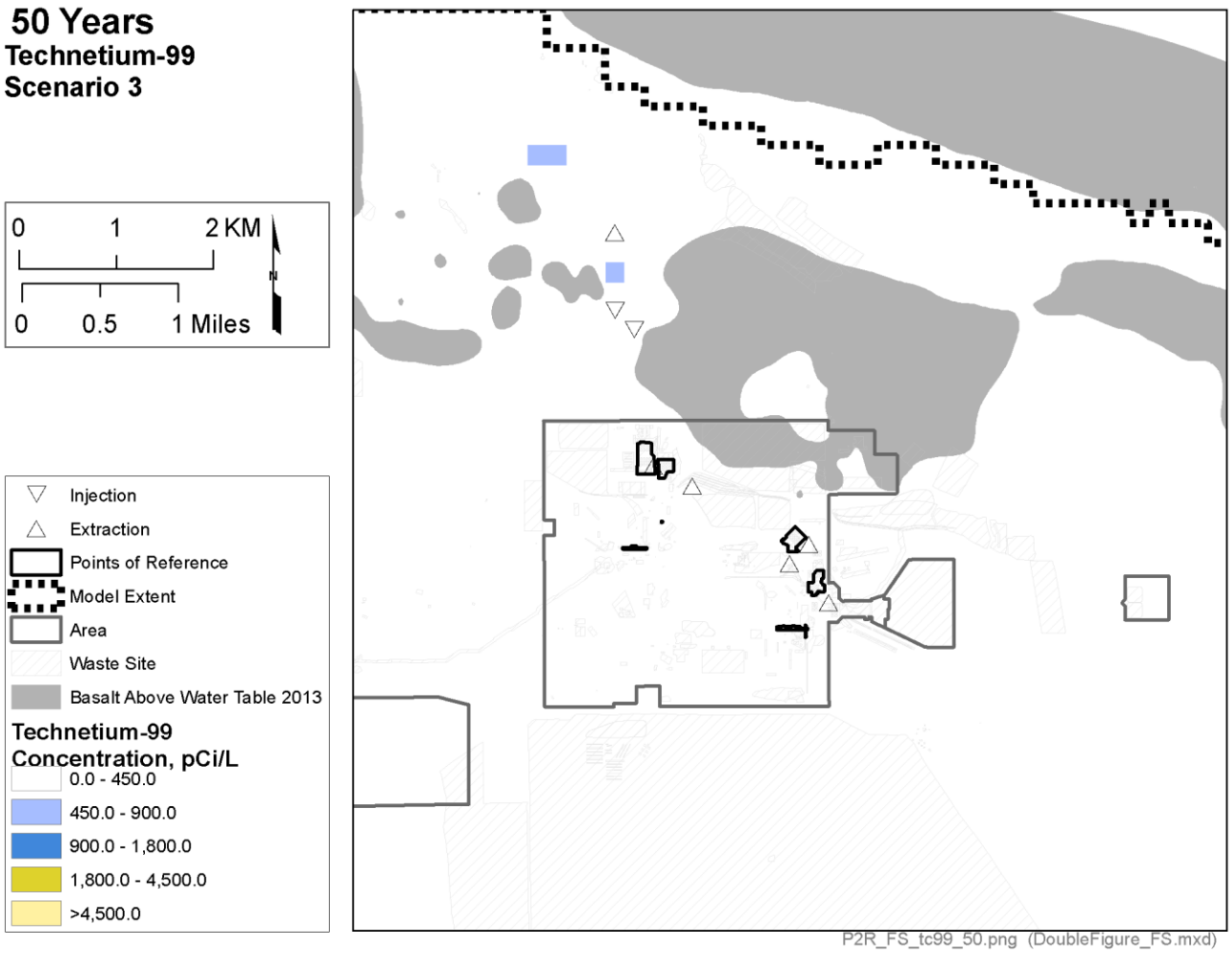

Figure B-122 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 3 simulation.

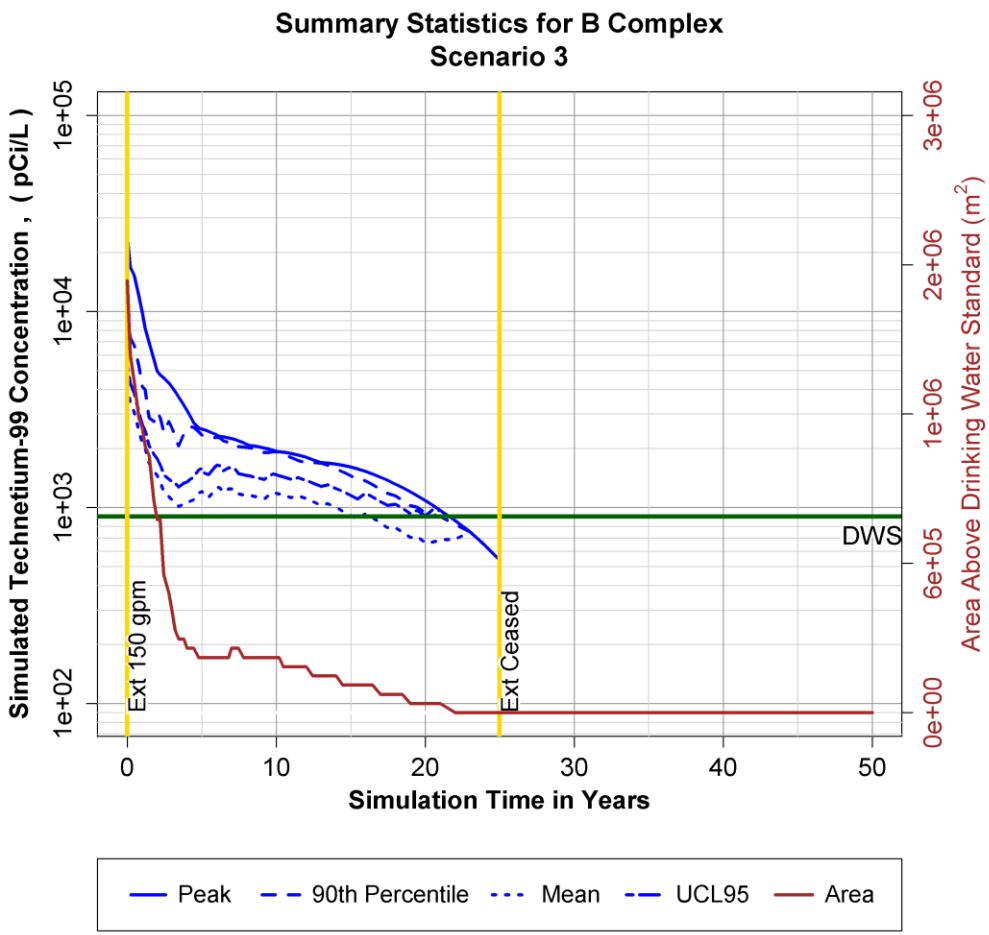

Figure B-123 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

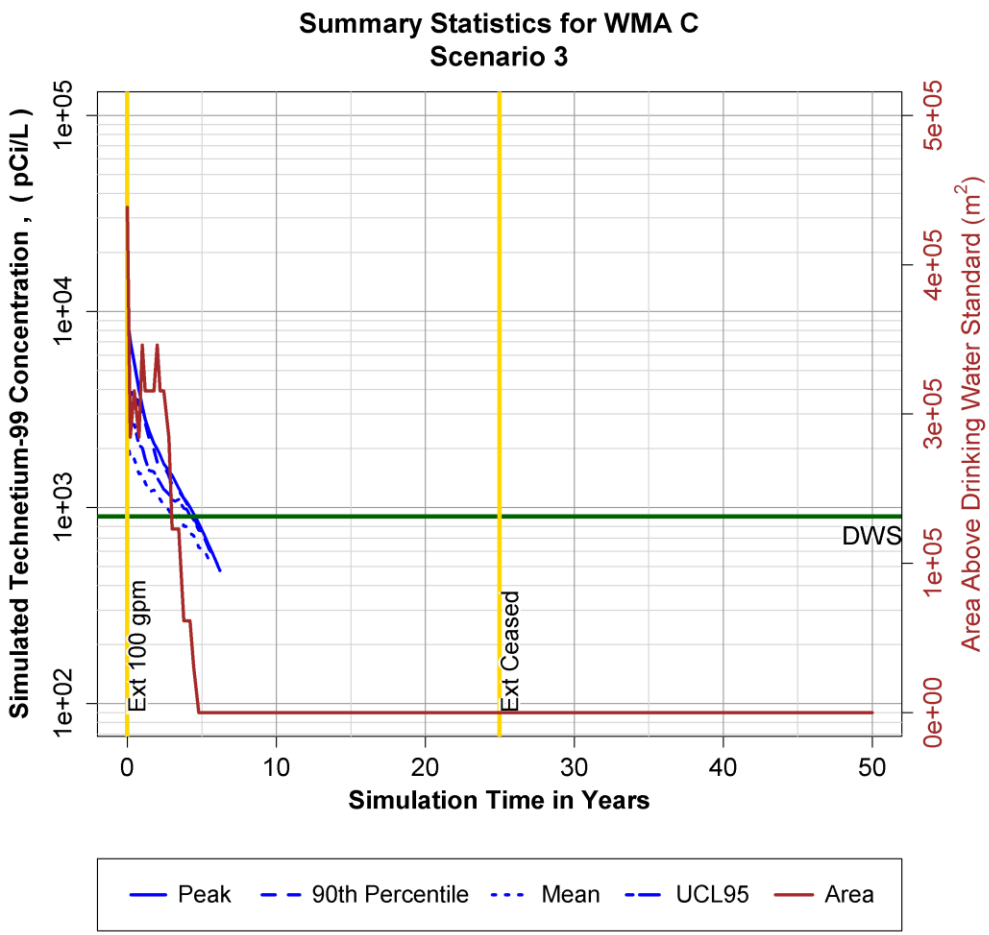

Figure B-124 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

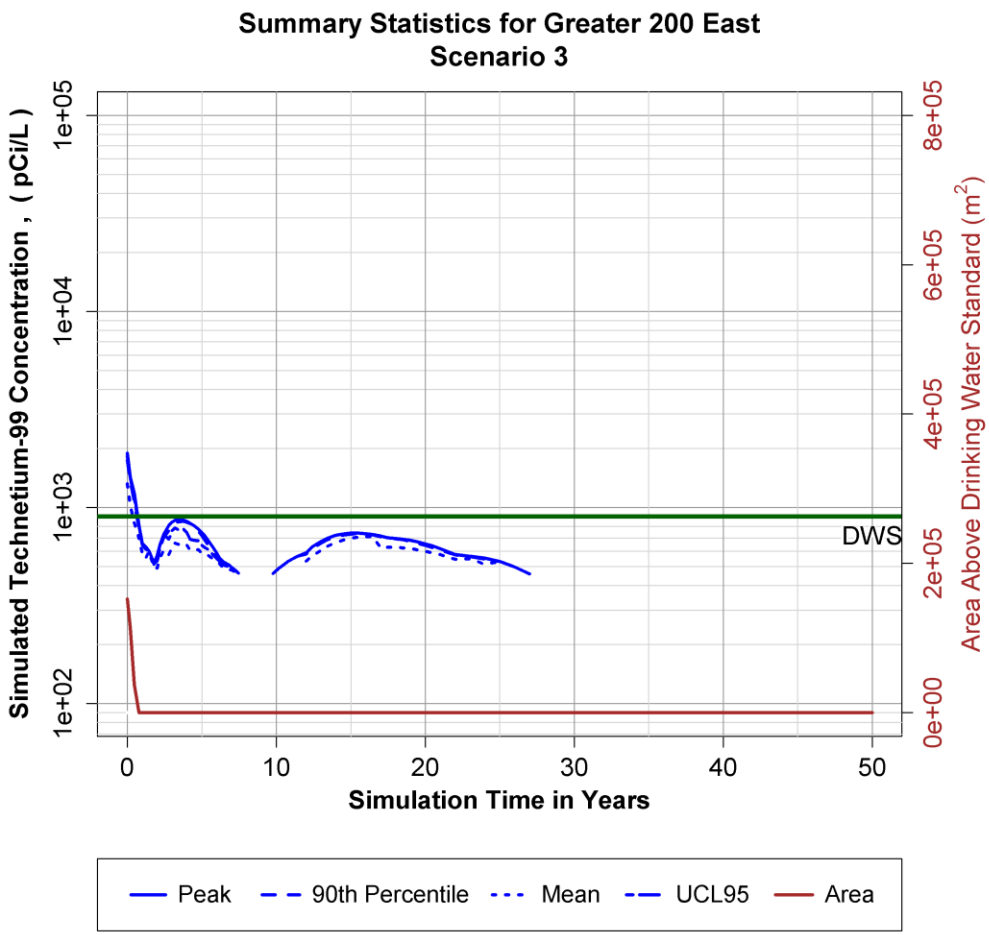

Figure B-125 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

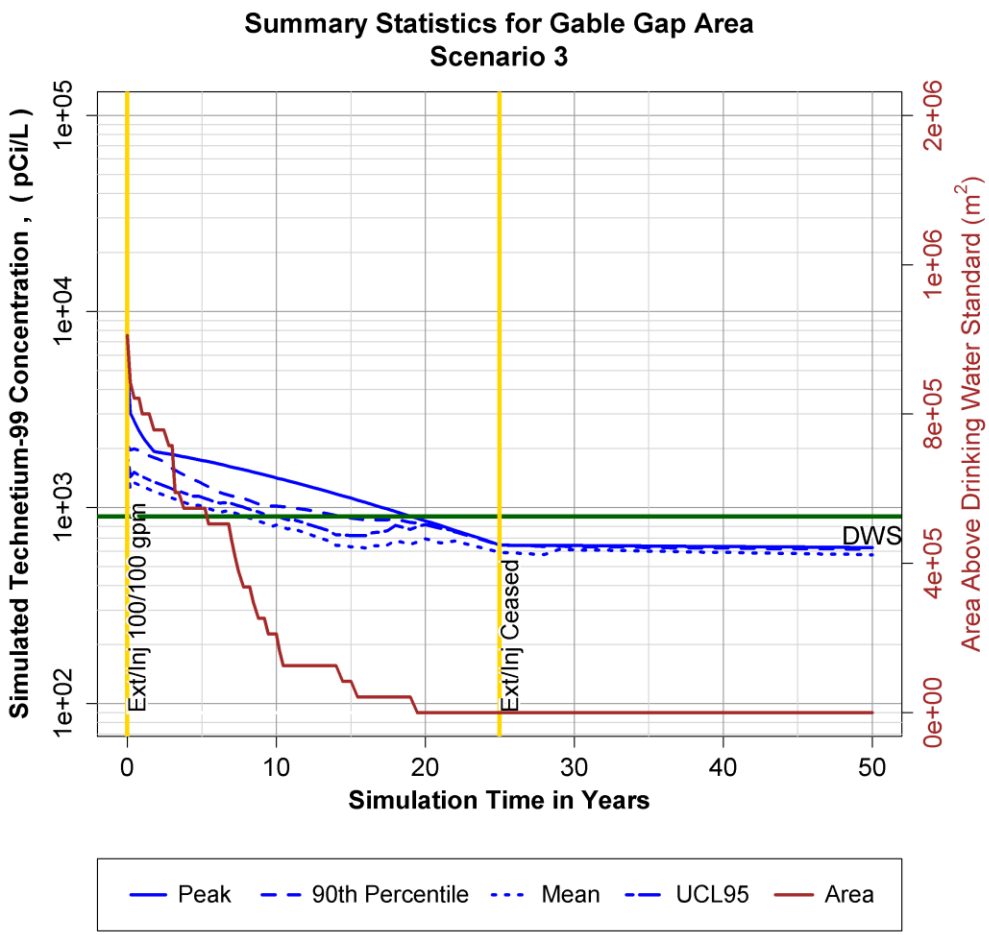

Figure B-126 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation.

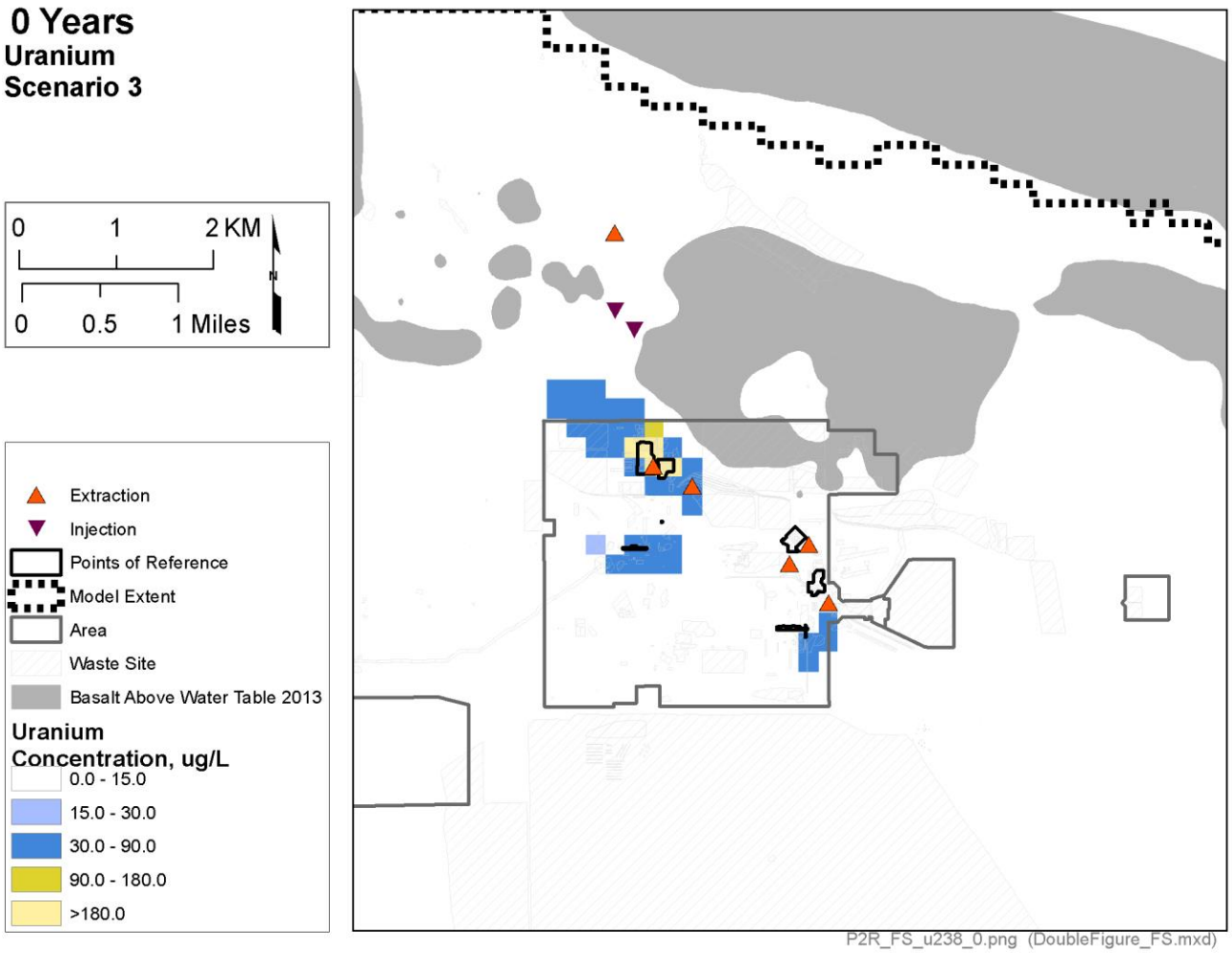

Figure B-127 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 3 simulation.

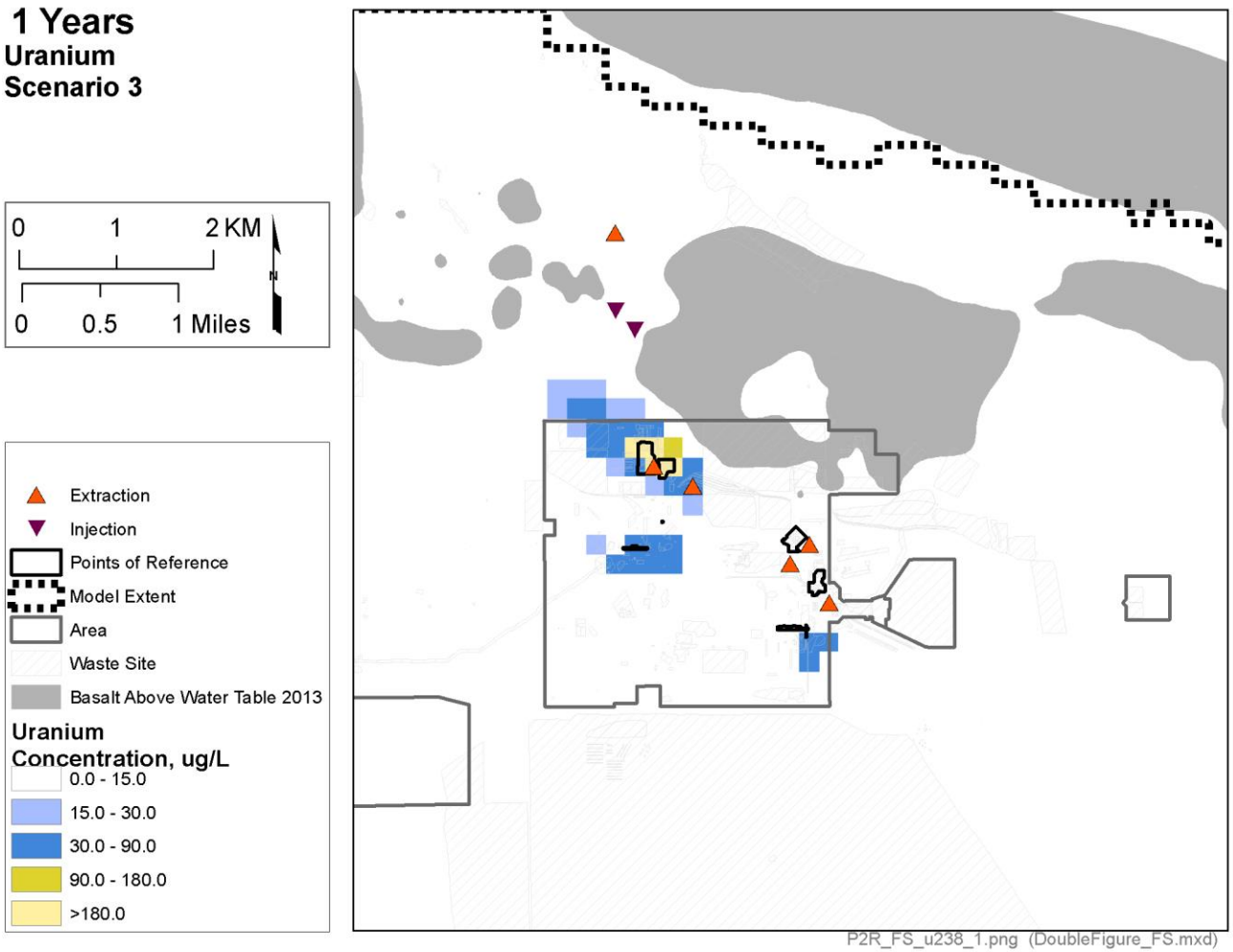

Figure B-128 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 3 simulation.

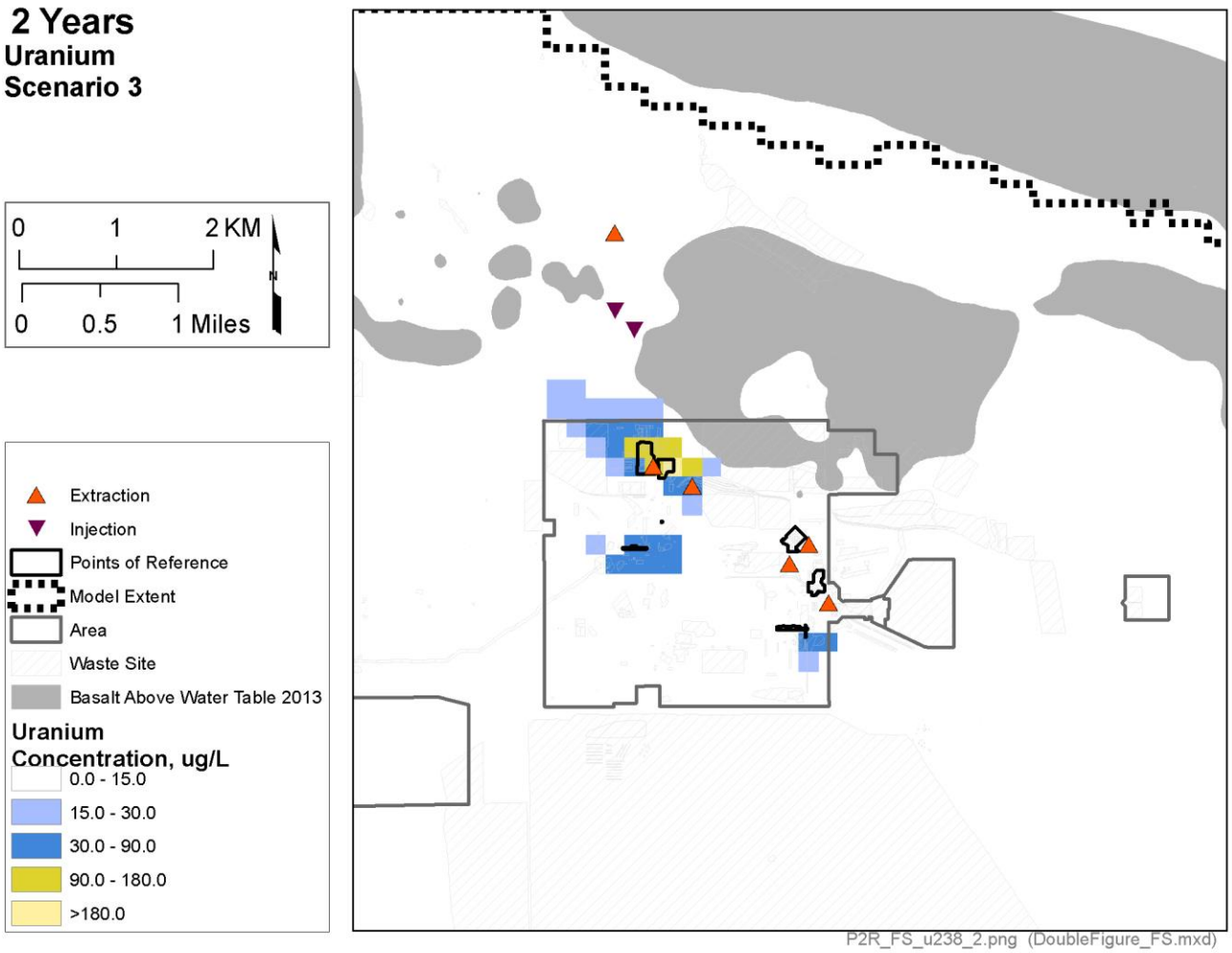

Figure B-129 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 3 simulation.

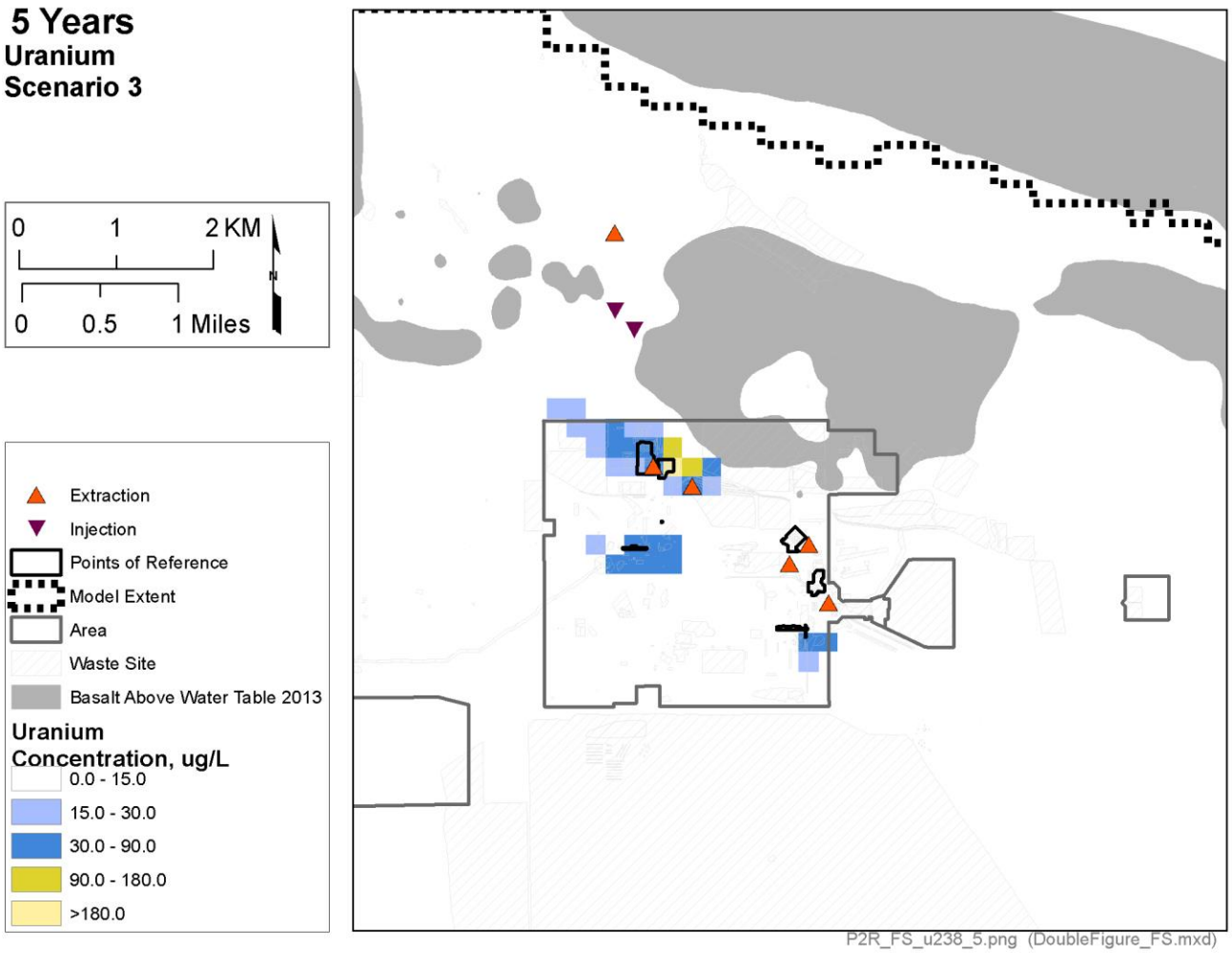

Figure B-130 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 3 simulation.

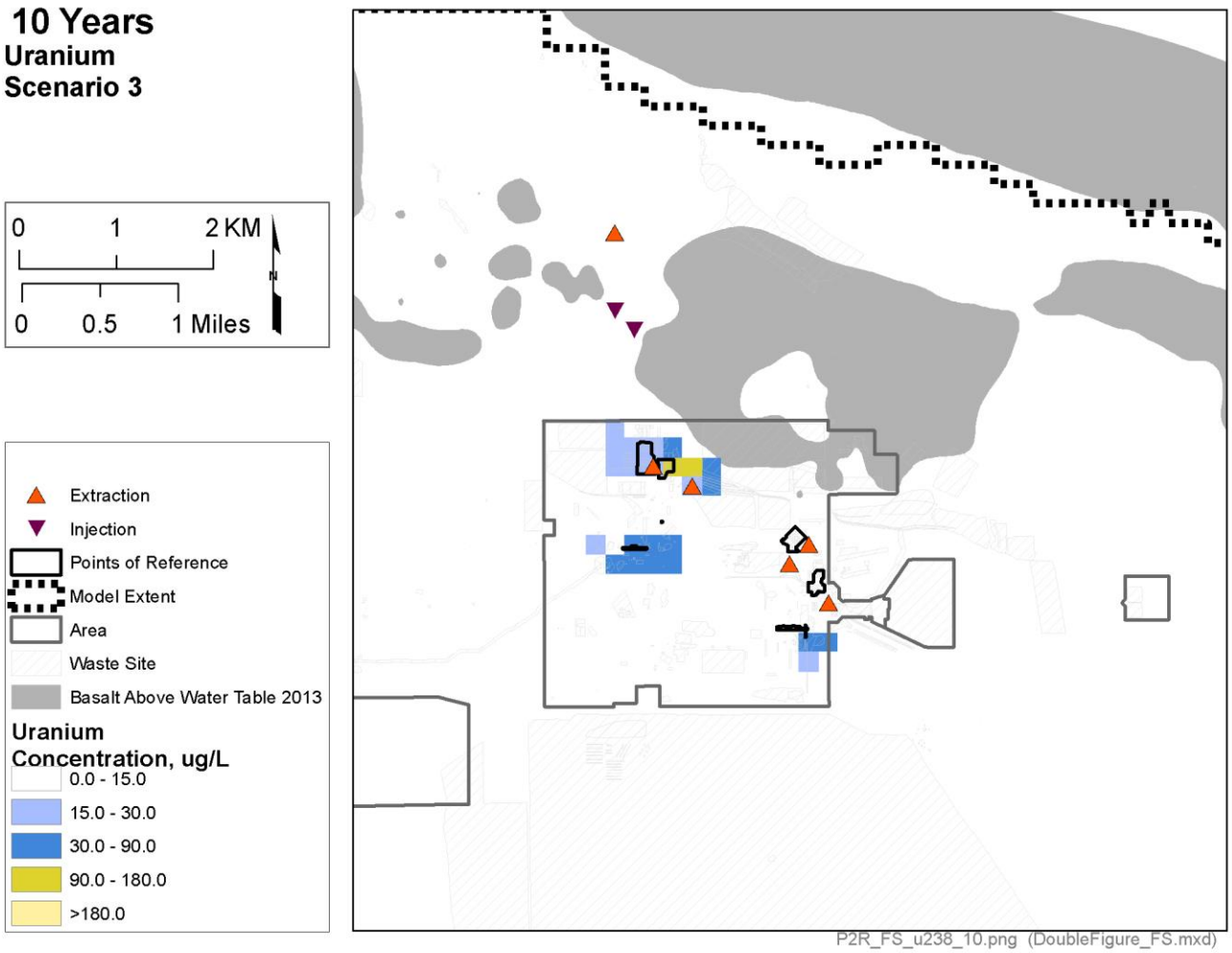

Figure B-131 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 3 simulation.

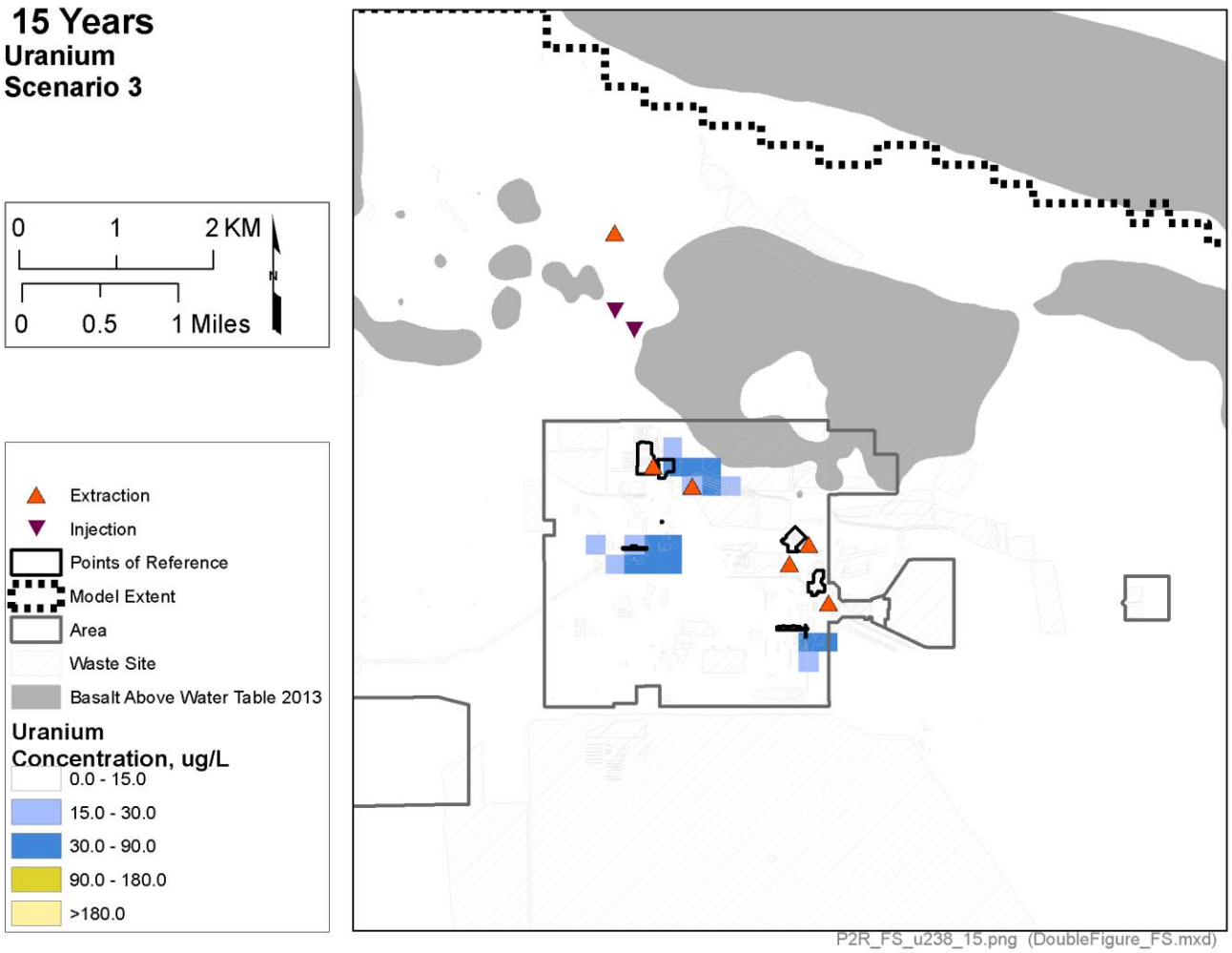

Figure B-132 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 3 simulation.

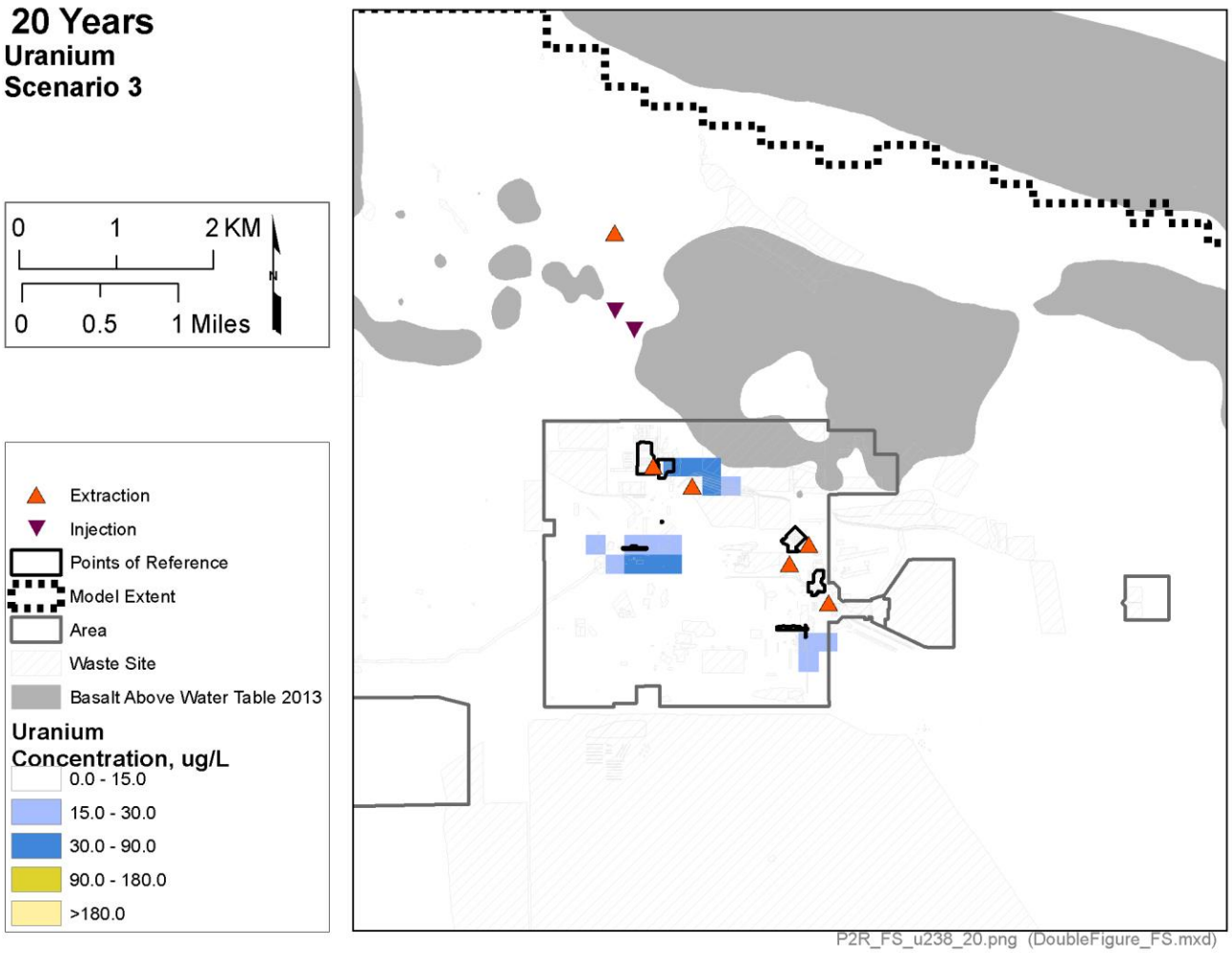

Figure B-133 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 3 simulation.

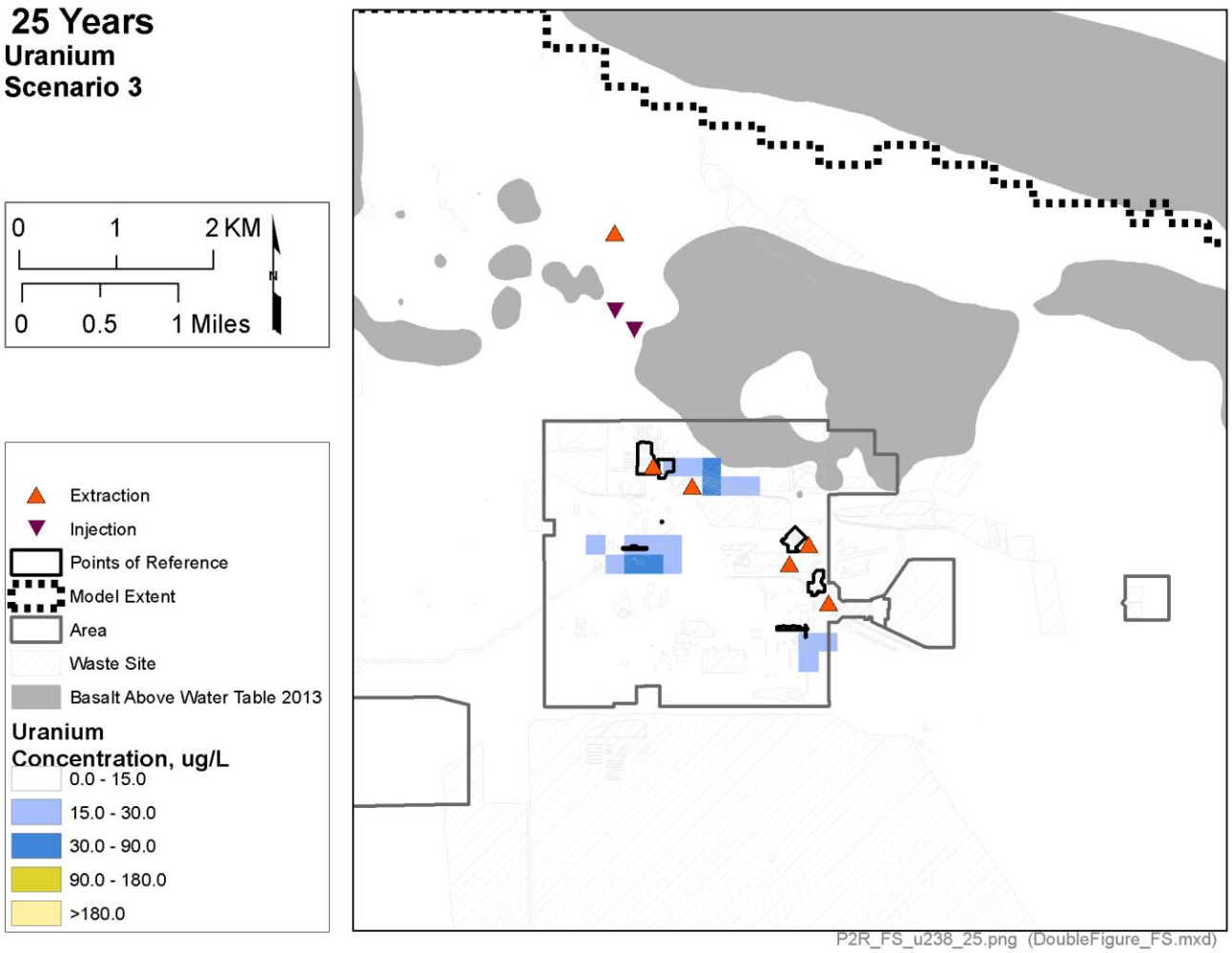

Figure B-134 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 3 simulation.

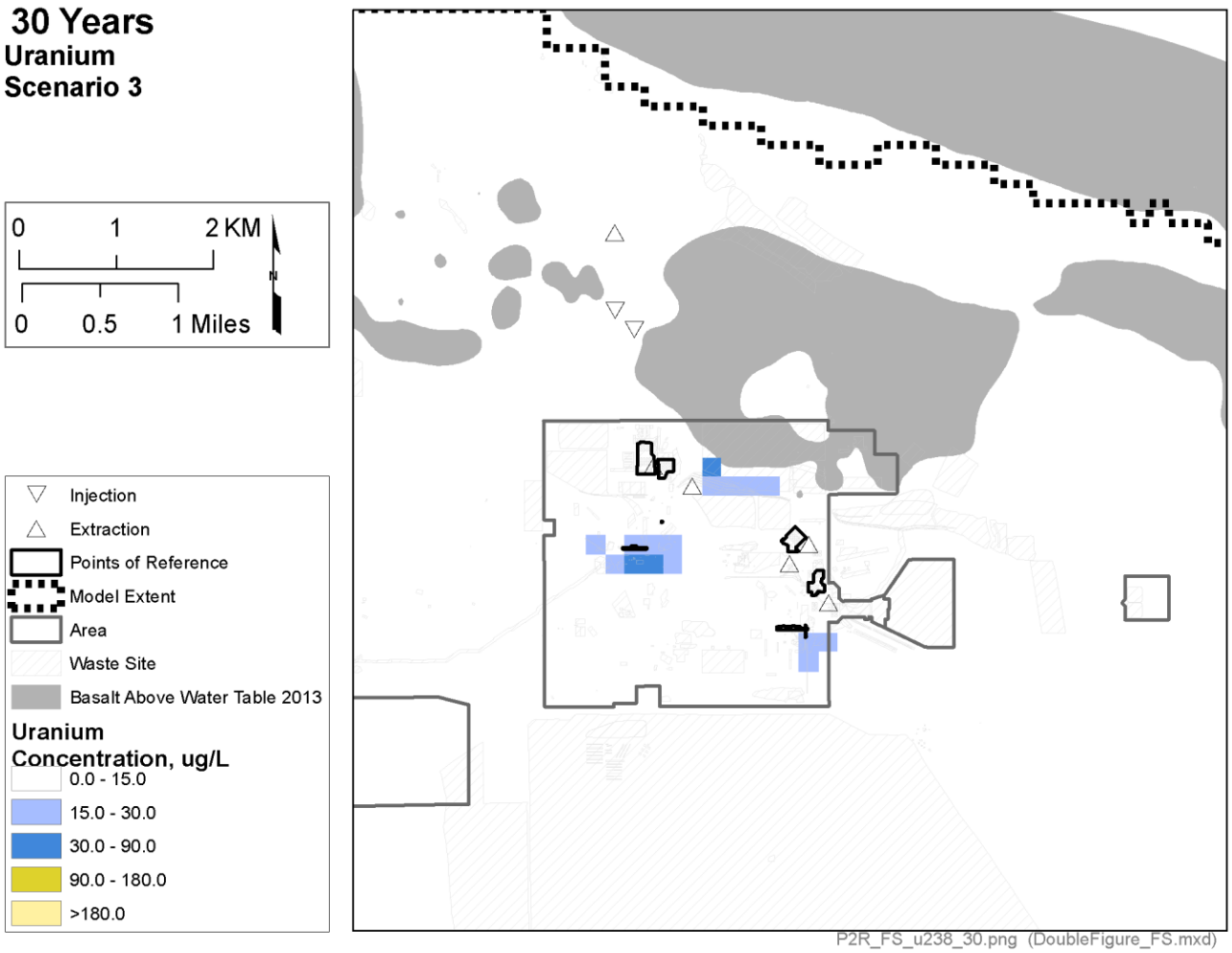

Figure B-135 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 3 simulation.

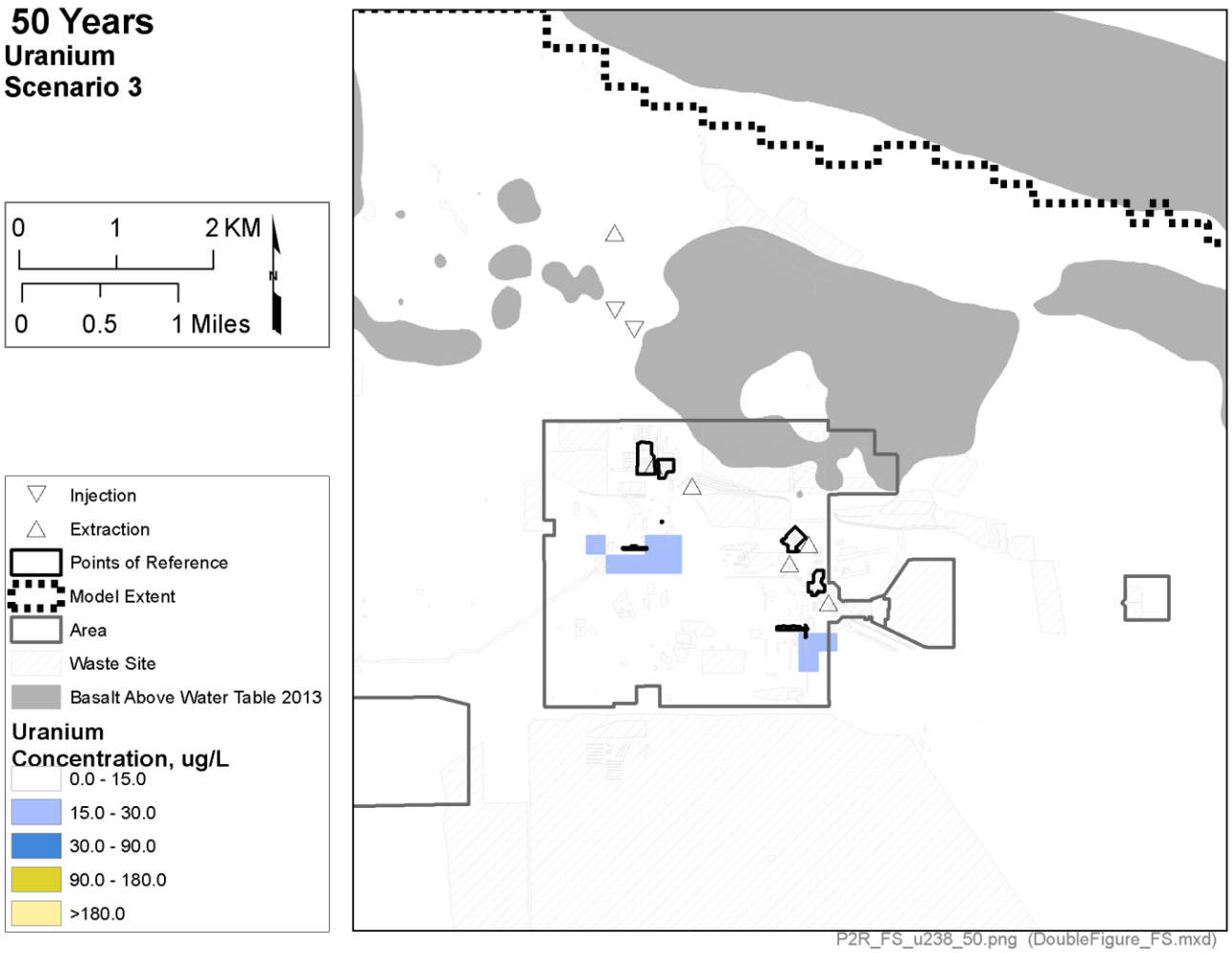

Figure B-136 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 3 simulation.

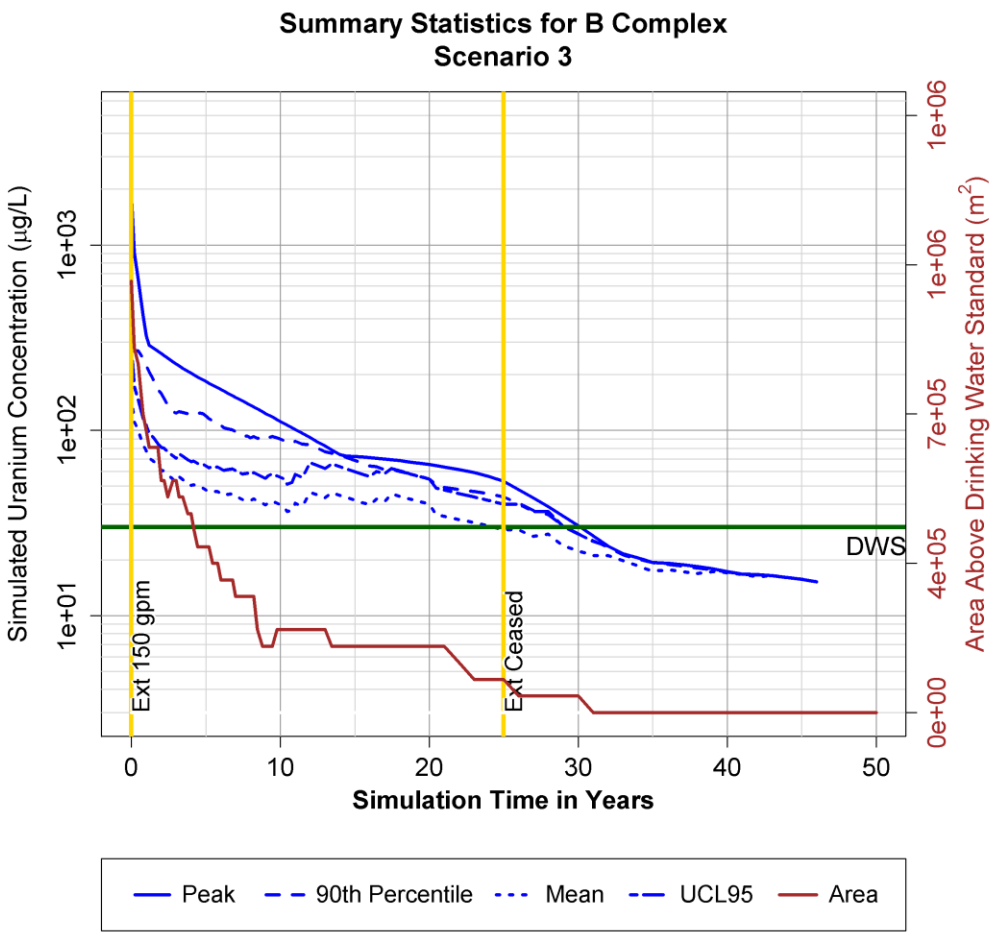

Figure B-137 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

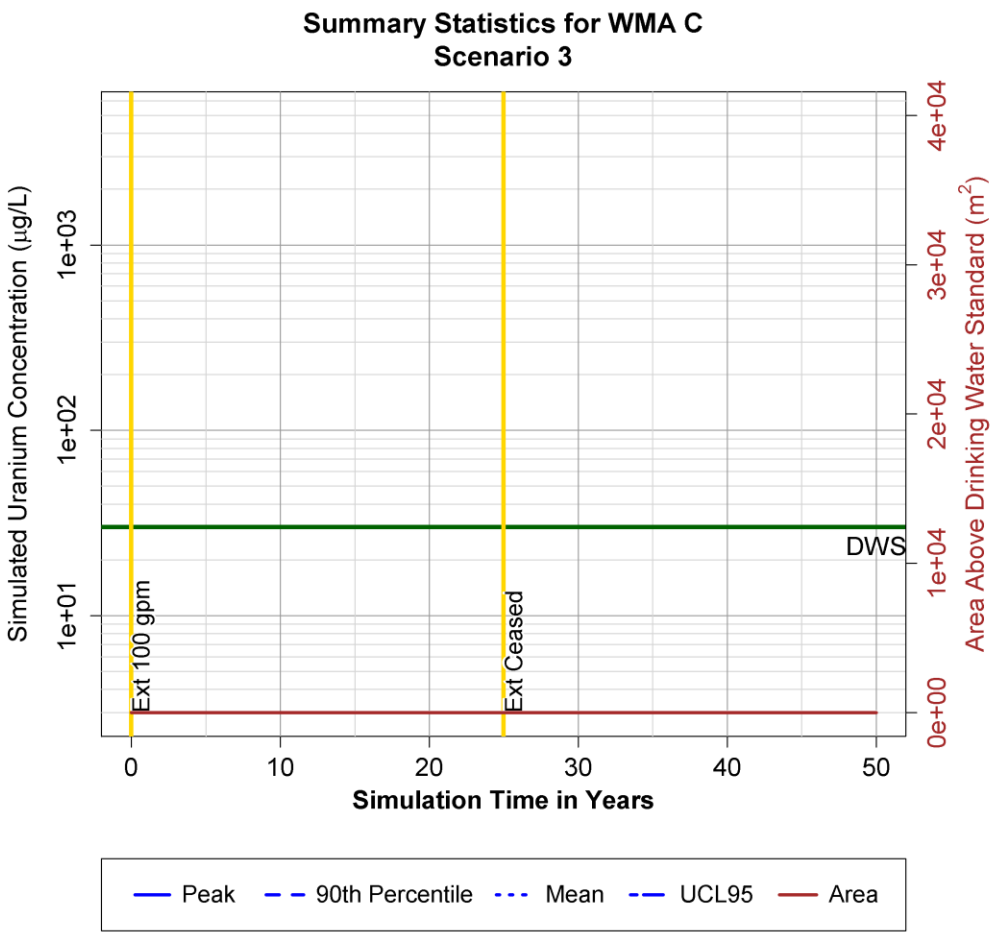

Figure B-138 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

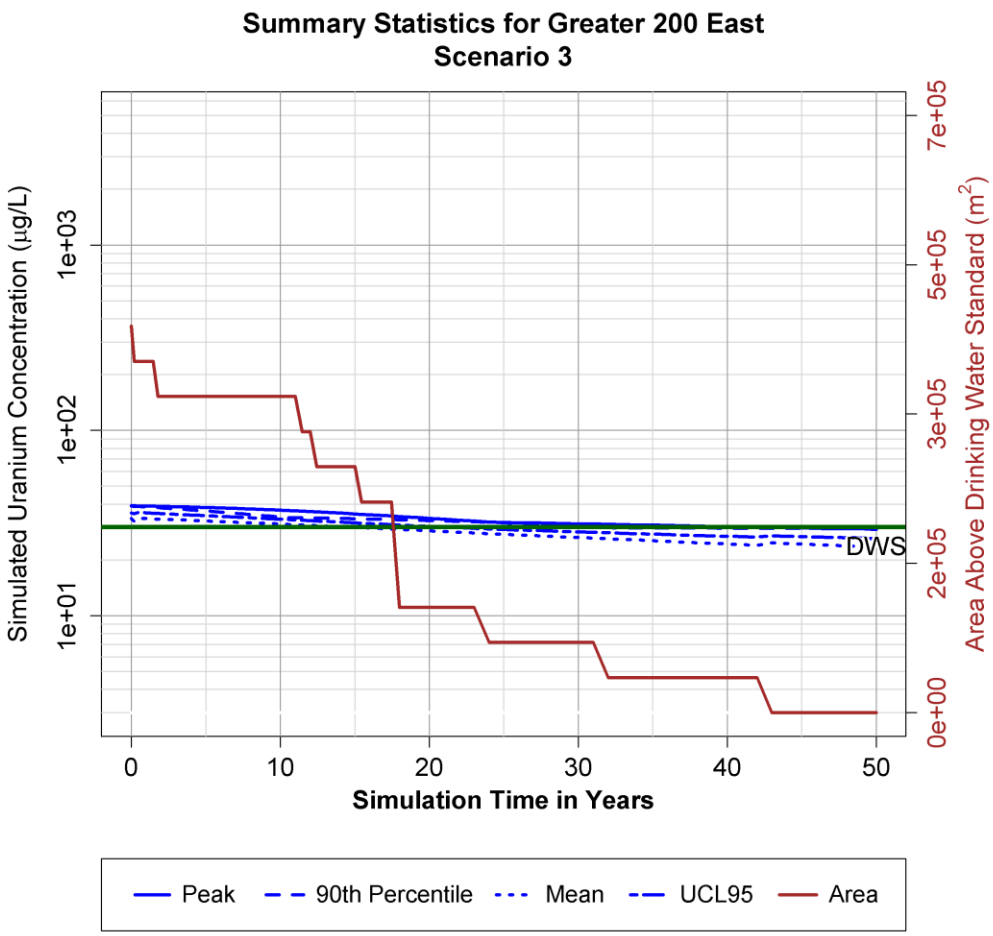

Figure B-139 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

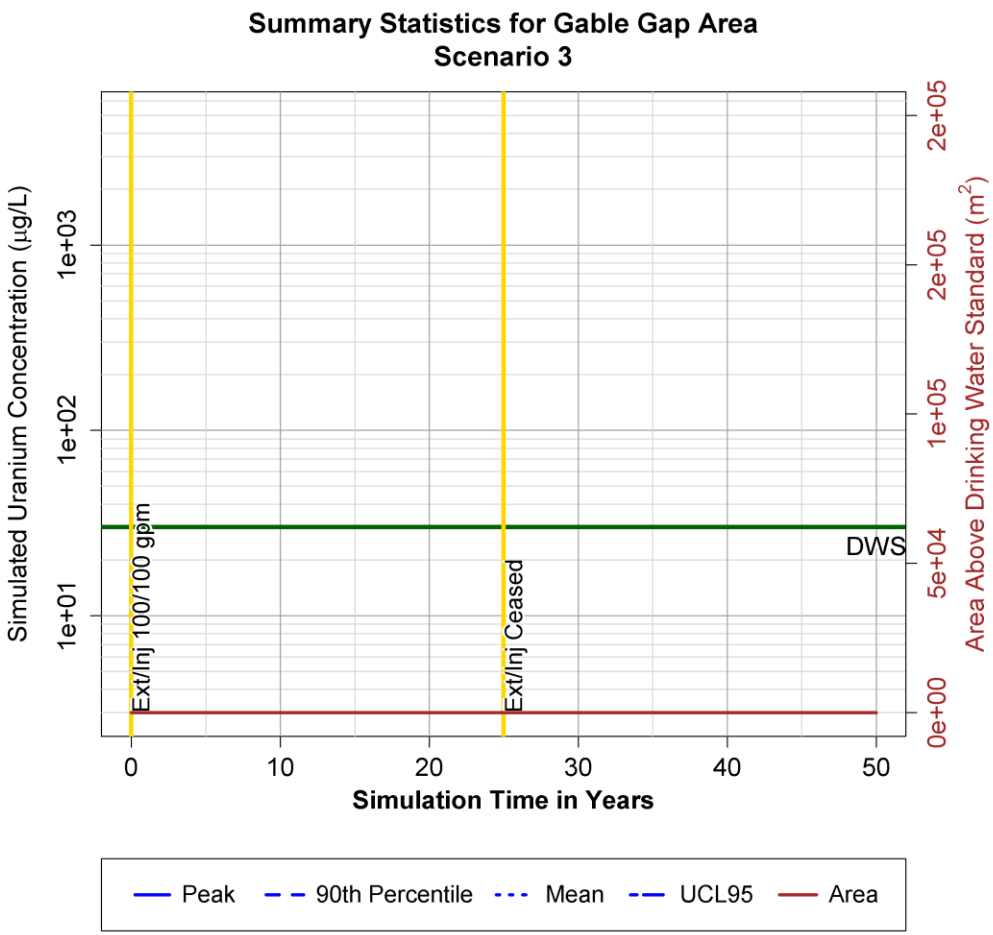

Figure B-140 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation.

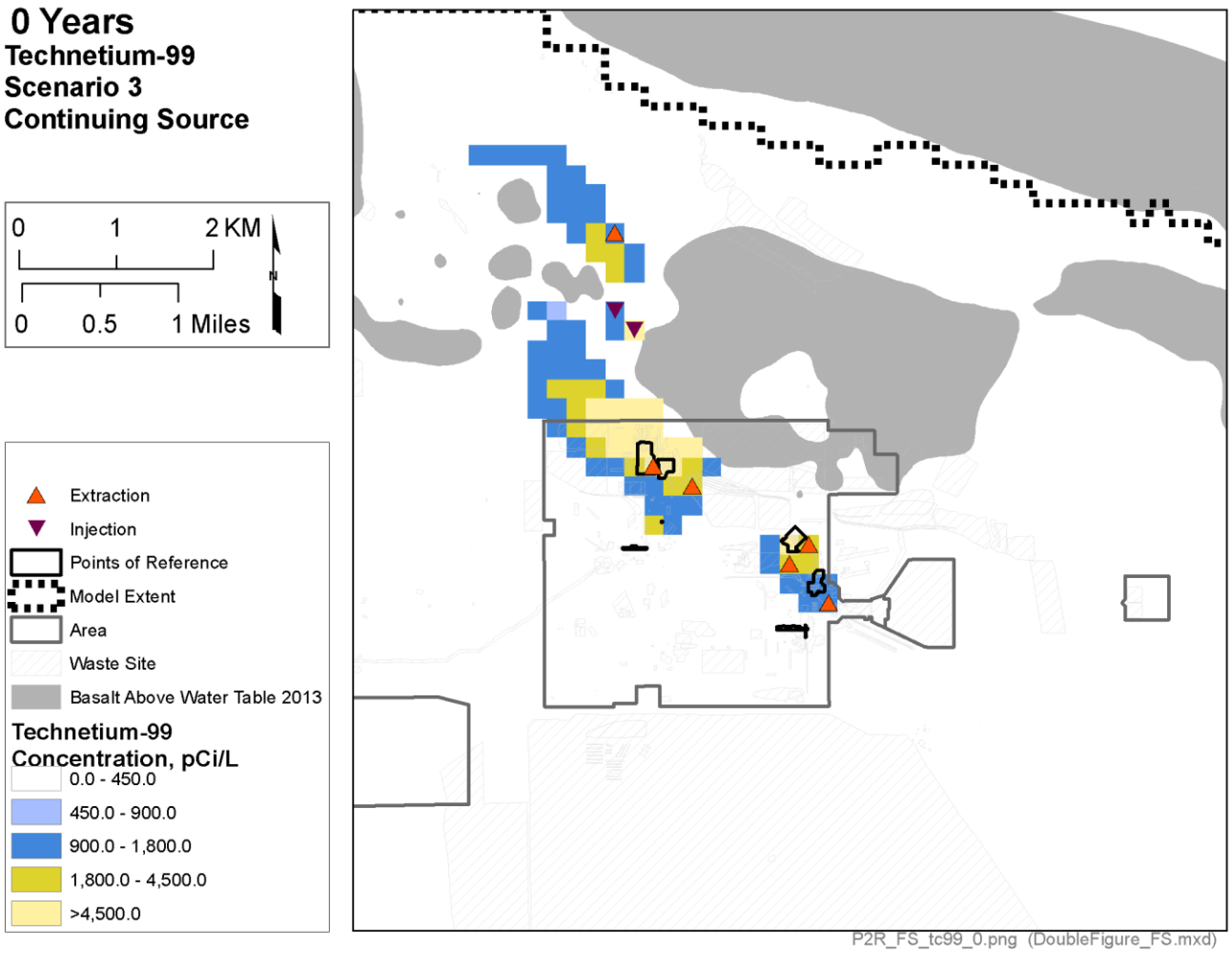

Figure B-141 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 3 simulation with a continuing source term.

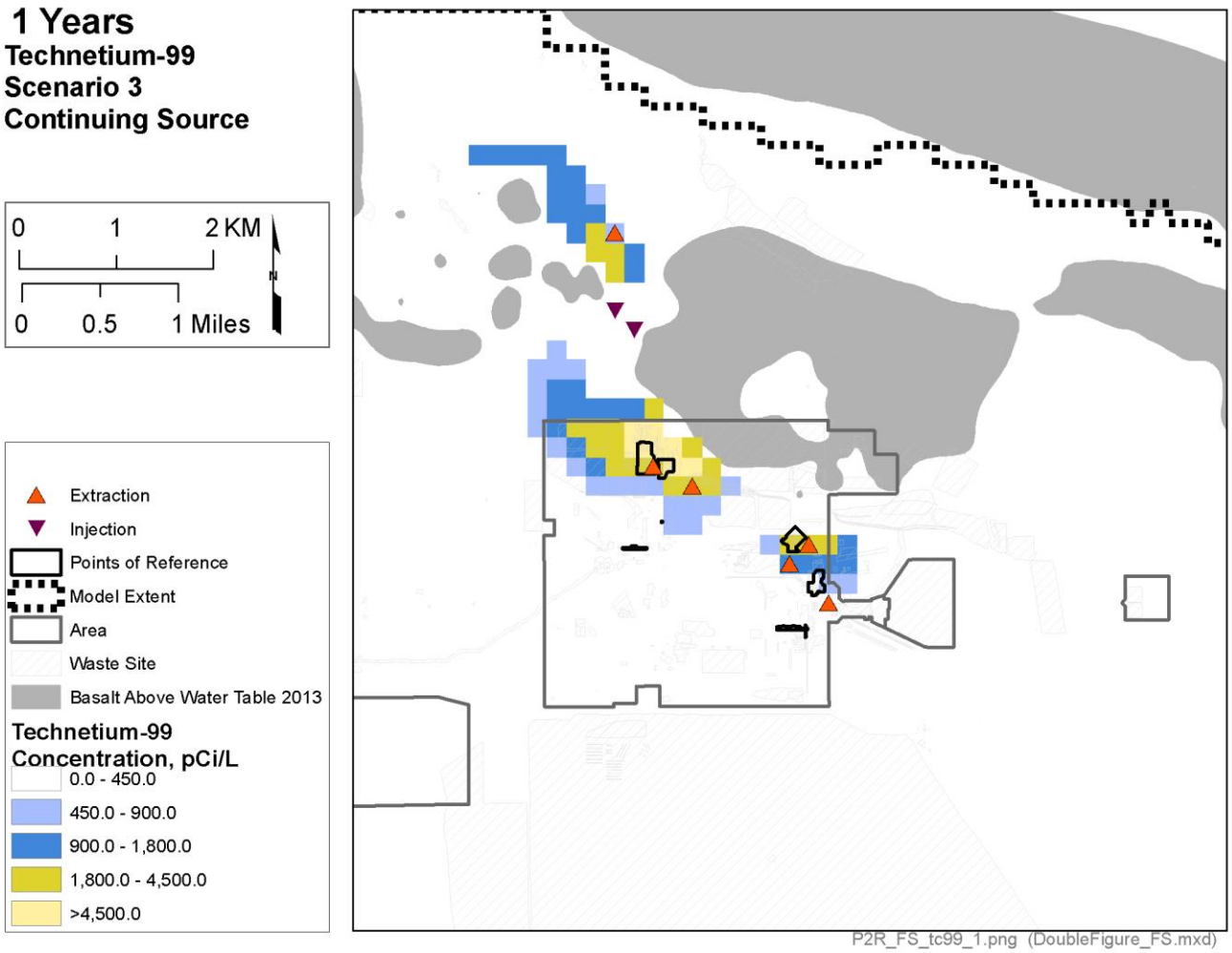

Figure B-142 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 3 simulation with a continuing source term.

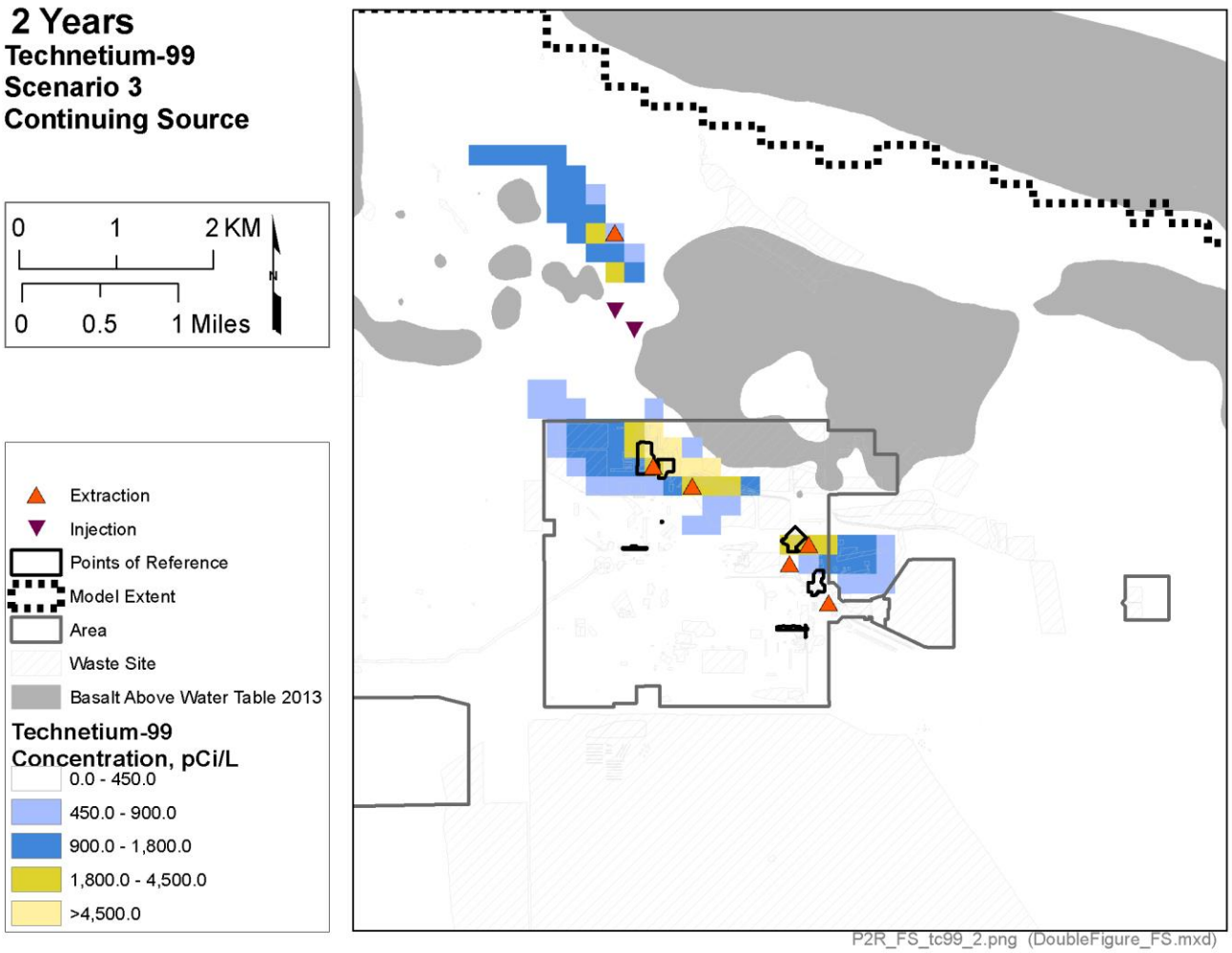

Figure B-143 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 3 simulation with a continuing source term.

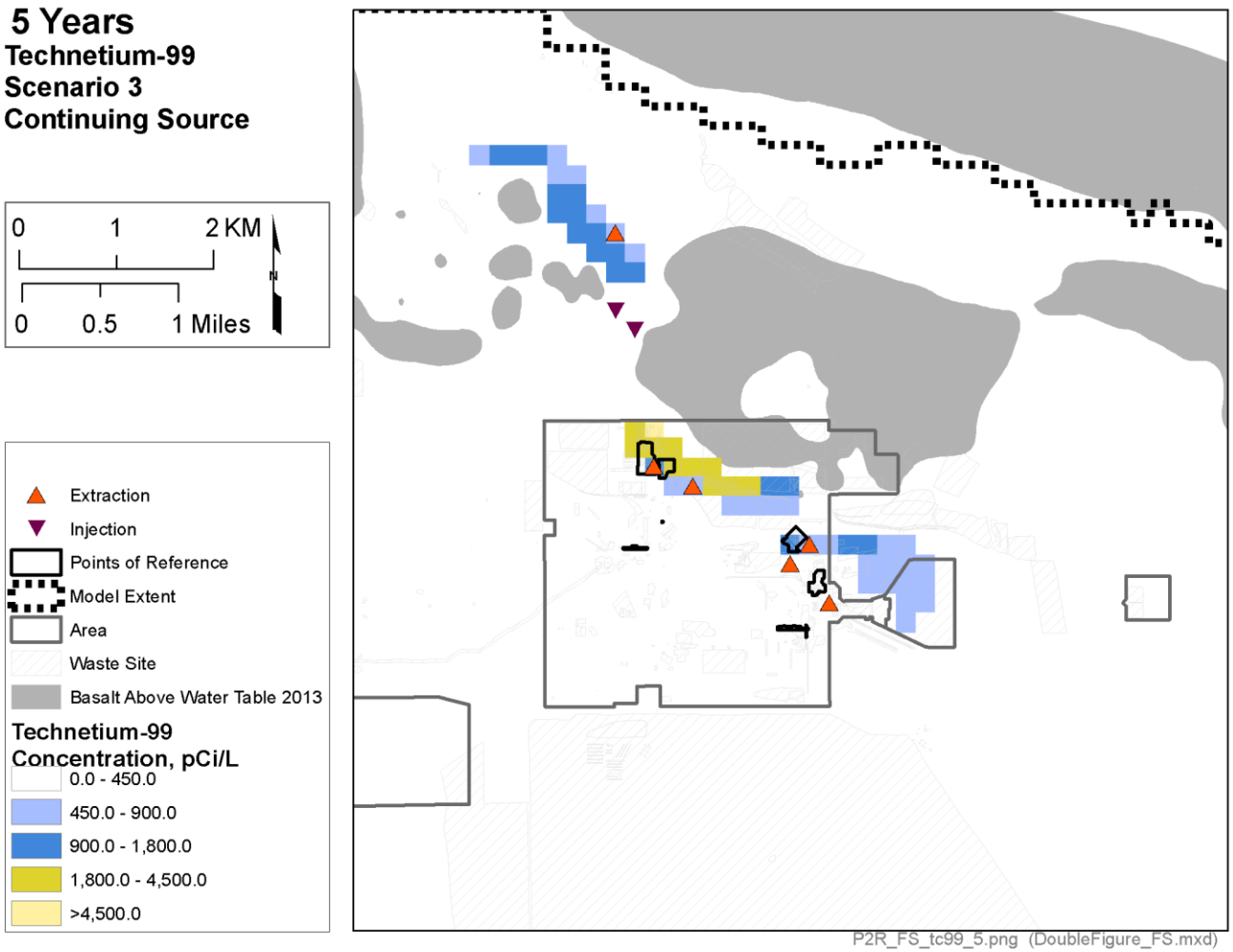

Figure B-144 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 3 simulation with a continuing source term.

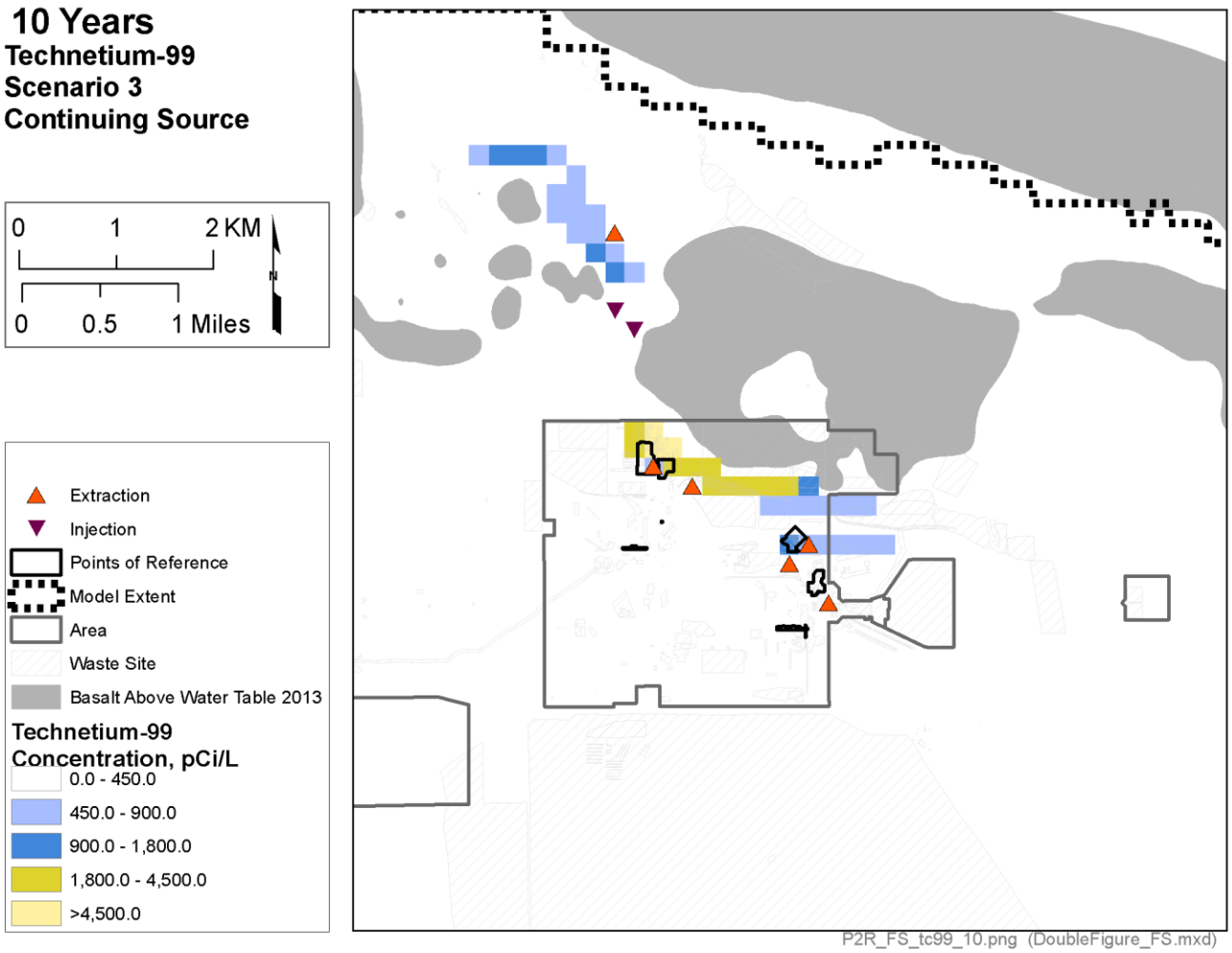

Figure B-145 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 3 simulation with a continuing source term.

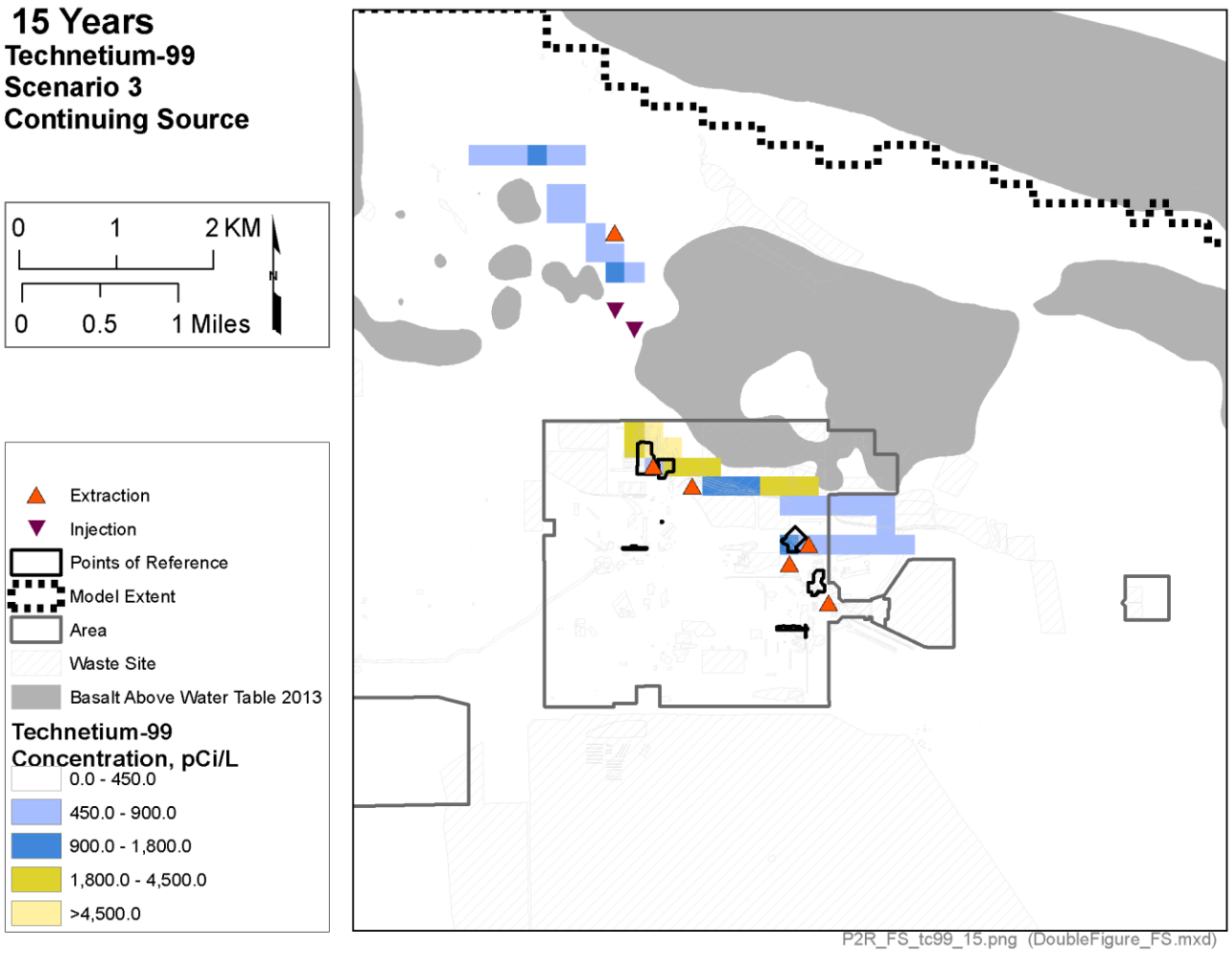

Figure B-146 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 3 simulation with a continuing source term.

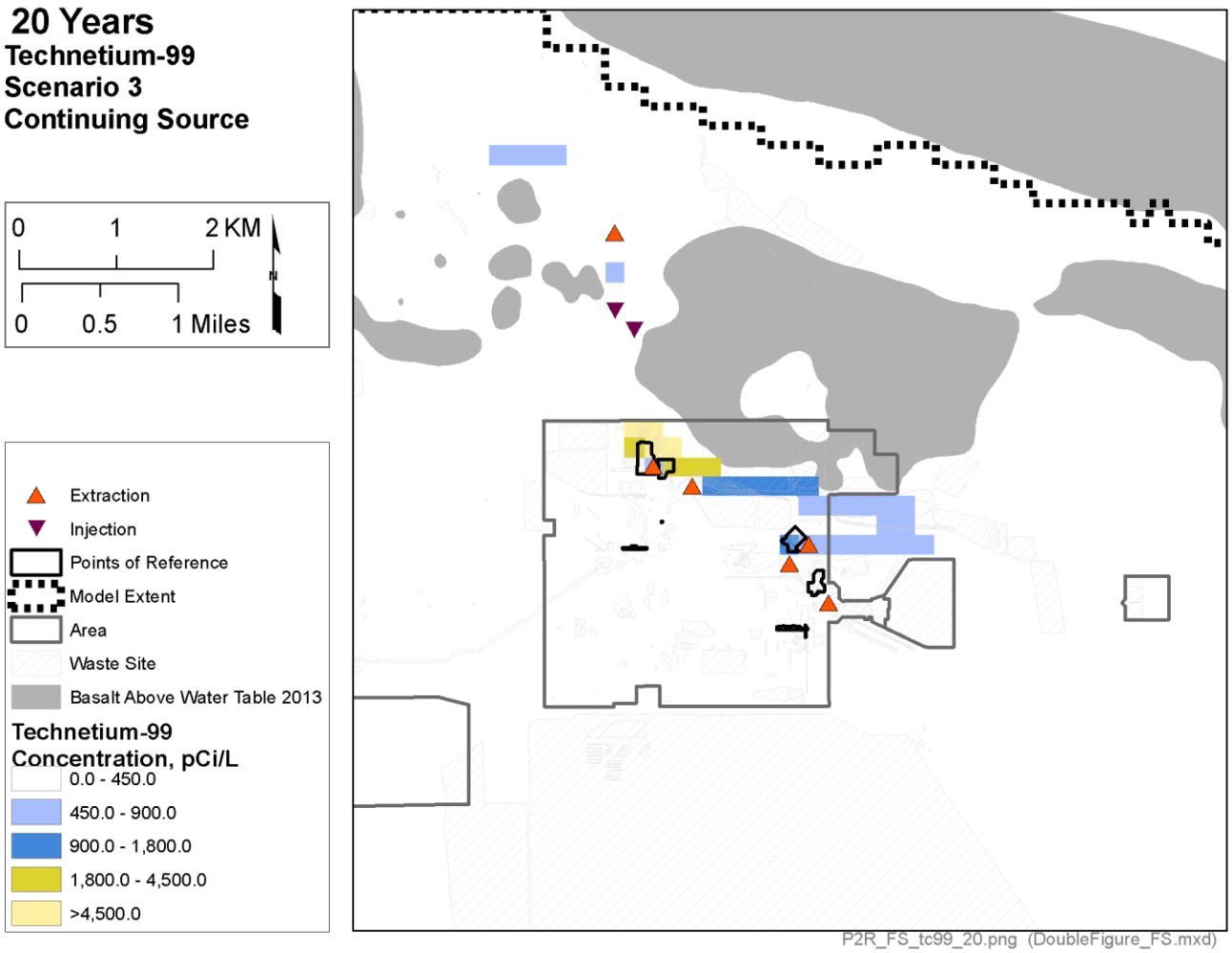

Figure B-147 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 3 simulation with a continuing source term.

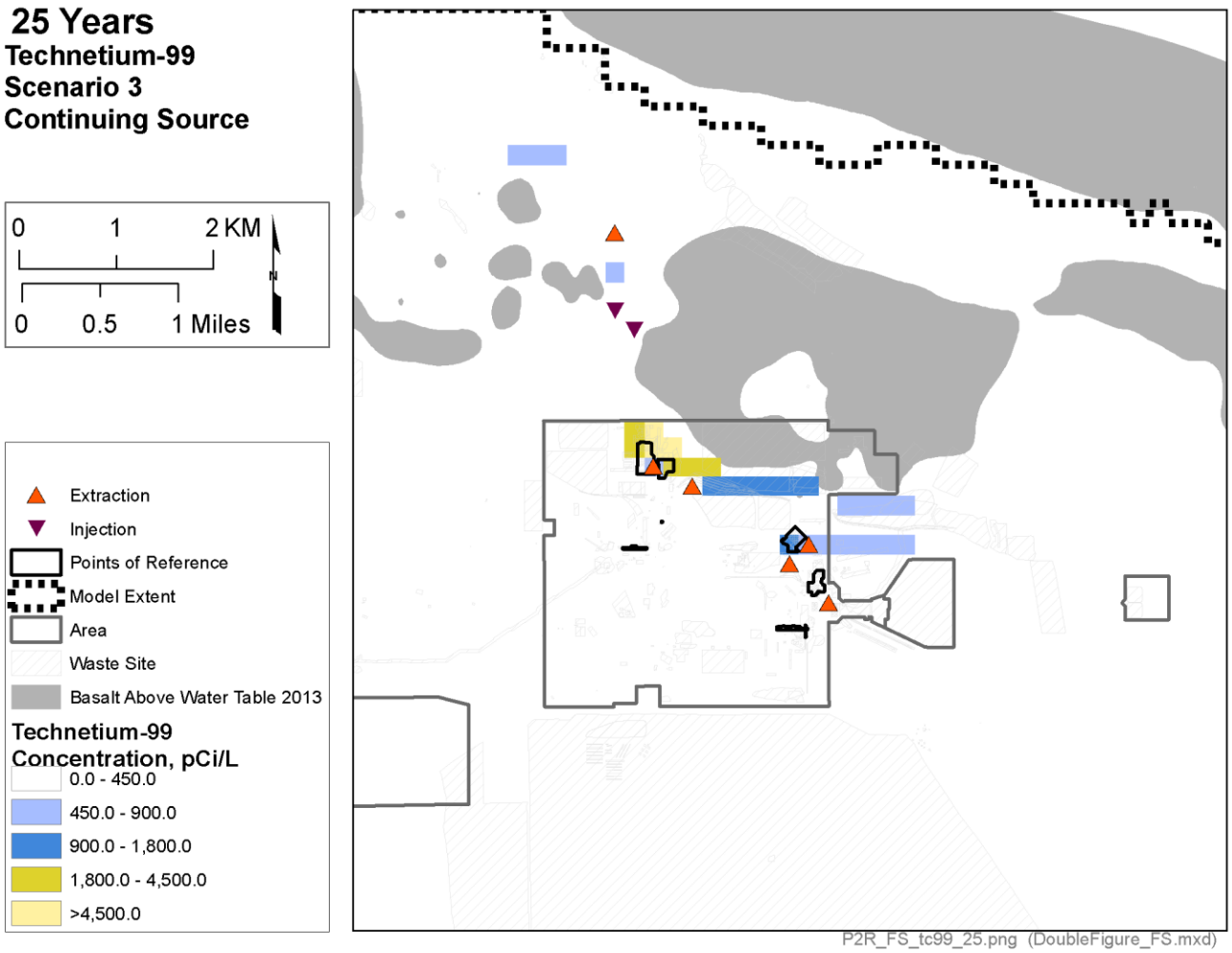

Figure B-148 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 3 simulation with a continuing source term.

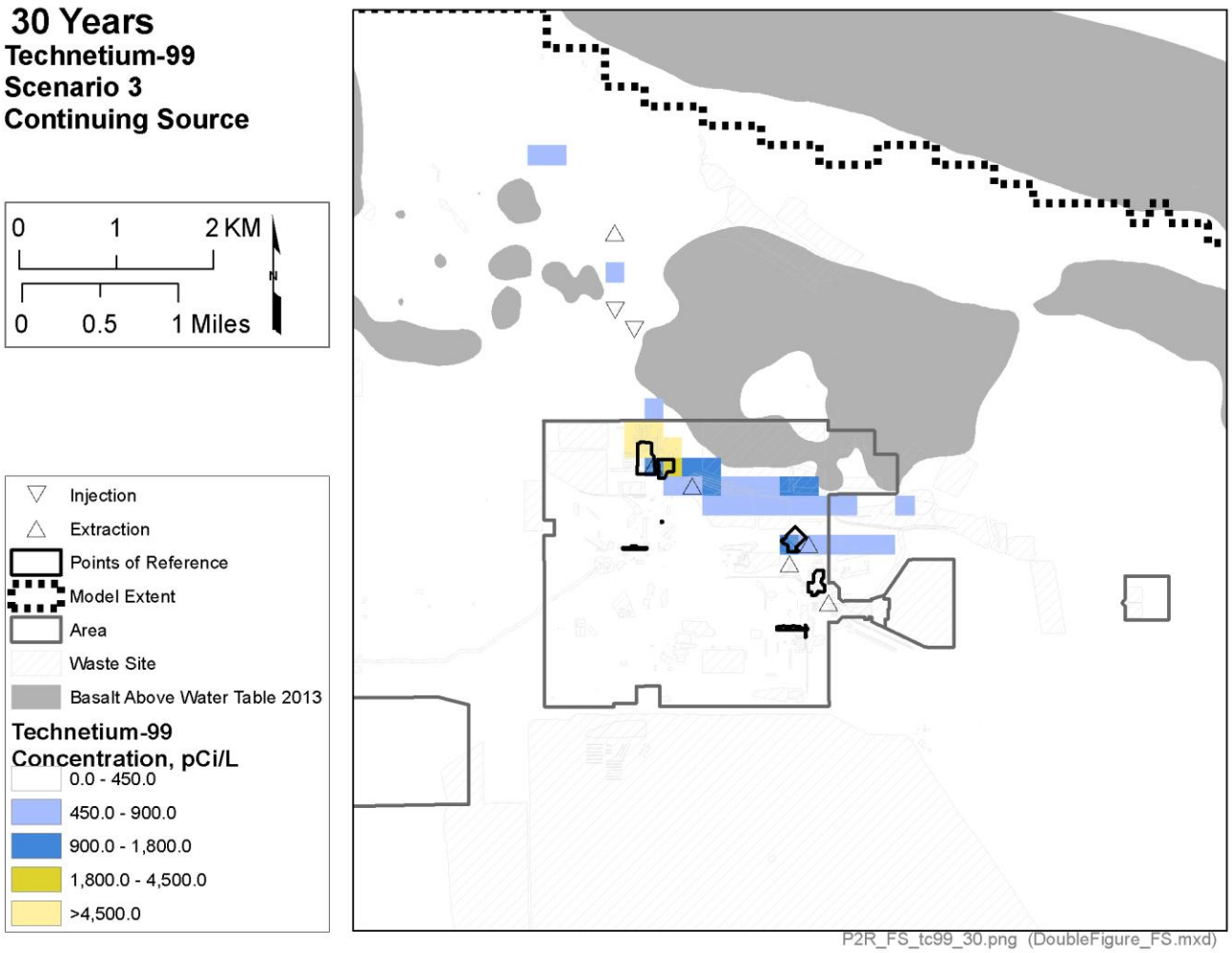

Figure B-149 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 3 simulation with a continuing source term.

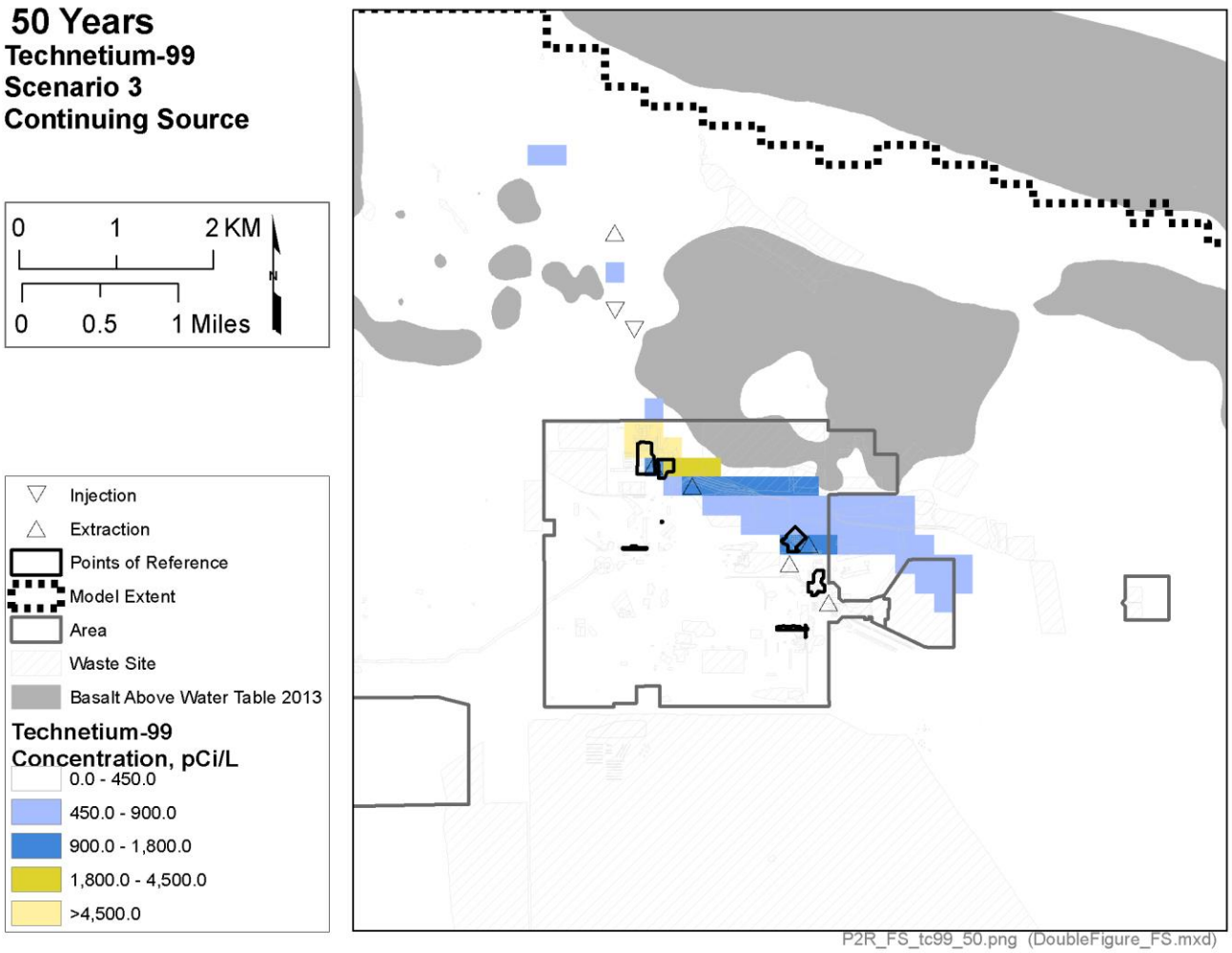

Figure B-150 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 3 simulation with a continuing source term.

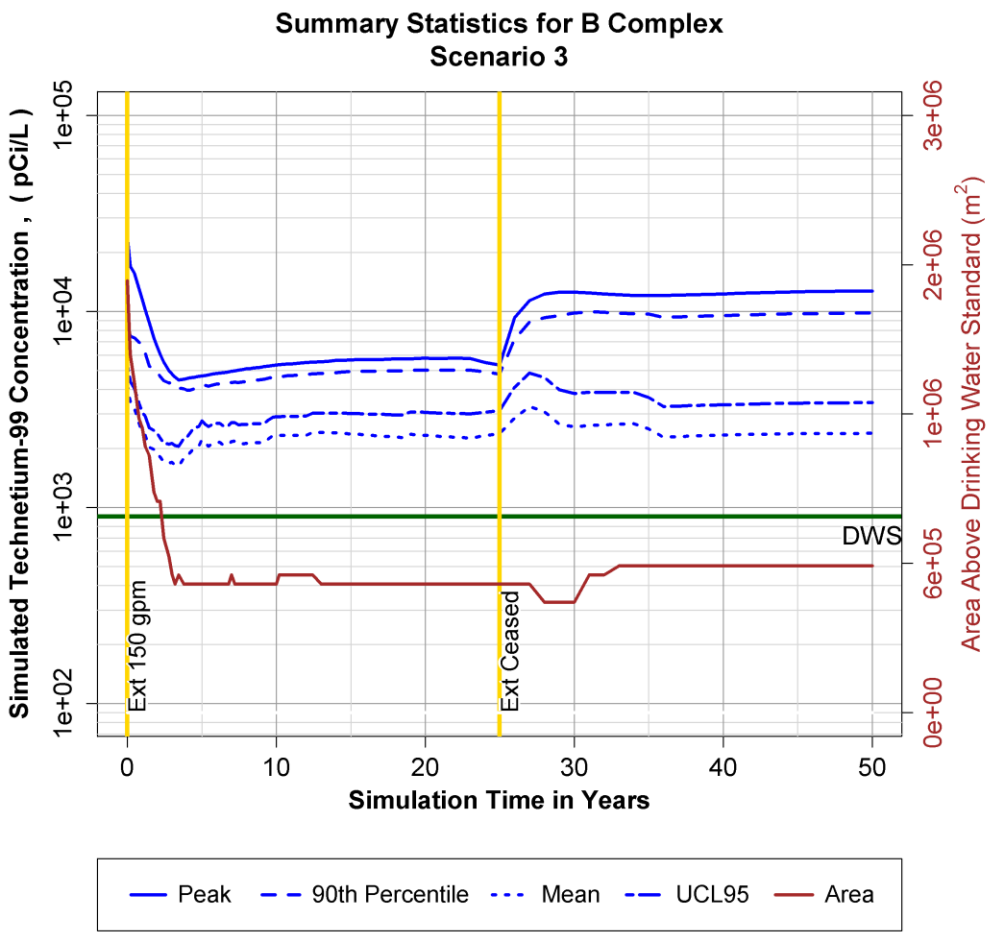

Figure B-151 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

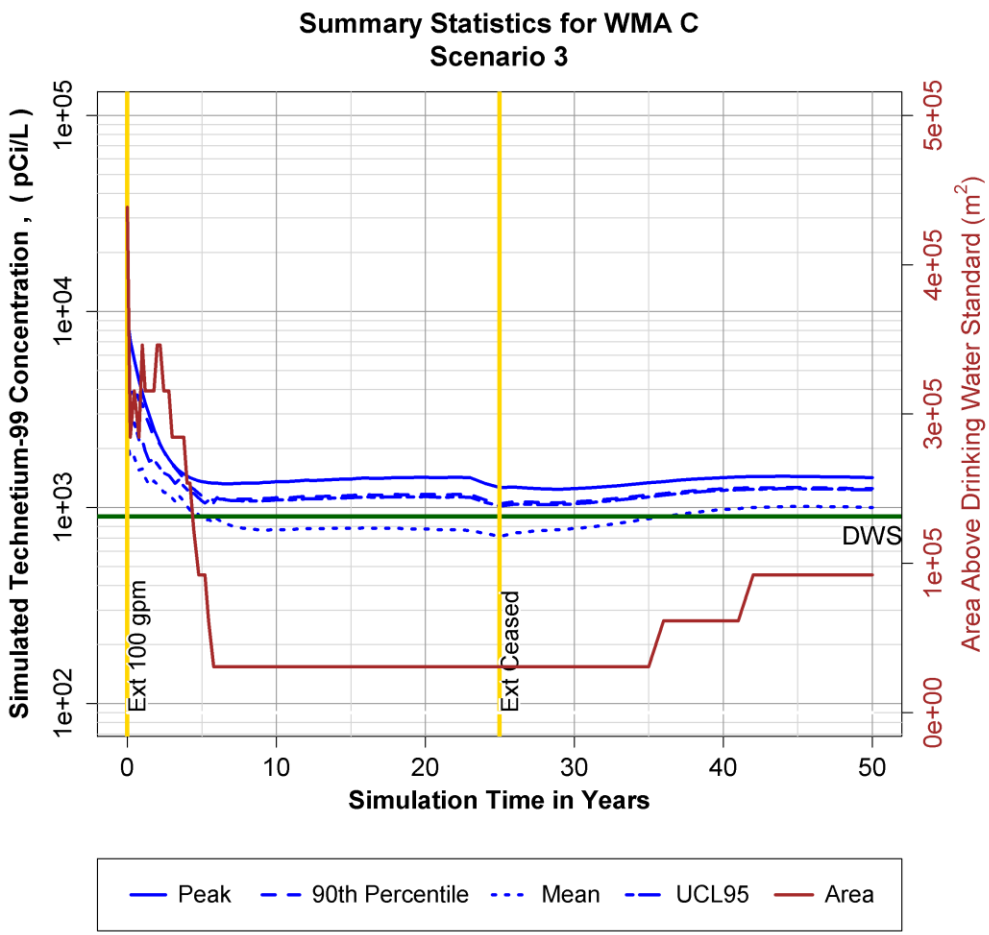

Figure B-152 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

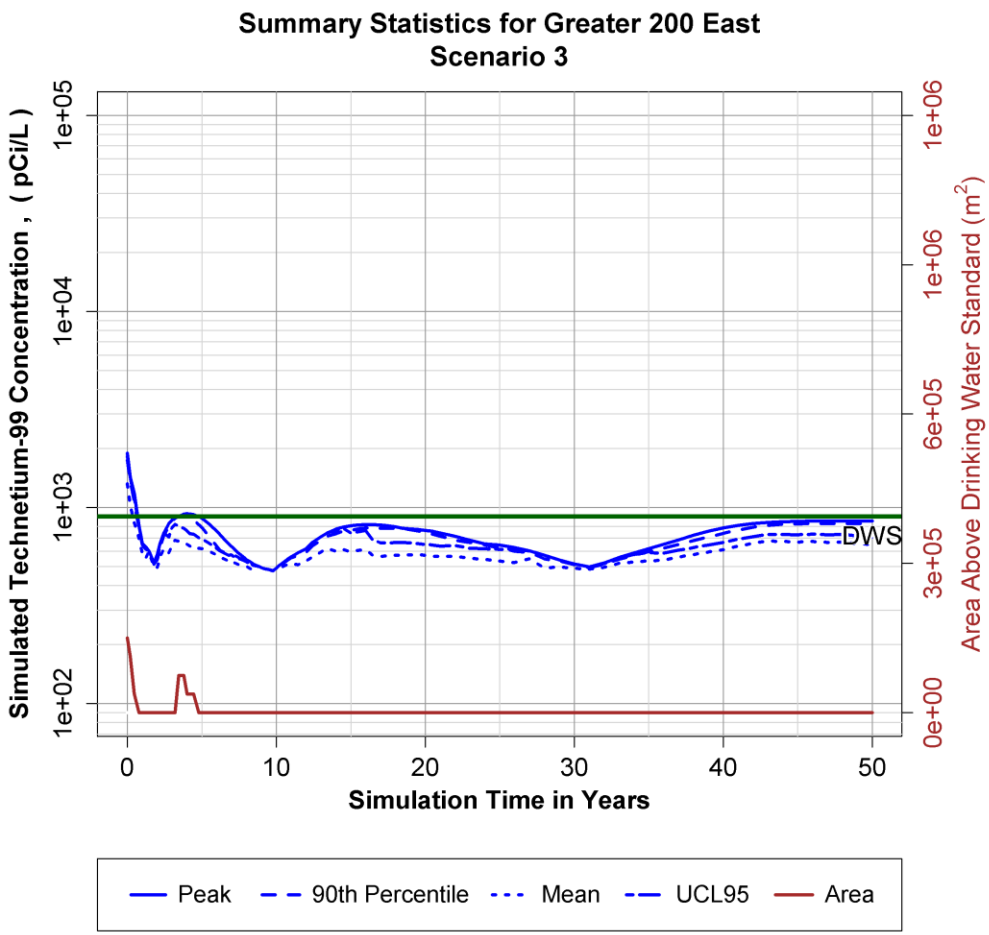

Figure B-153 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

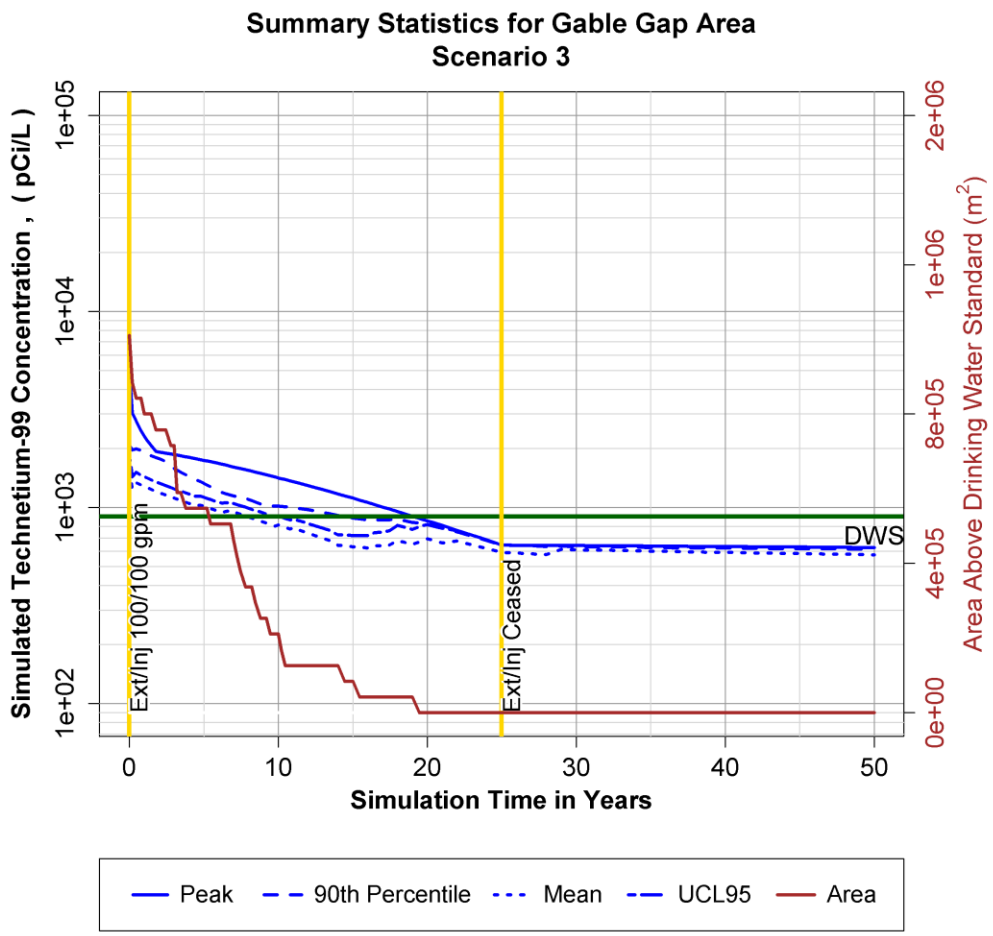

Figure B-154 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 3 simulation with a continuing source term.

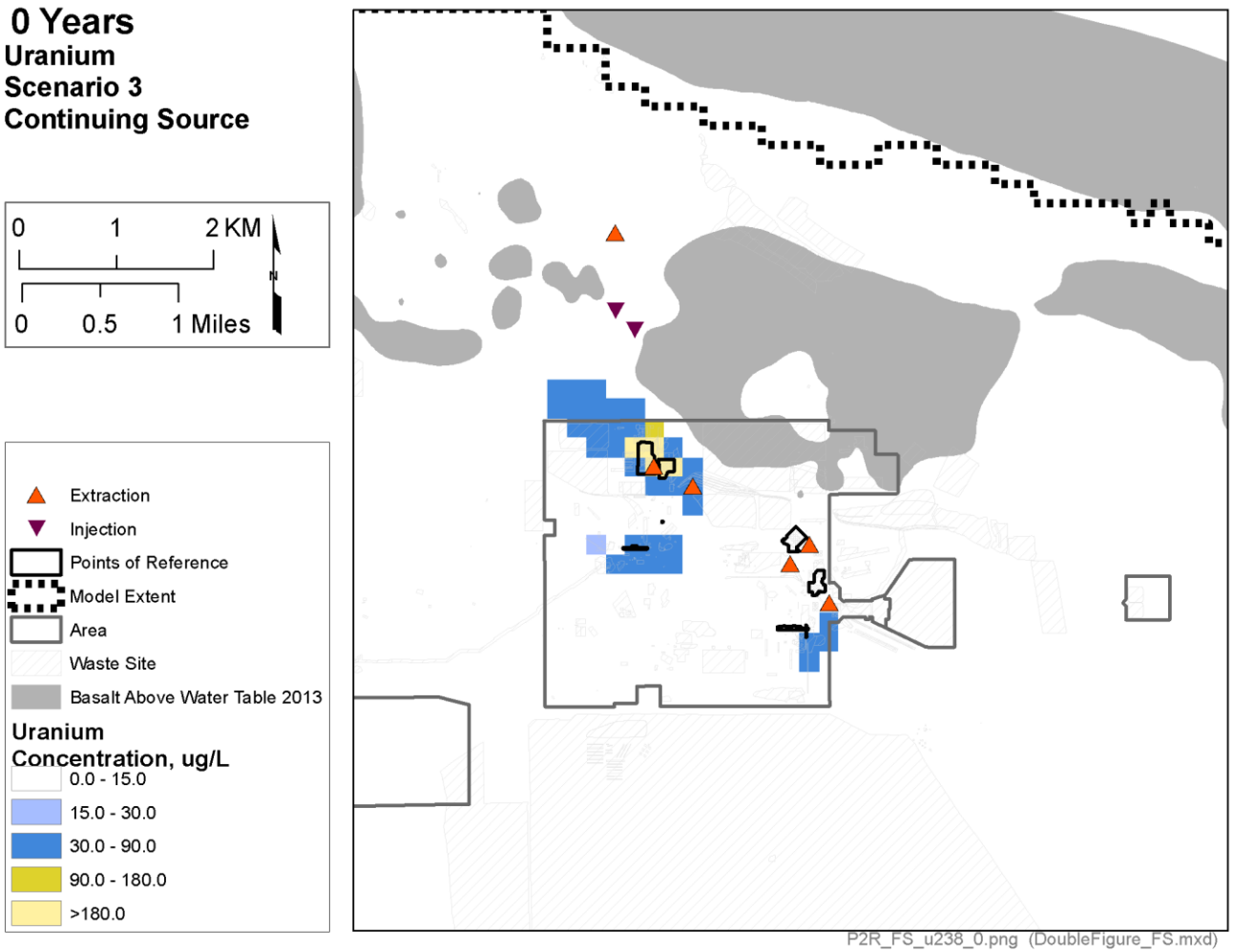

Figure B-155 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 3 simulation with a continuing source term.

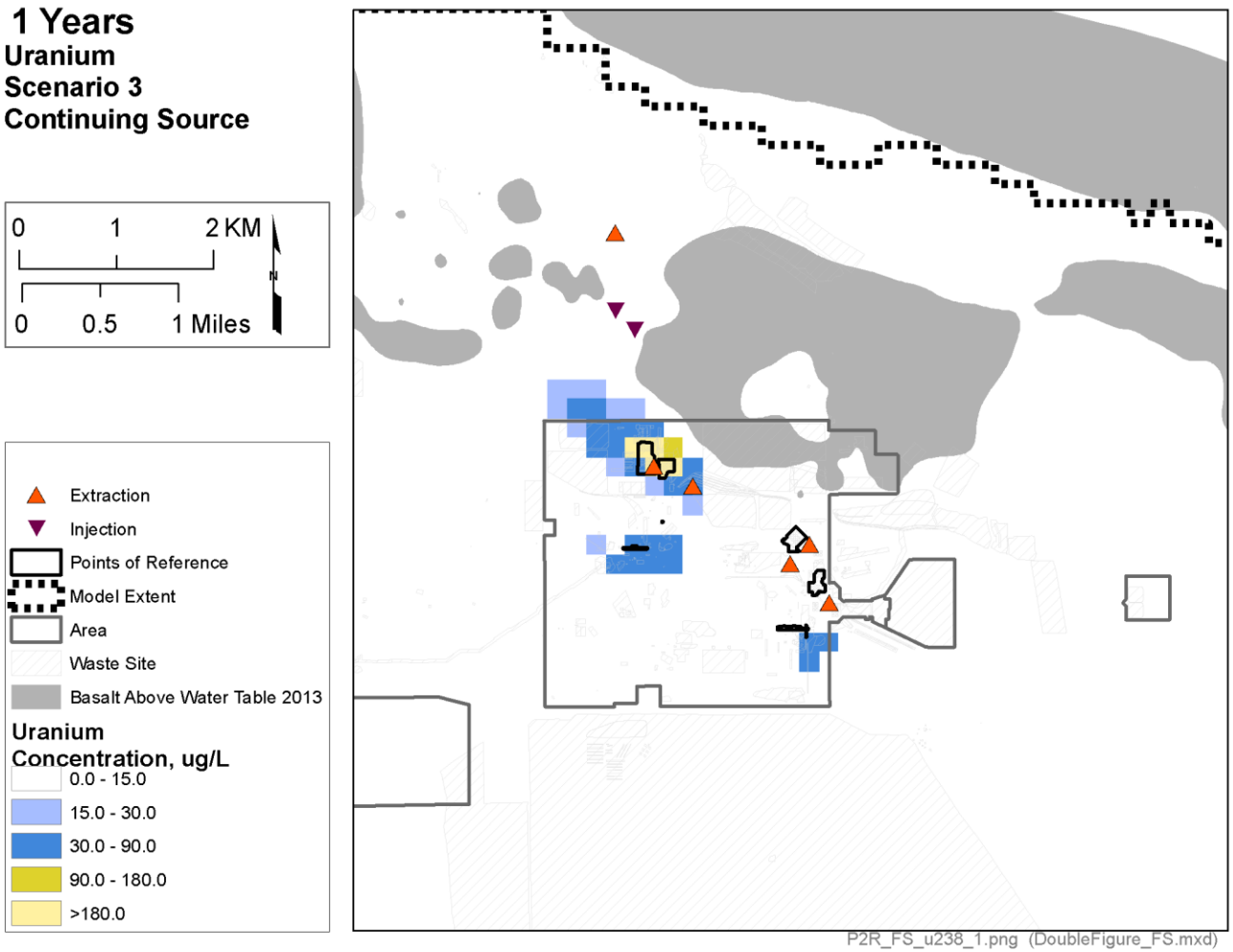

Figure B-156 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 3 simulation with a continuing source term.

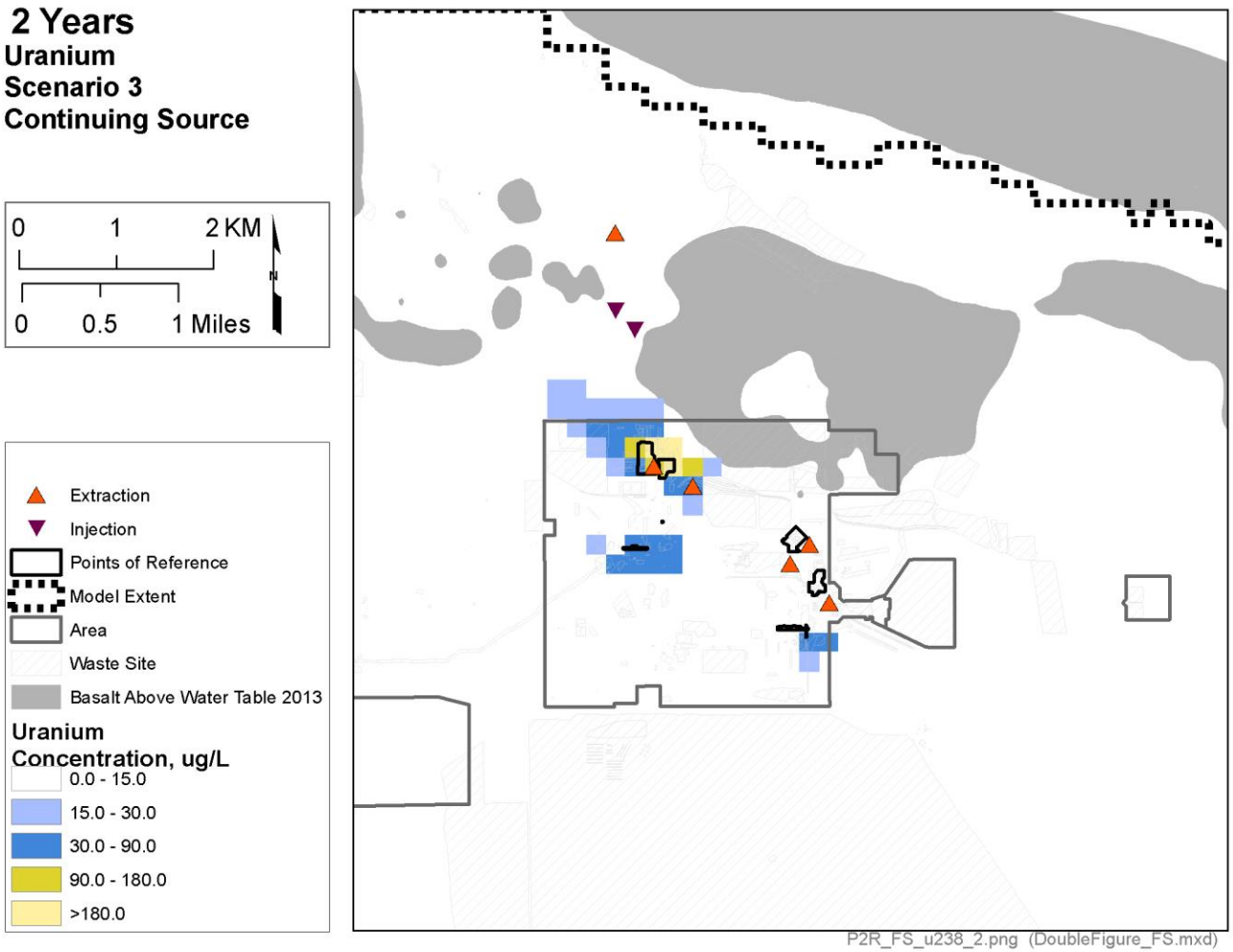

Figure B-157 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 3 simulation with a continuing source term.

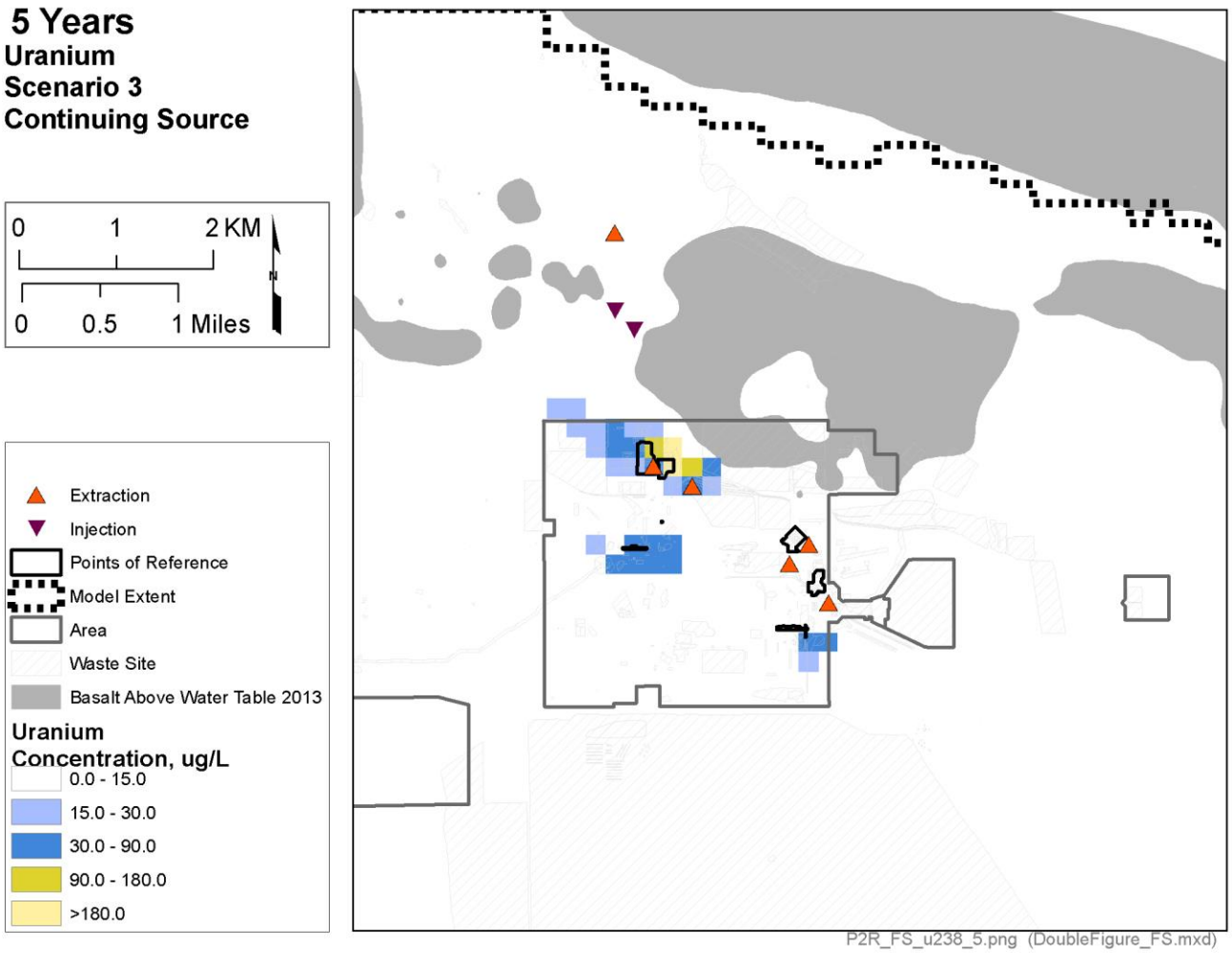

Figure B-158 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 3 simulation with a continuing source term.

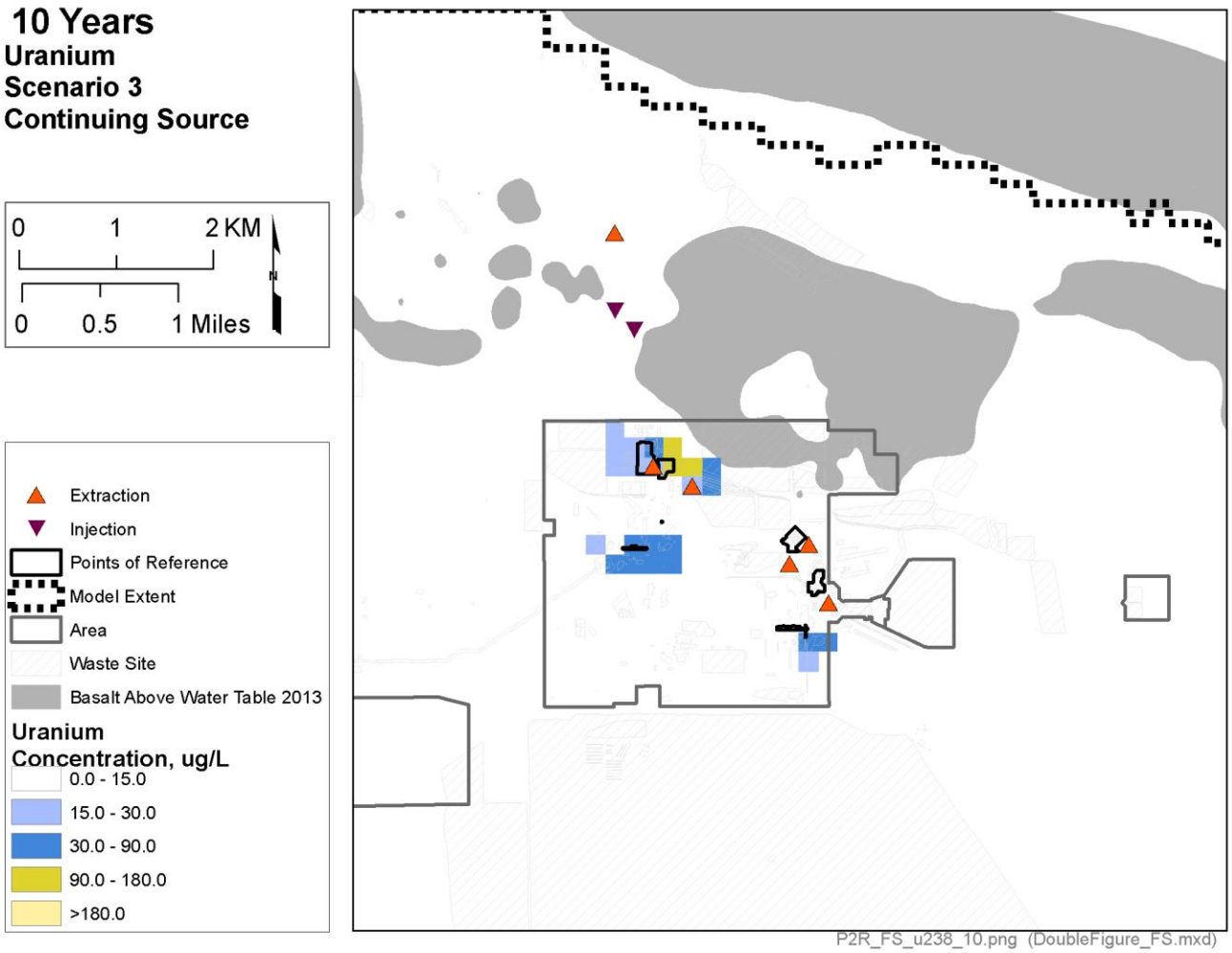

Figure B-159 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 3 simulation with a continuing source term.

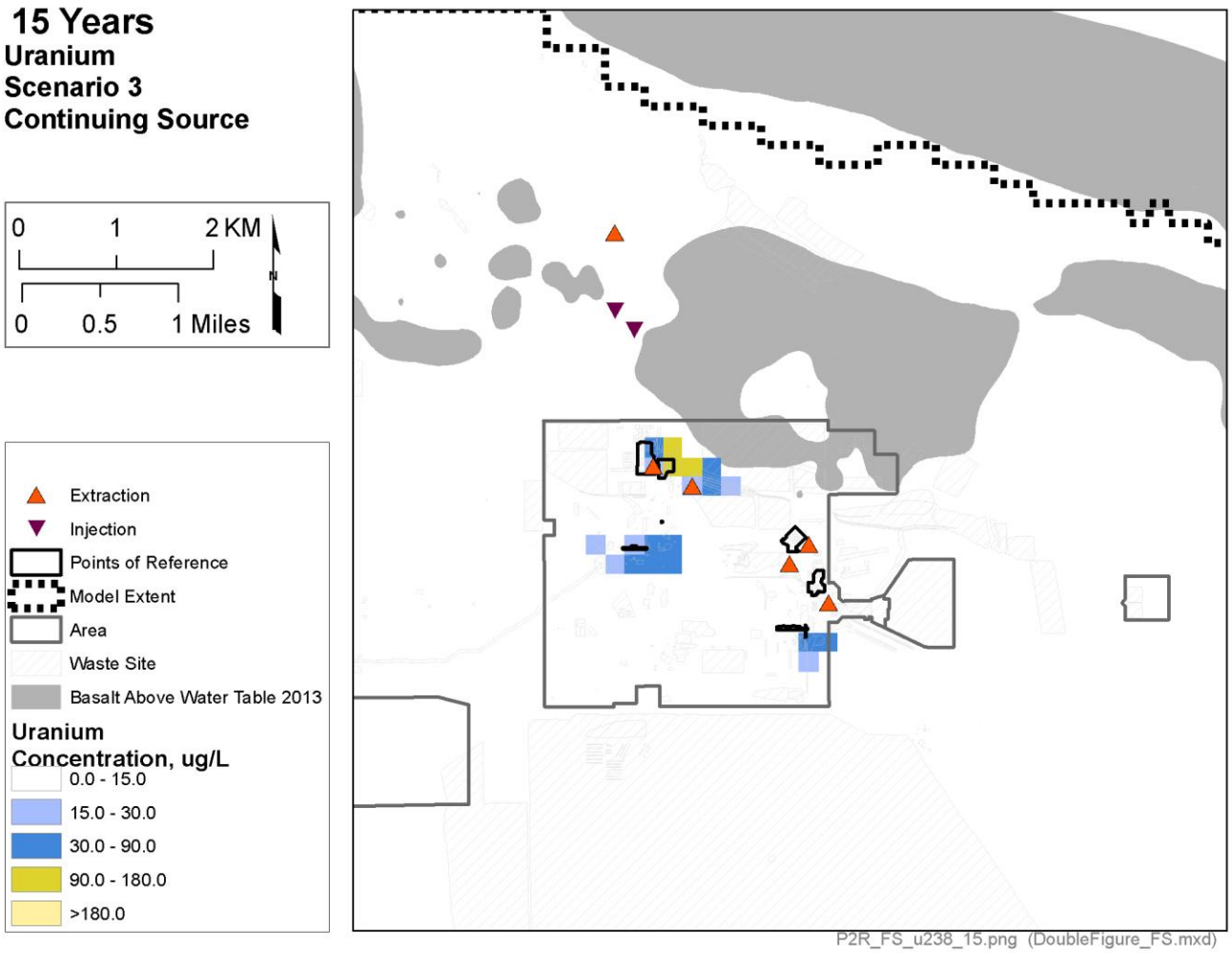

Figure B-160 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 3 simulation with a continuing source term.

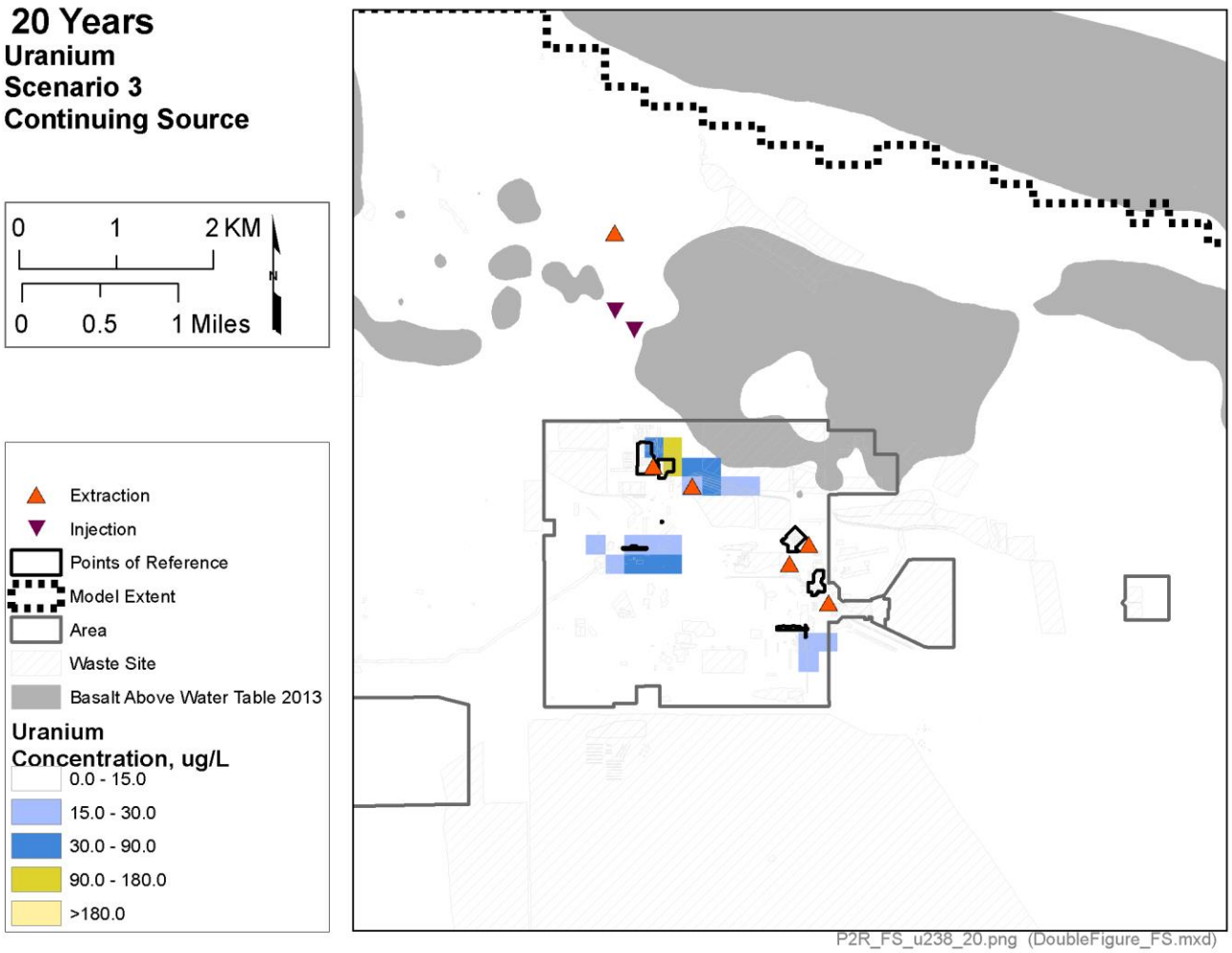

Figure B-161 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 3 simulation with a continuing source term.

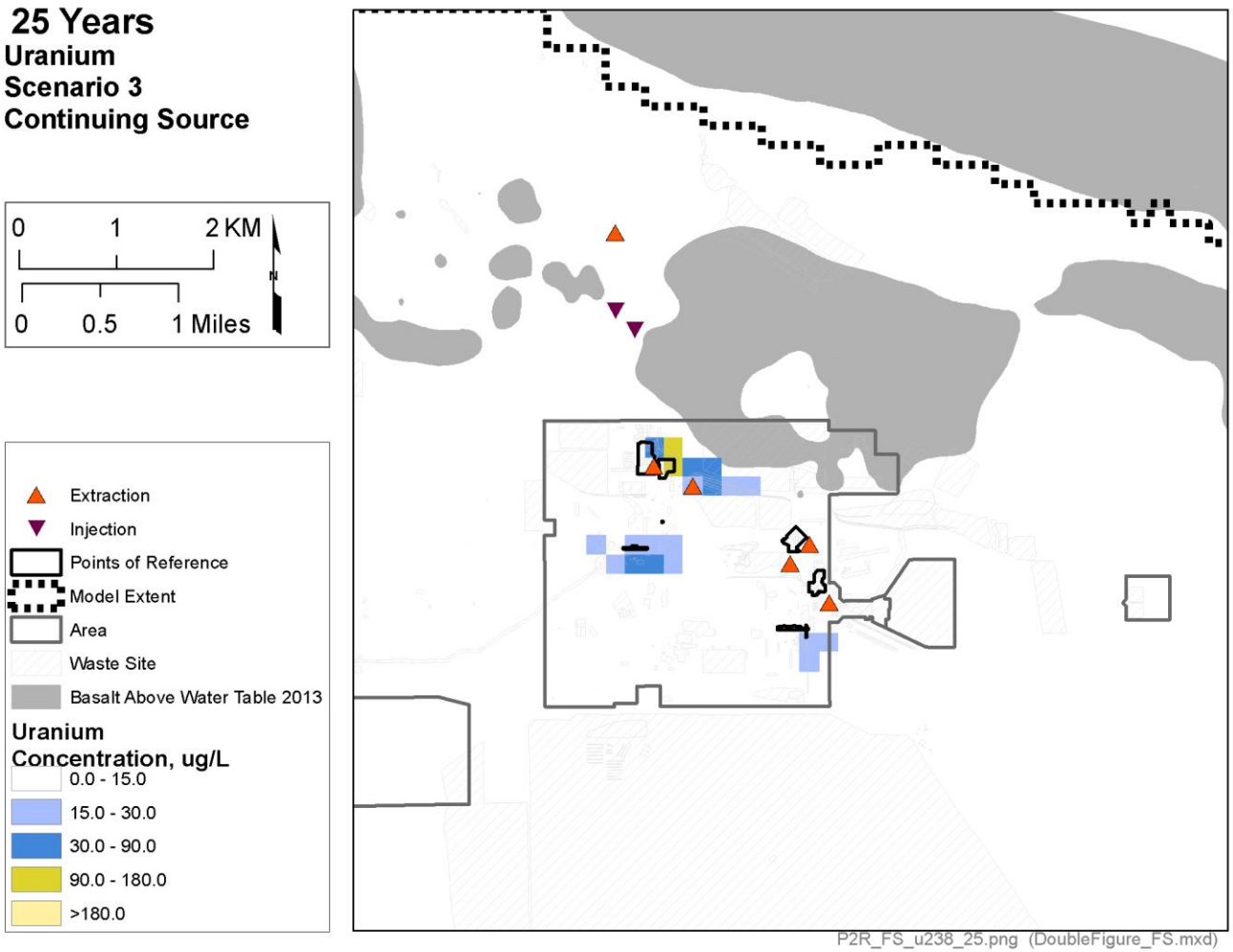

Figure B-162 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 3 simulation with a continuing source term.

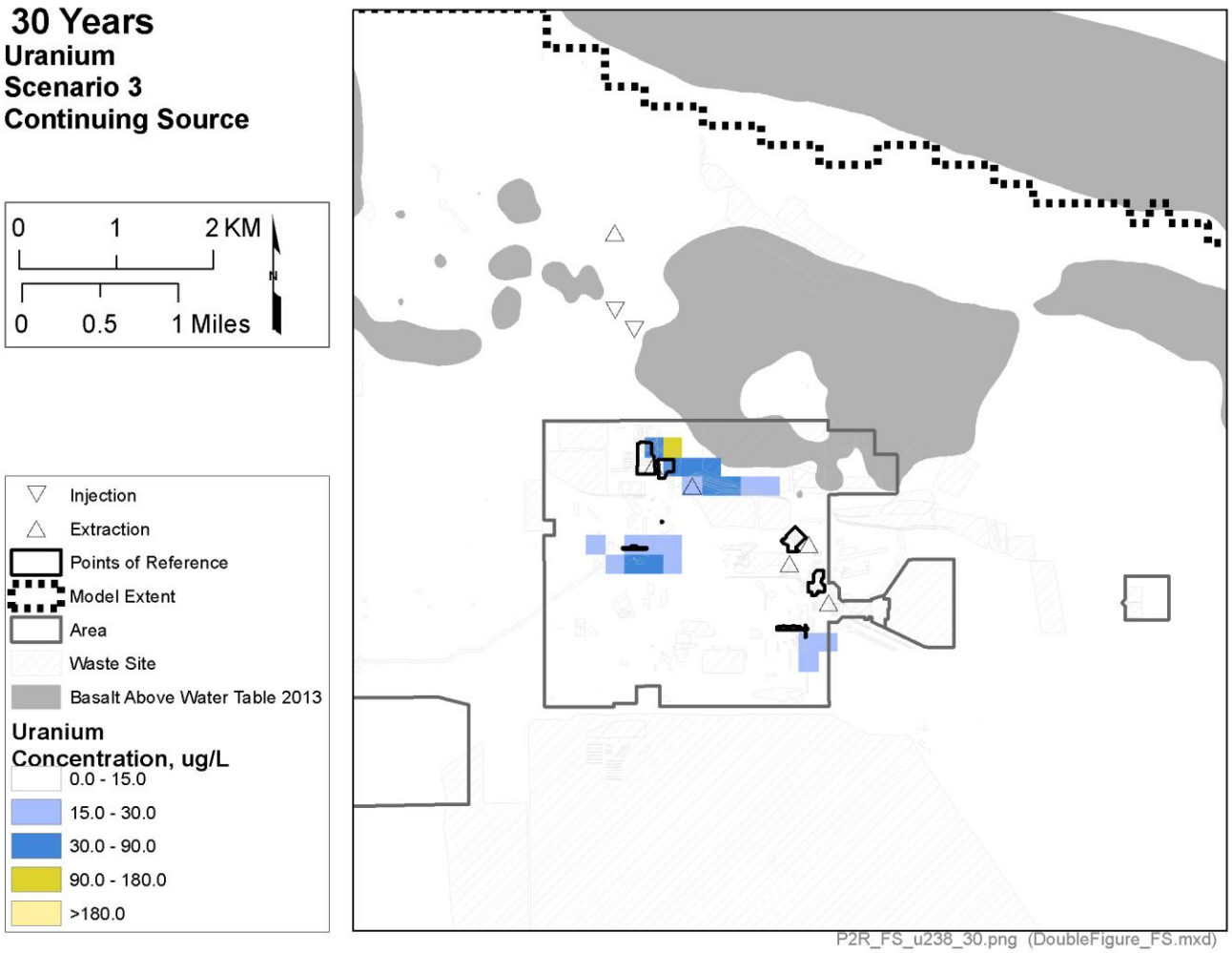

Figure B-163 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 3 simulation with a continuing source term.

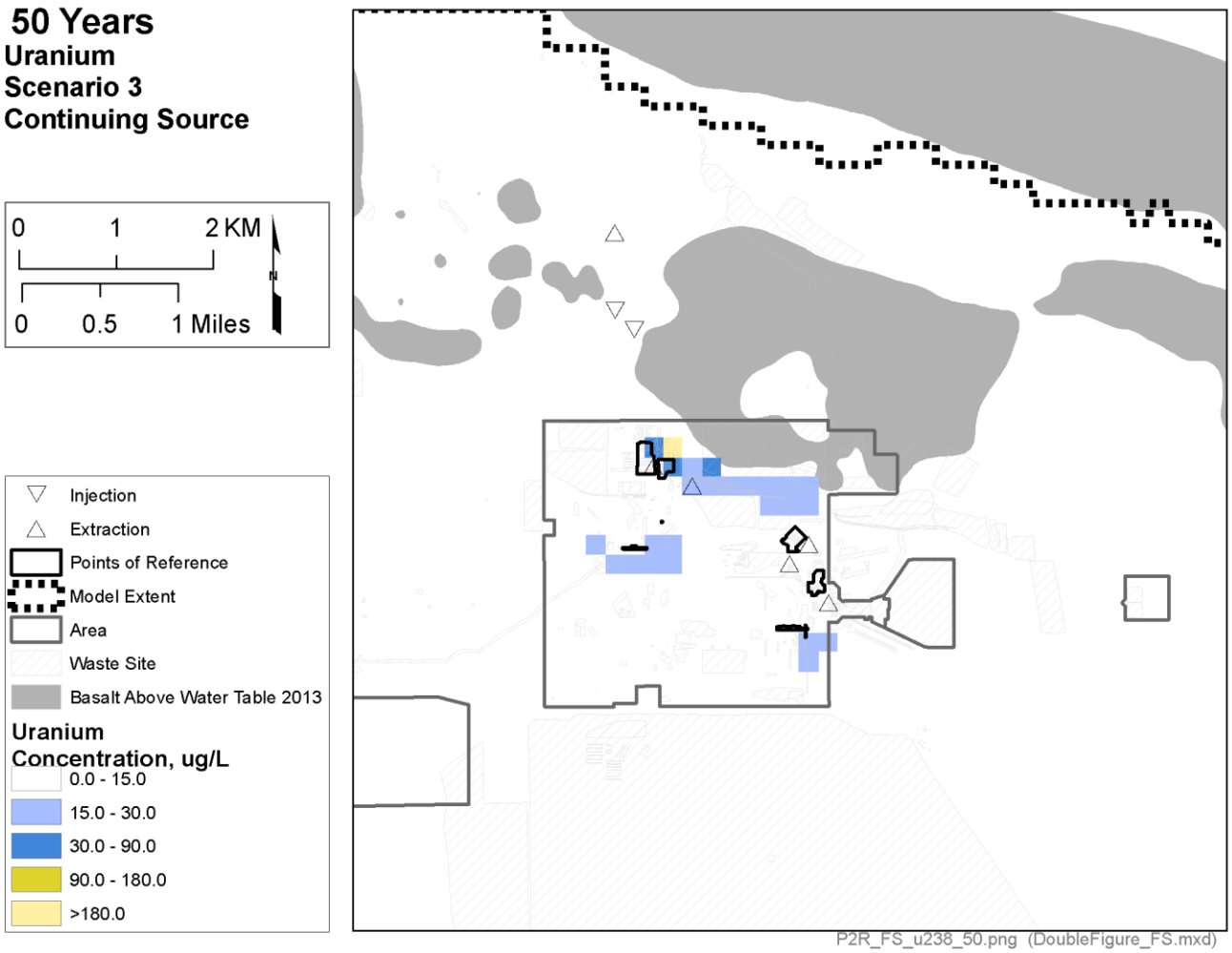

Figure B-164 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 3 simulation with a continuing source term.

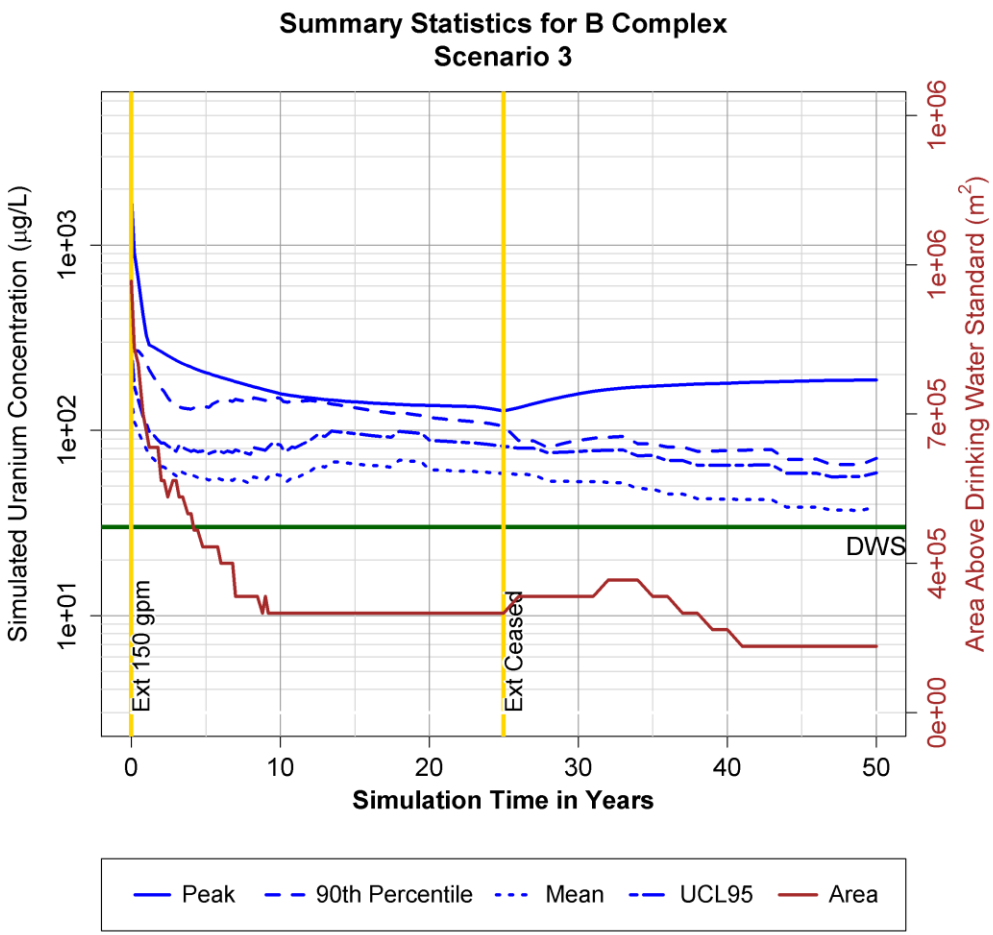

Figure B-165 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

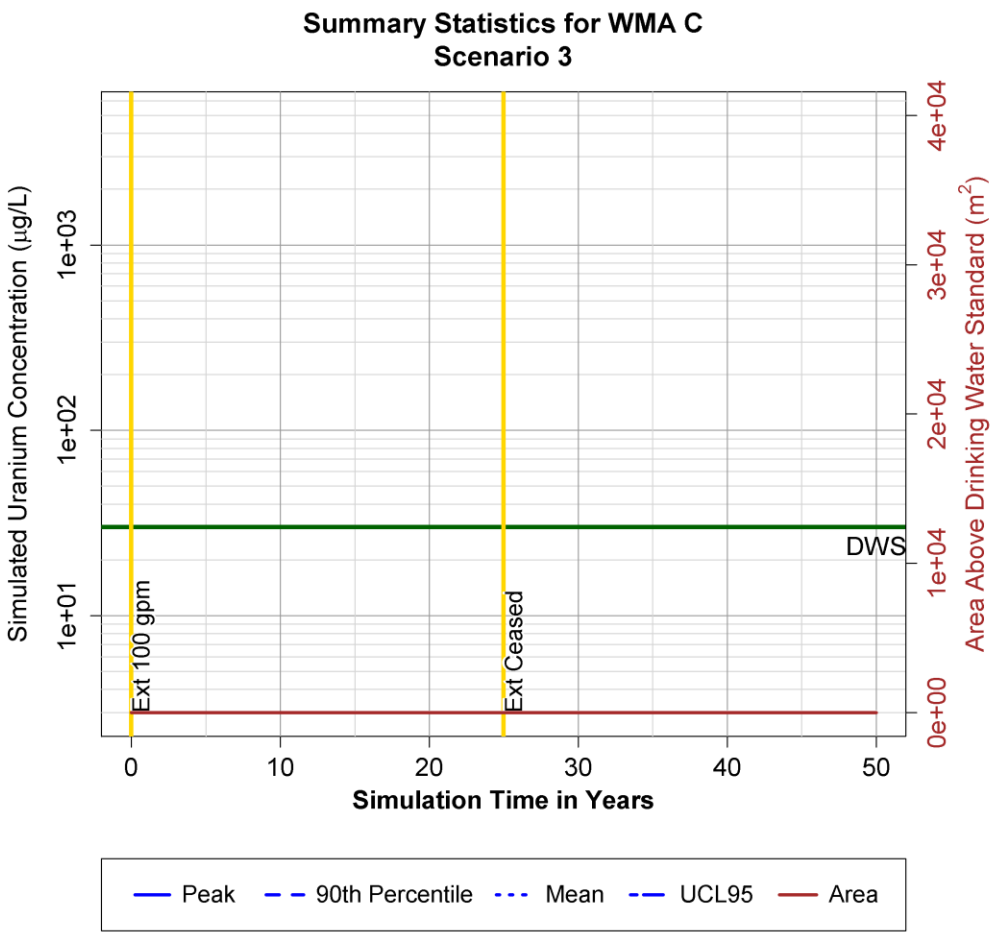

Figure B-166 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

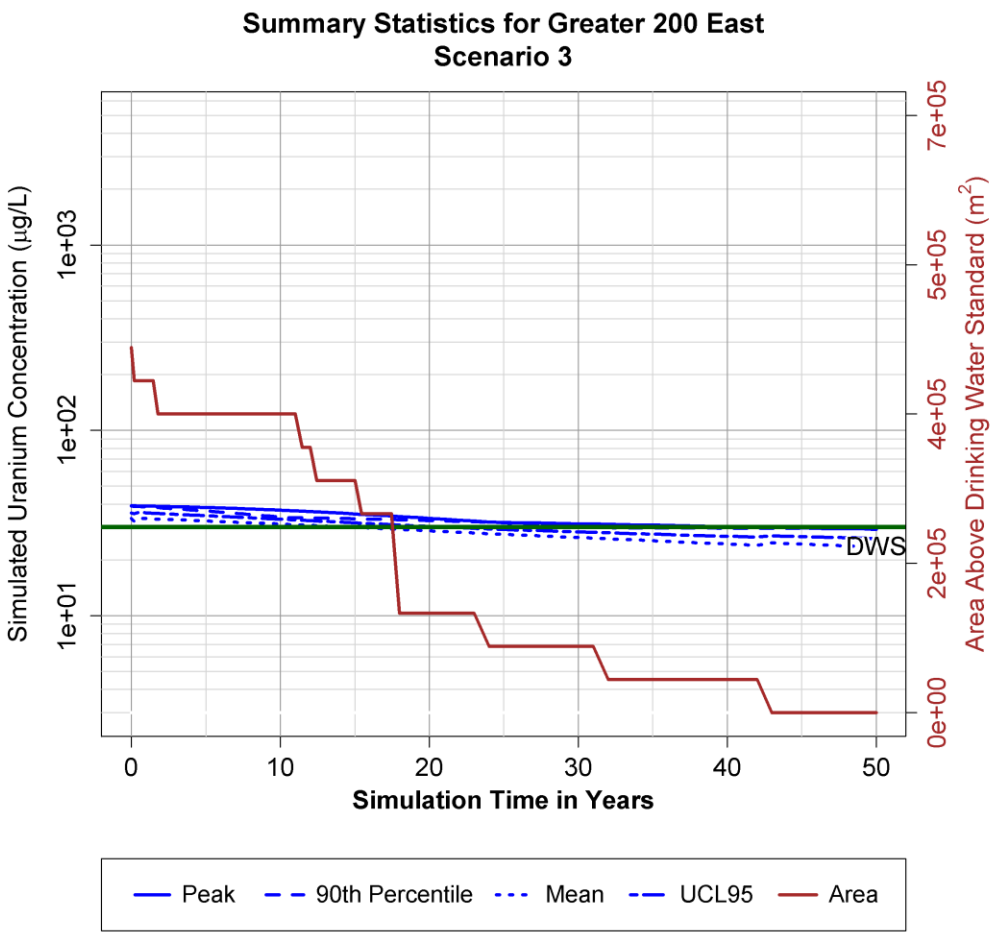

Figure B-167 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

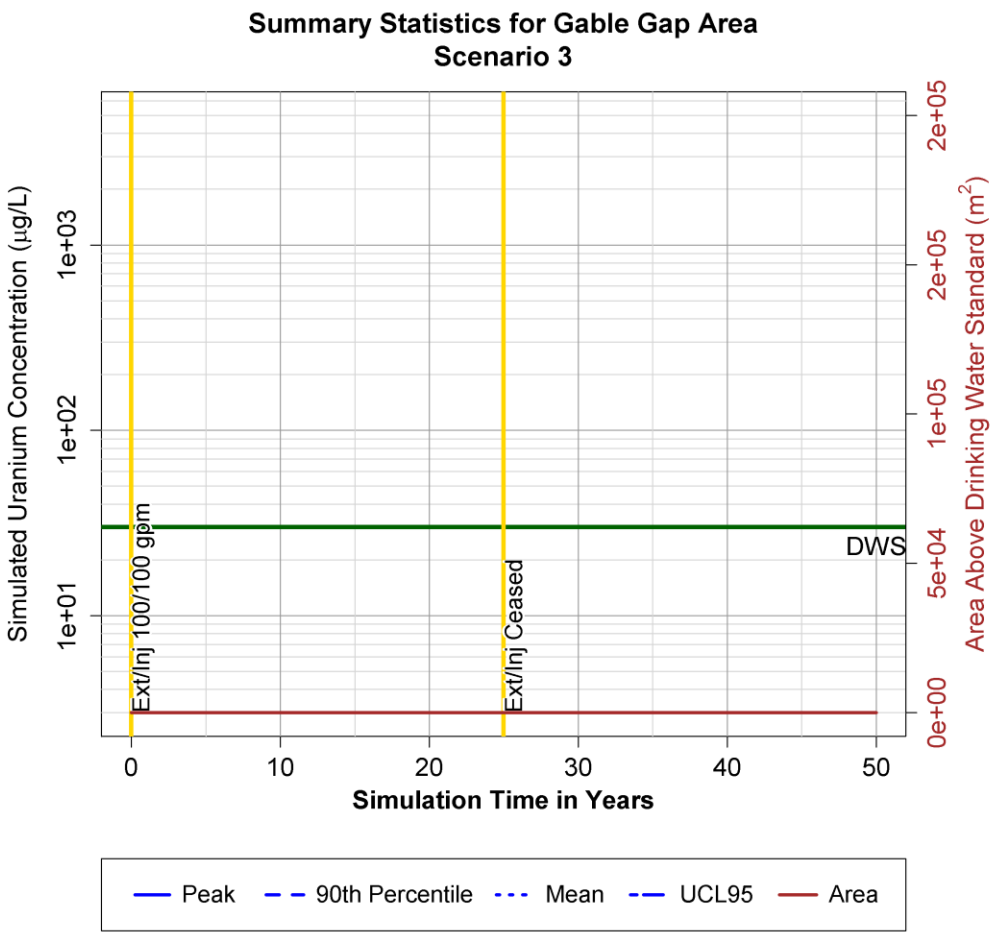

Figure B-168 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 3 simulation with a continuing source term.

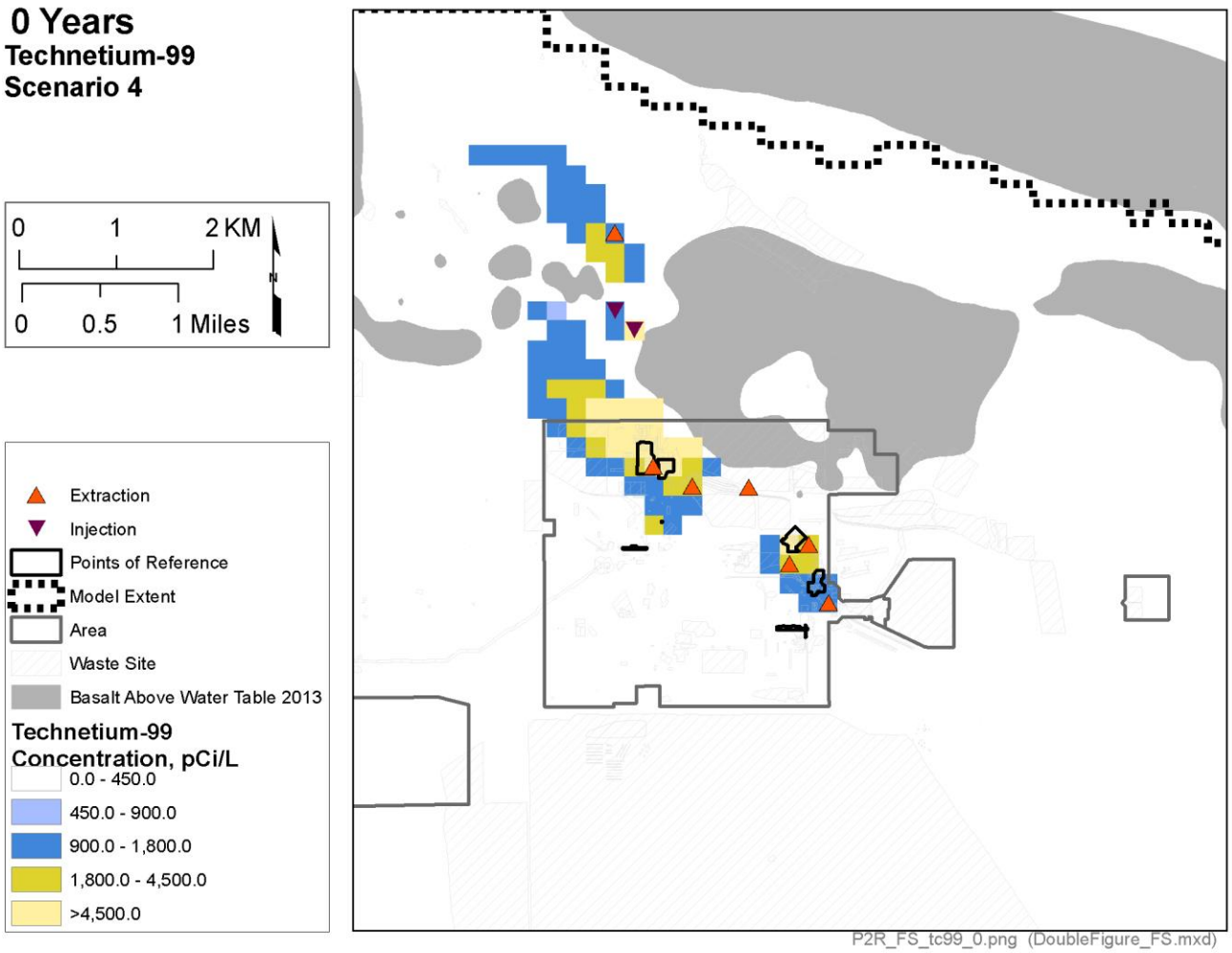

Figure B-169 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 4 simulation.

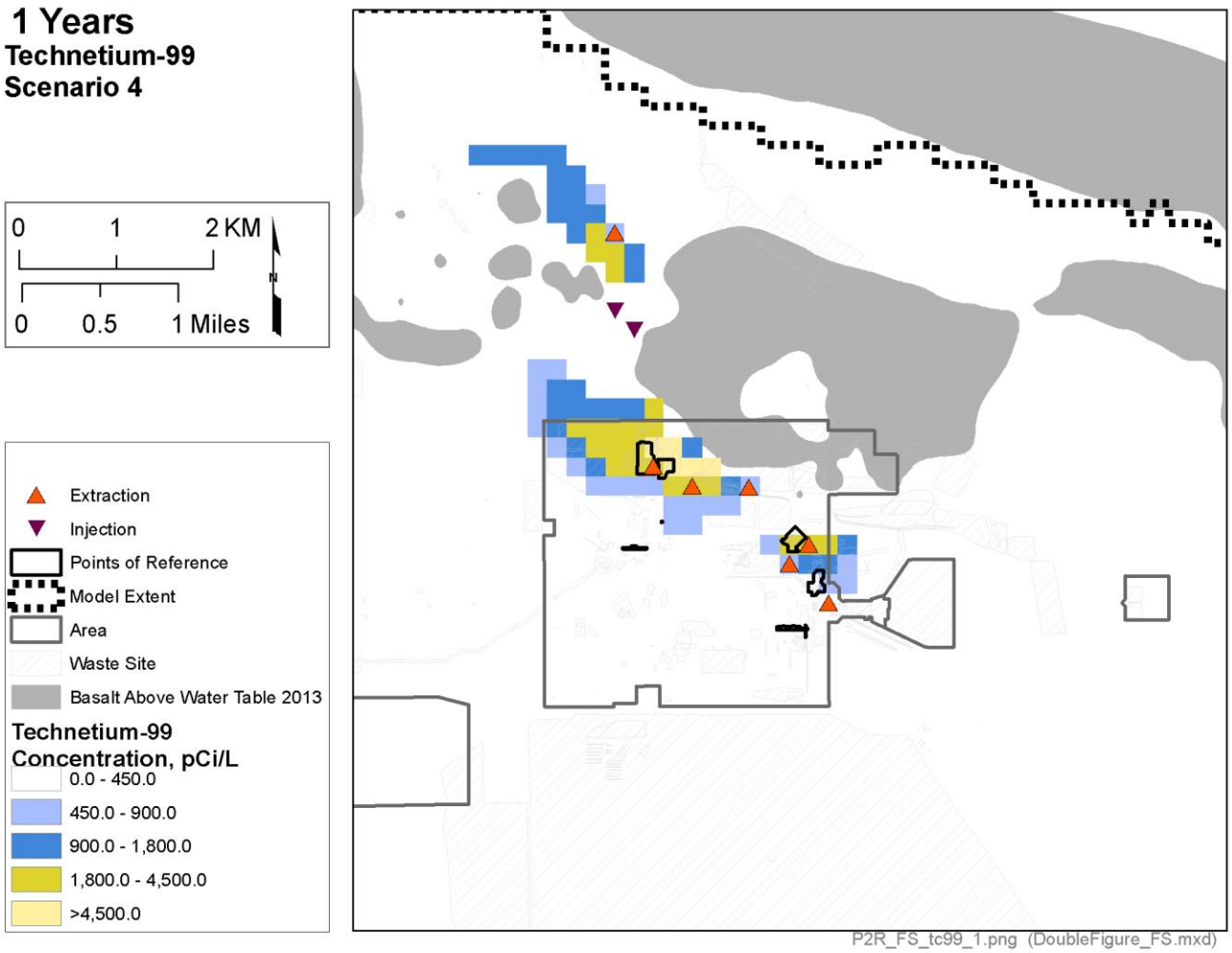

Figure B-170 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 4 simulation.

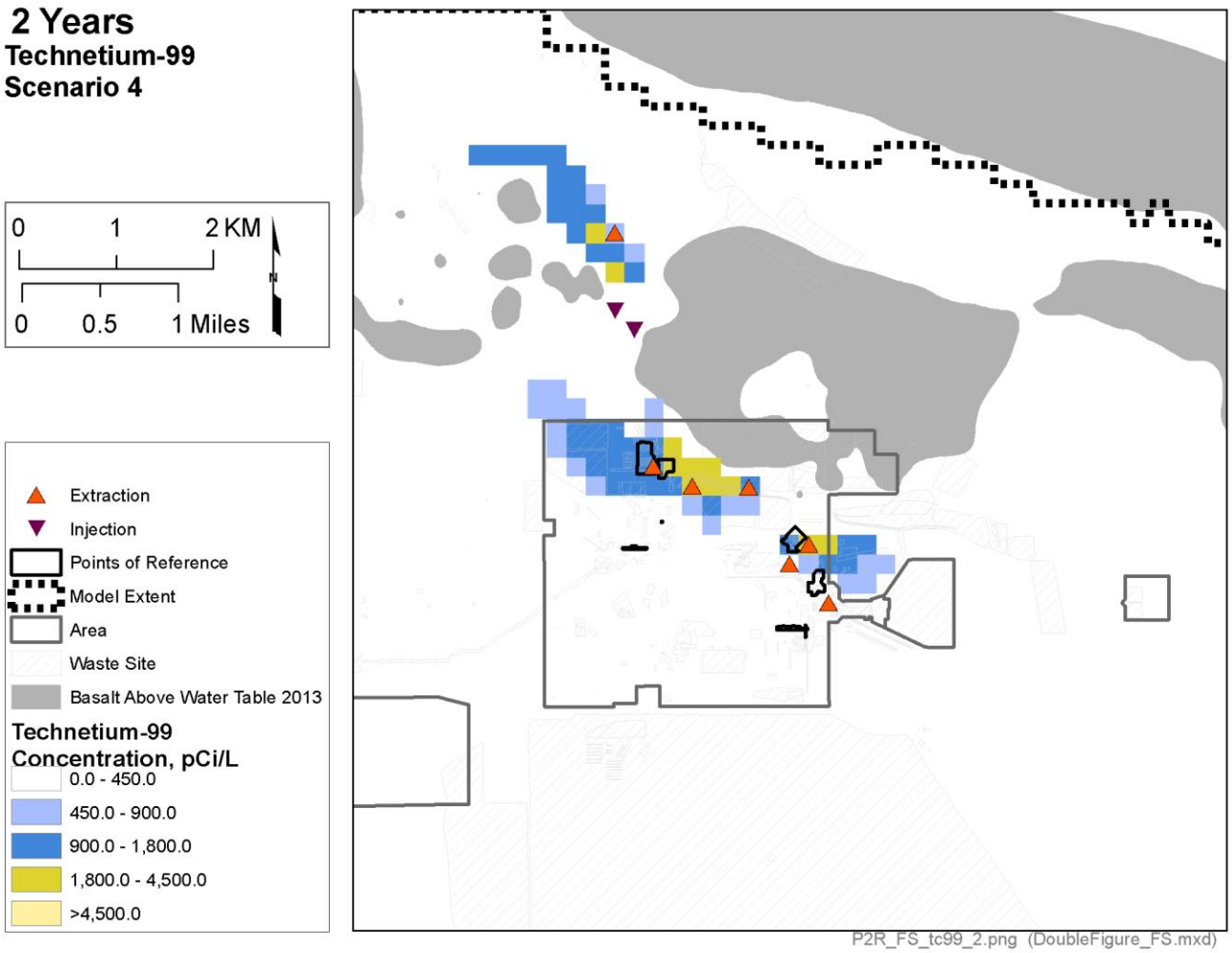

Figure B-171 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 4 simulation.

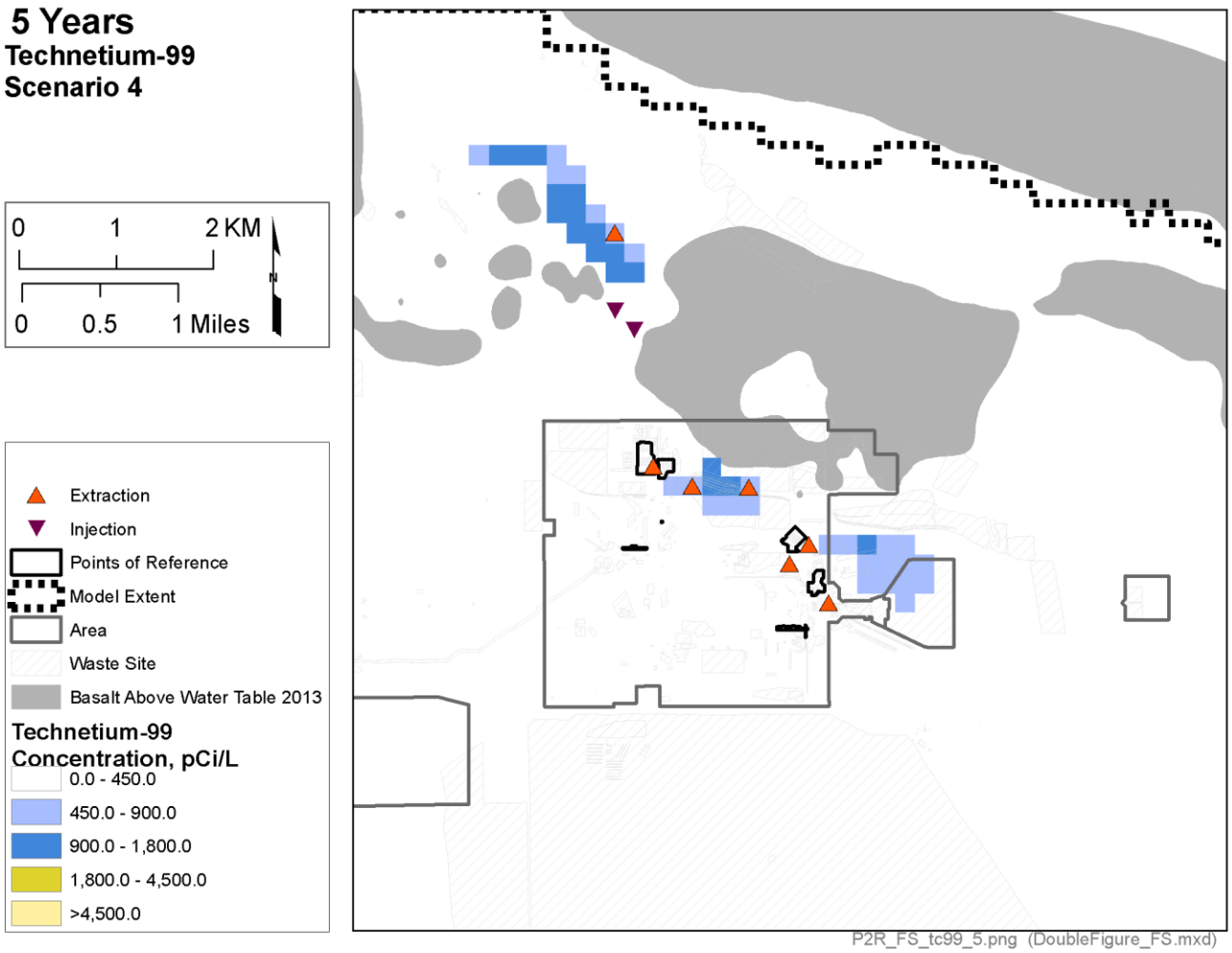

Figure B-172 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 4 simulation.

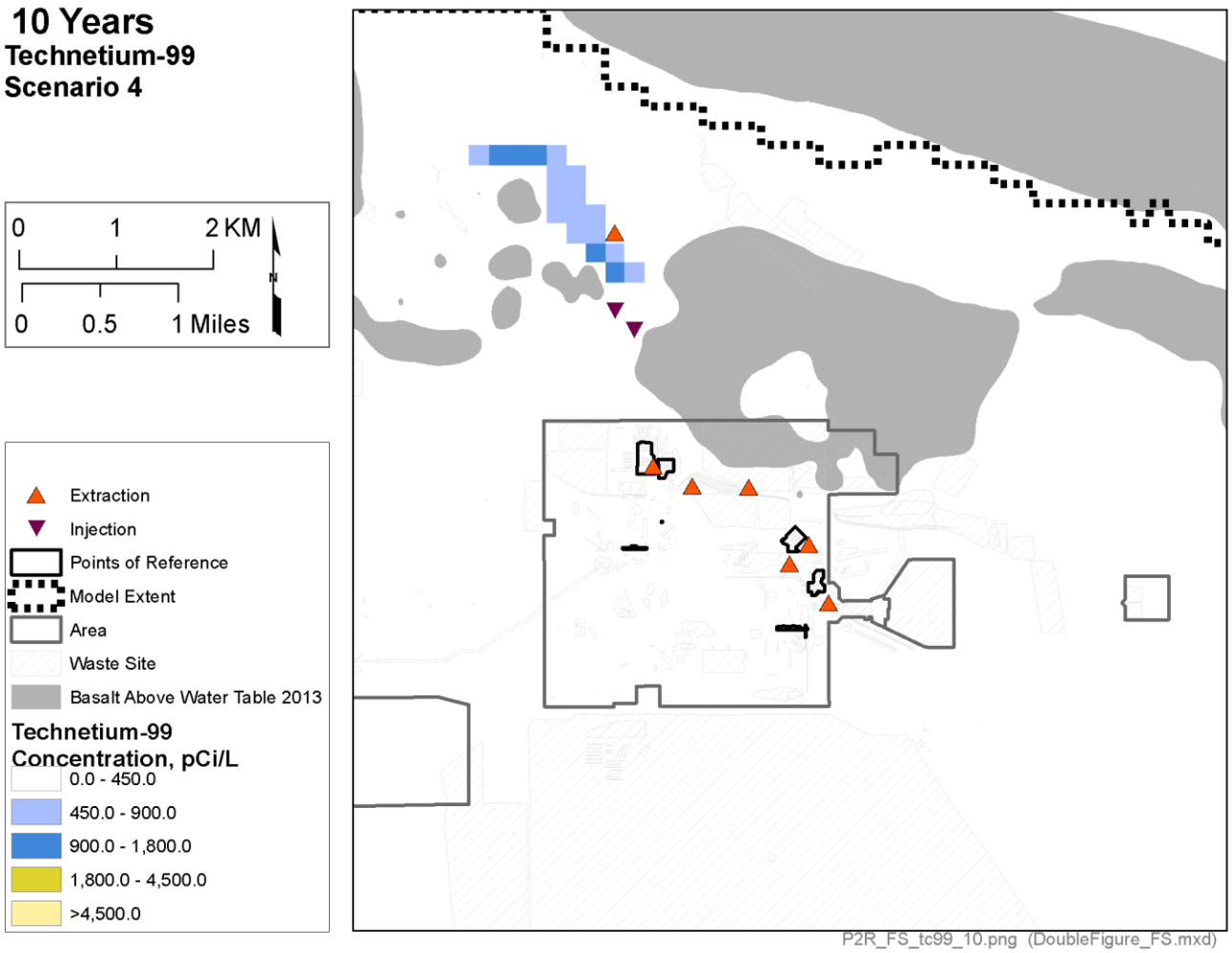

Figure B-173 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 4 simulation.

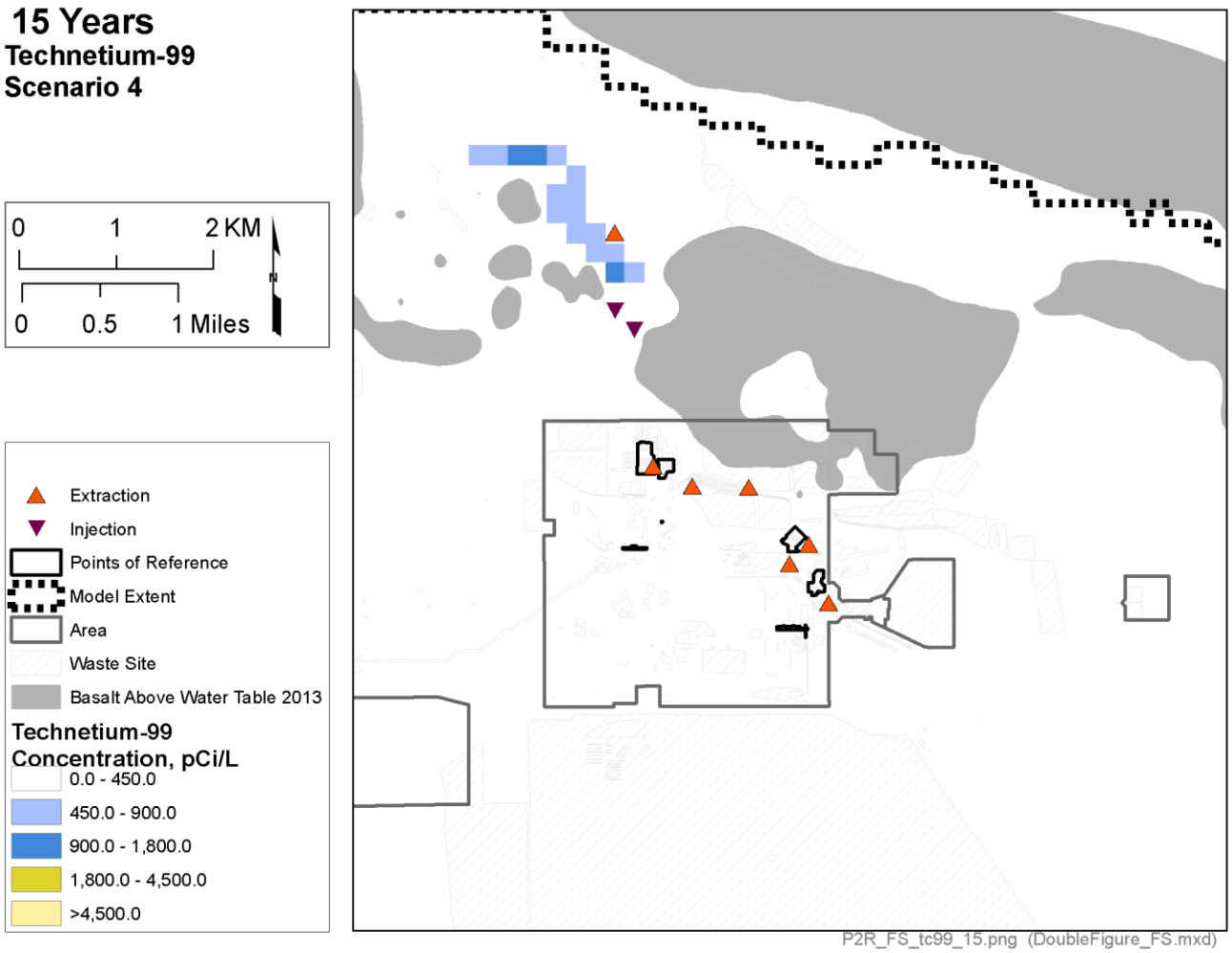

Figure B-174 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 4 simulation.

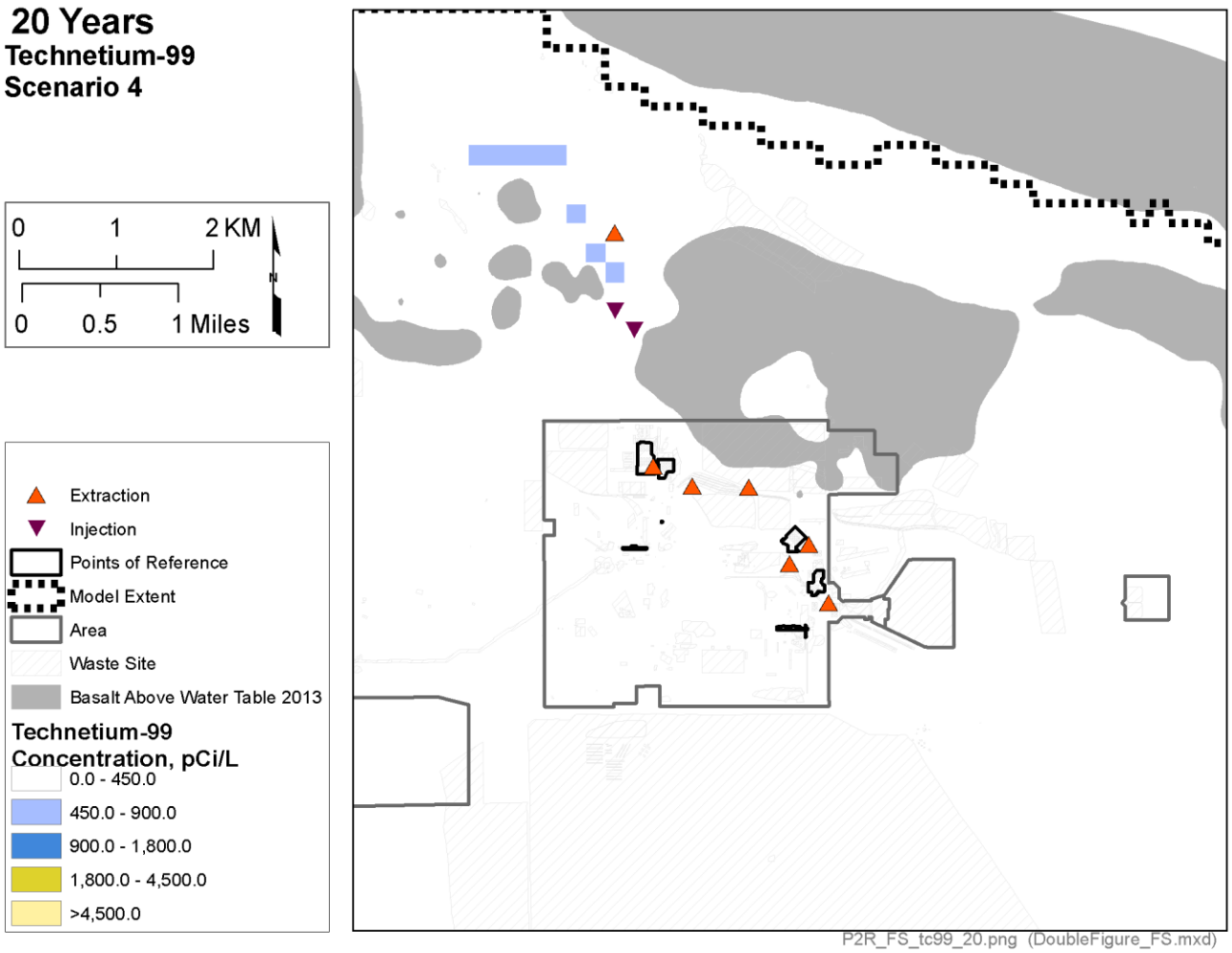

Figure B-175 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 4 simulation.

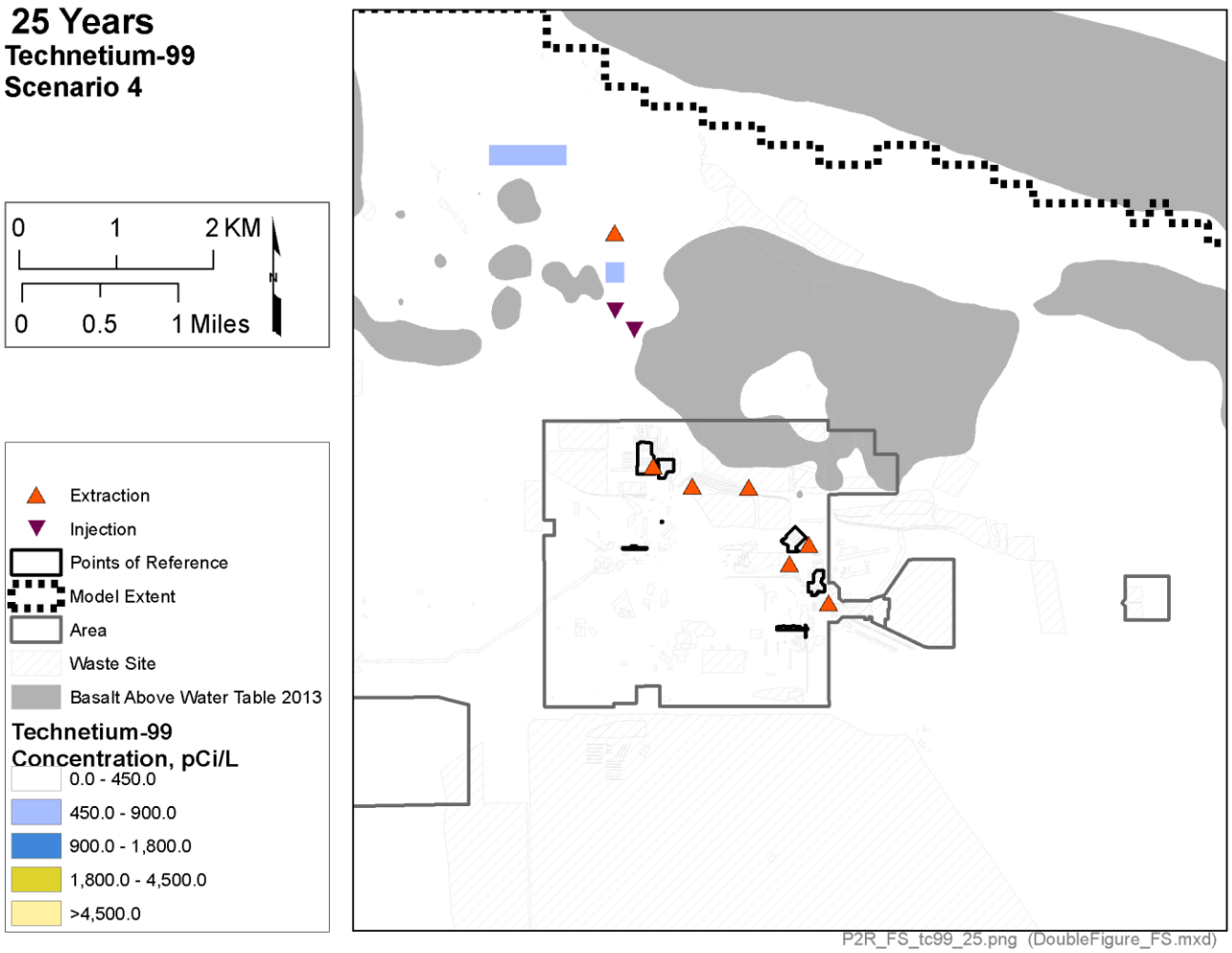

Figure B-176 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 4 simulation.

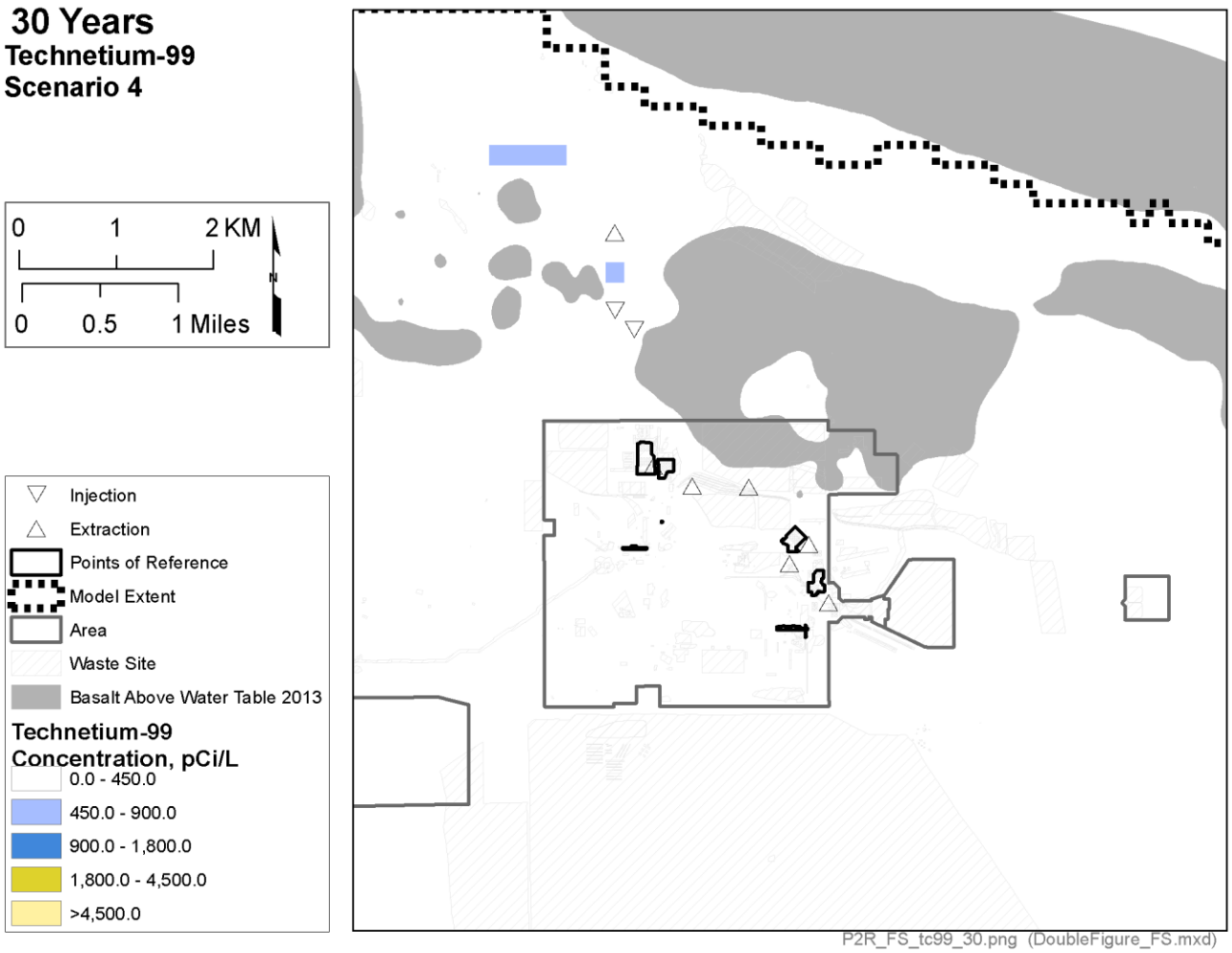

Figure B-177 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 4 simulation.

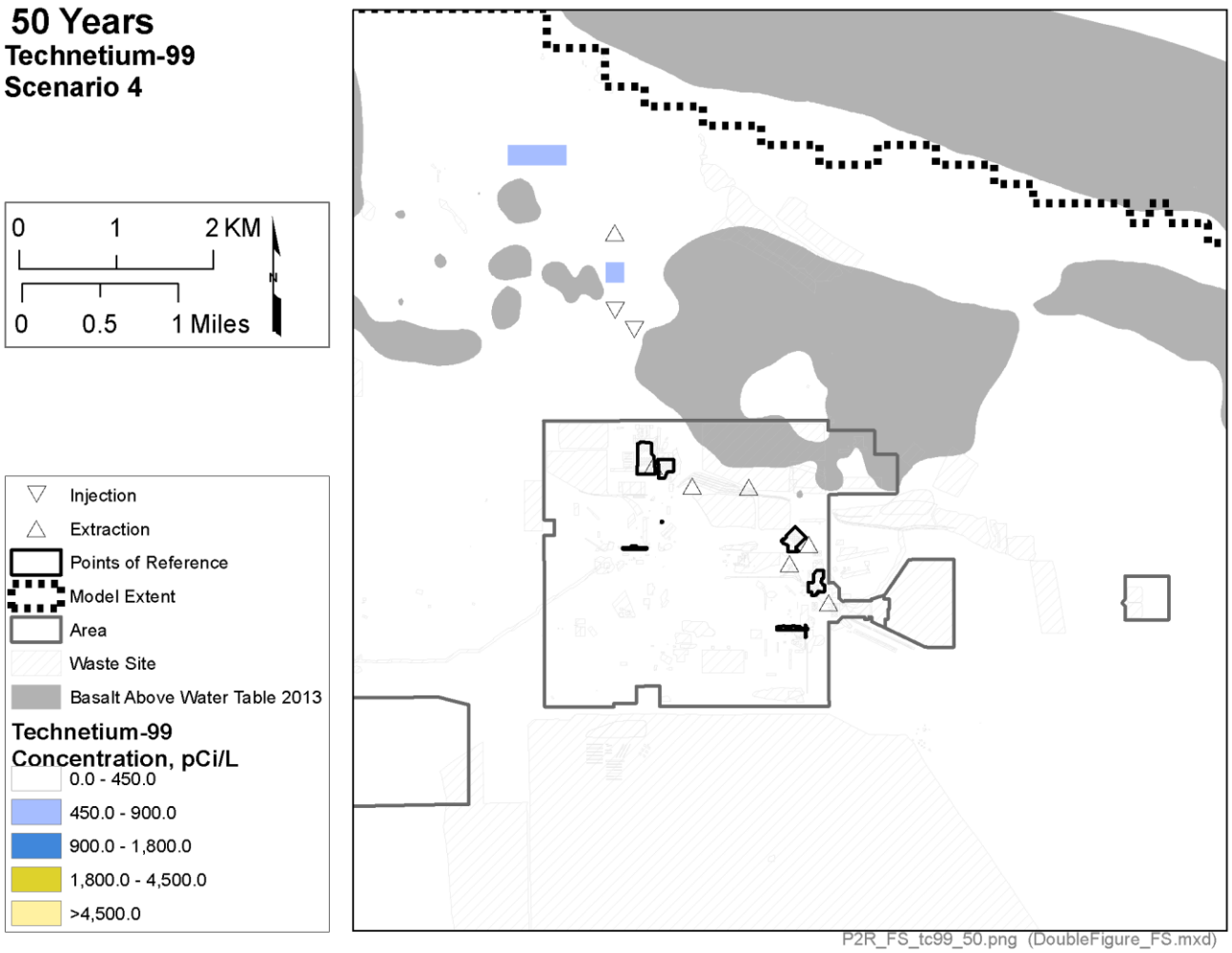

Figure B-178 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 4 simulation.

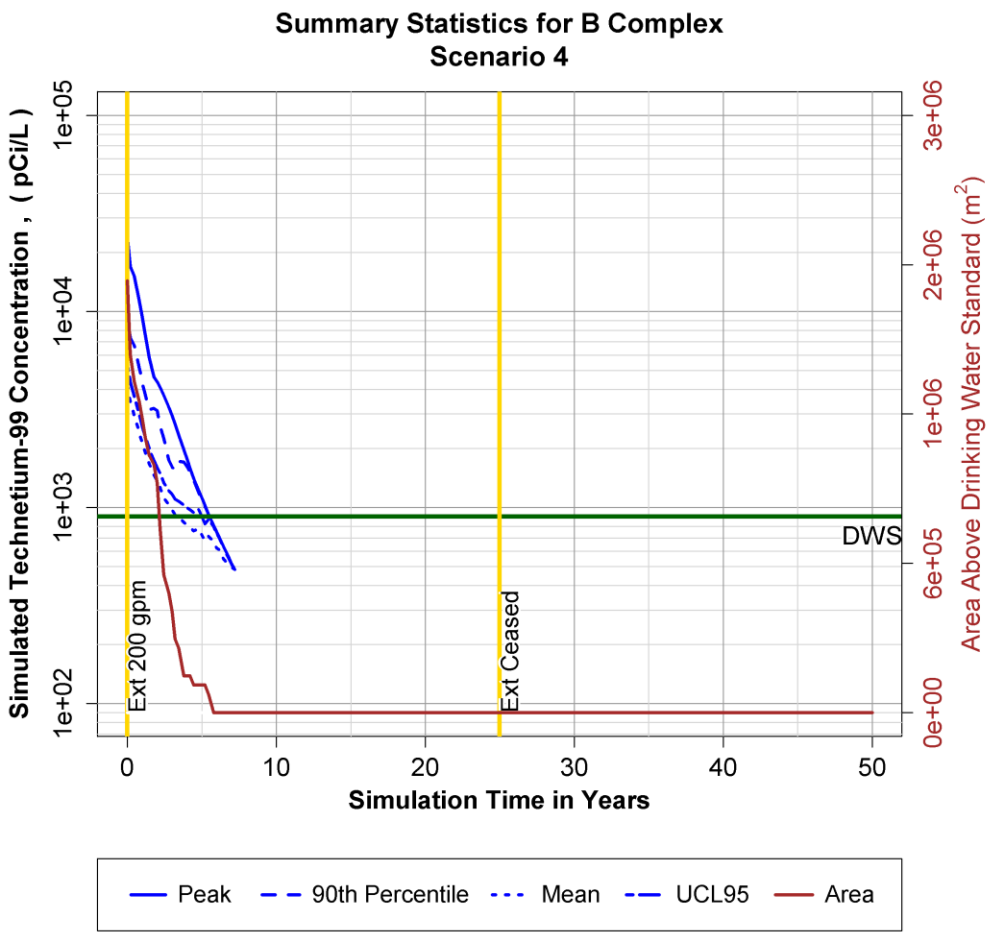

Figure B-179 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

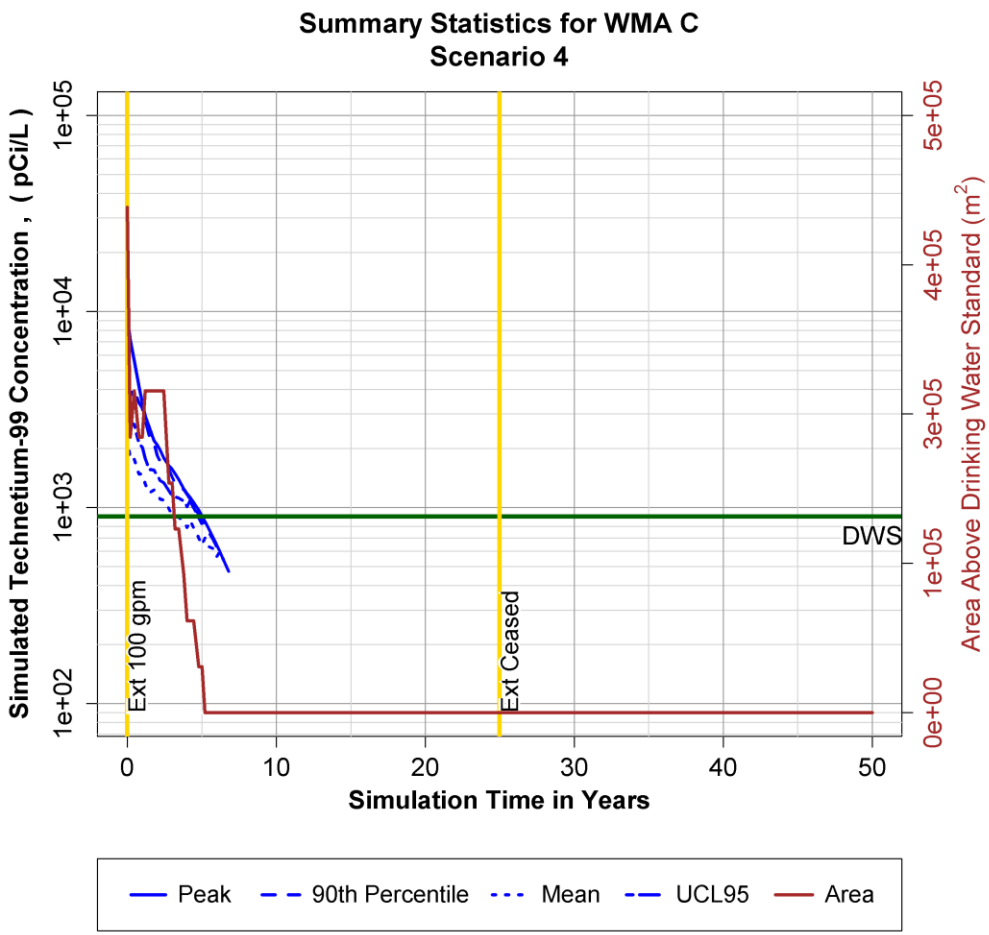

Figure B-180 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

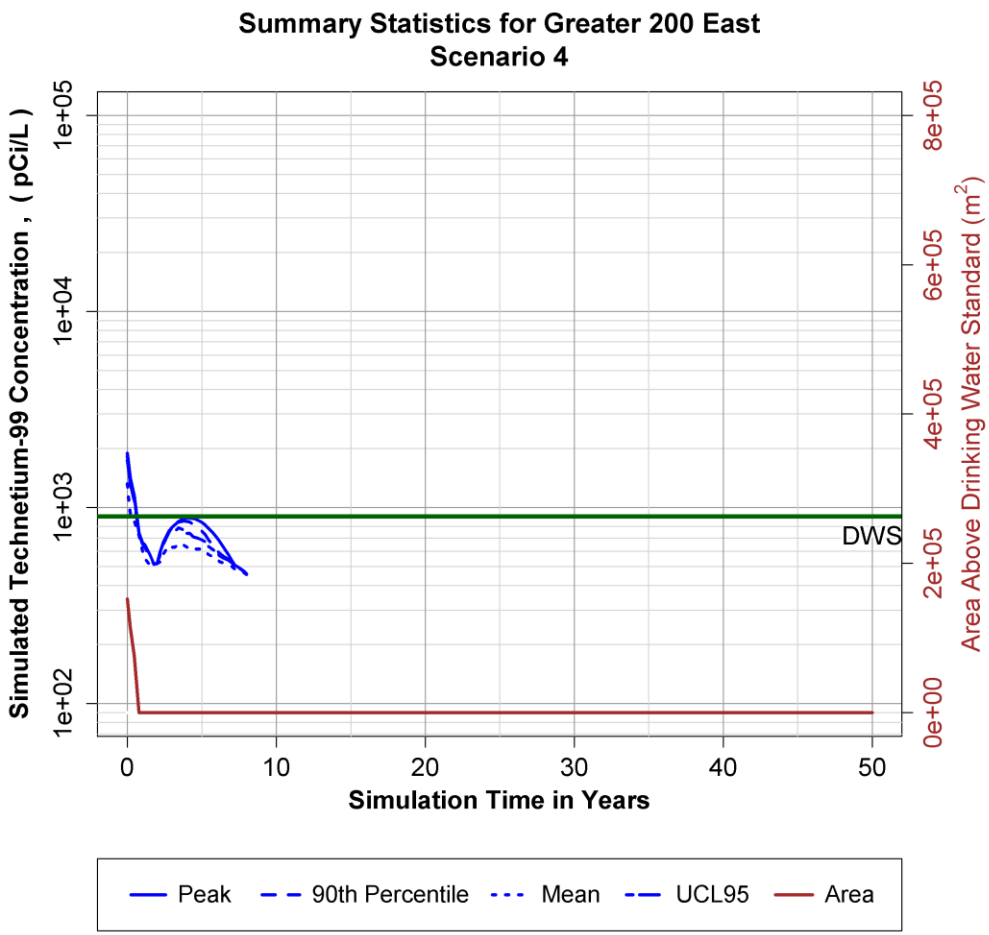

Figure B-181 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

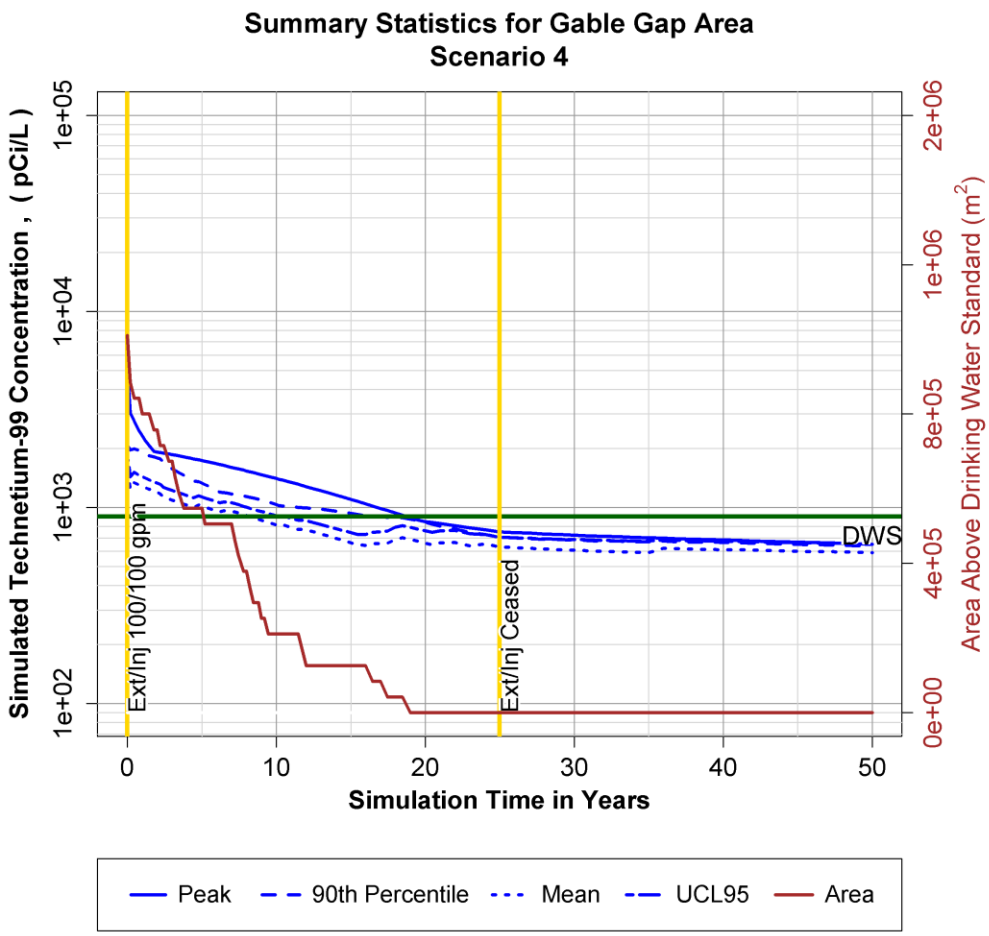

Figure B-182 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation.

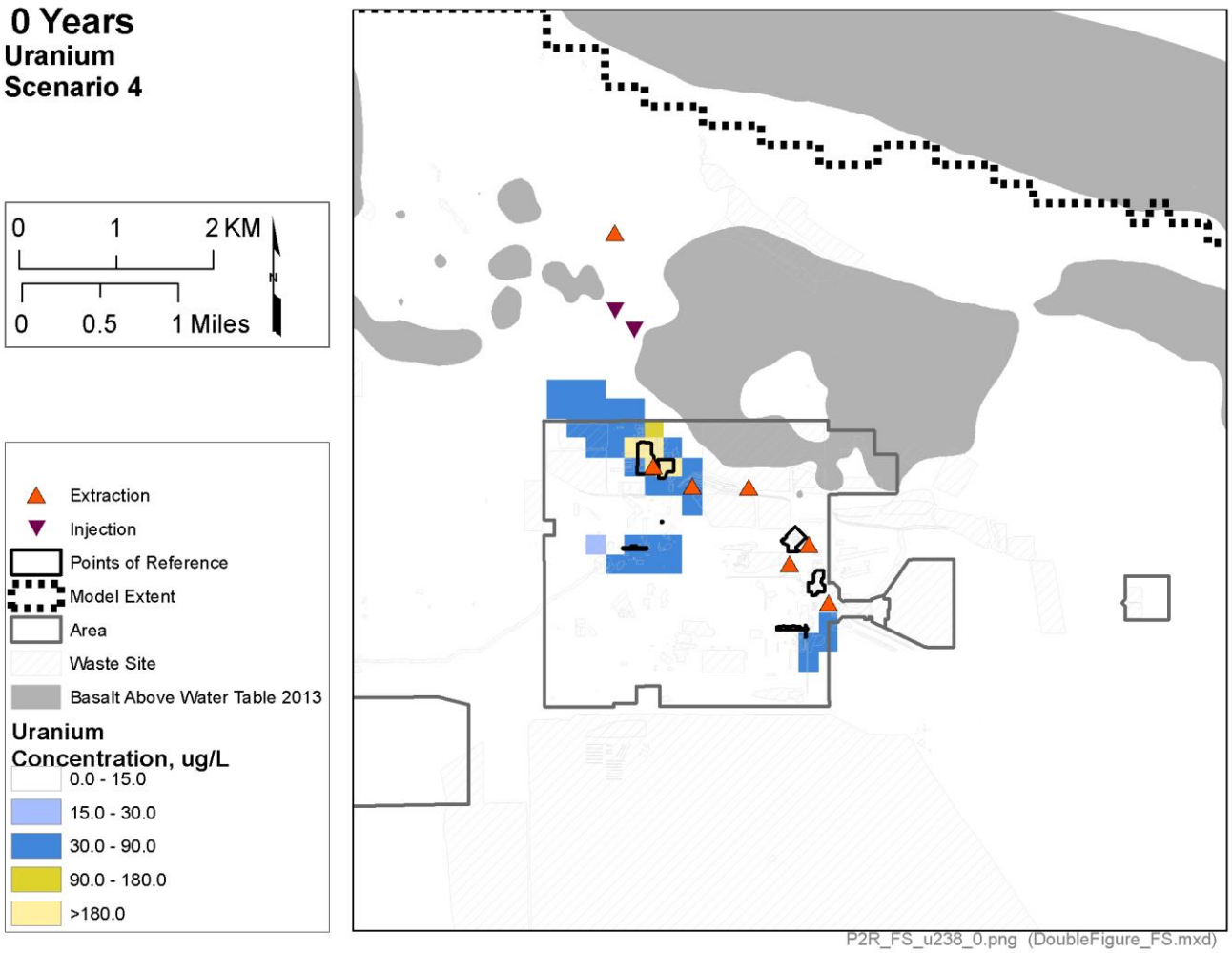

Figure B-183 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 4 simulation.

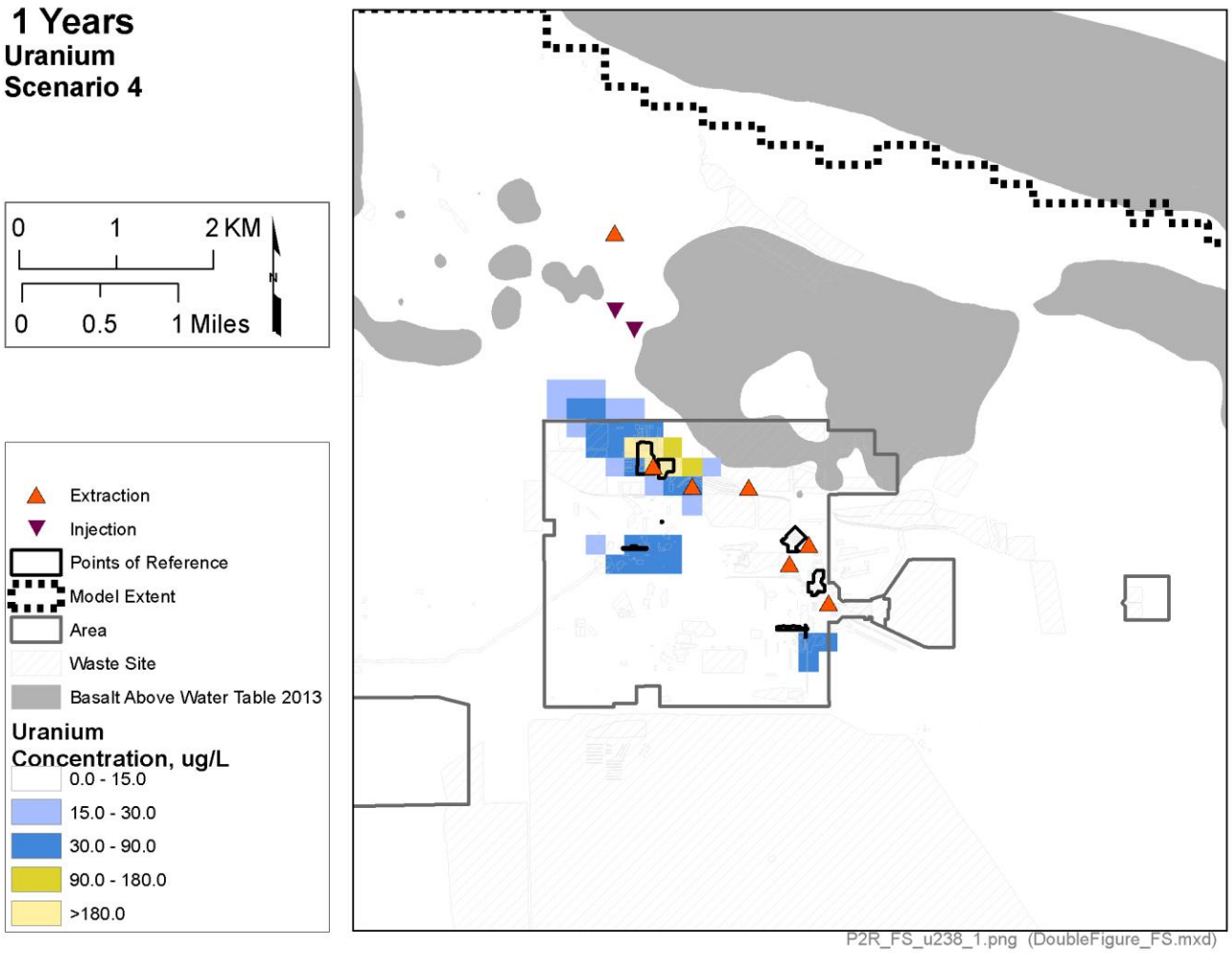

Figure B-184 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 4 simulation.

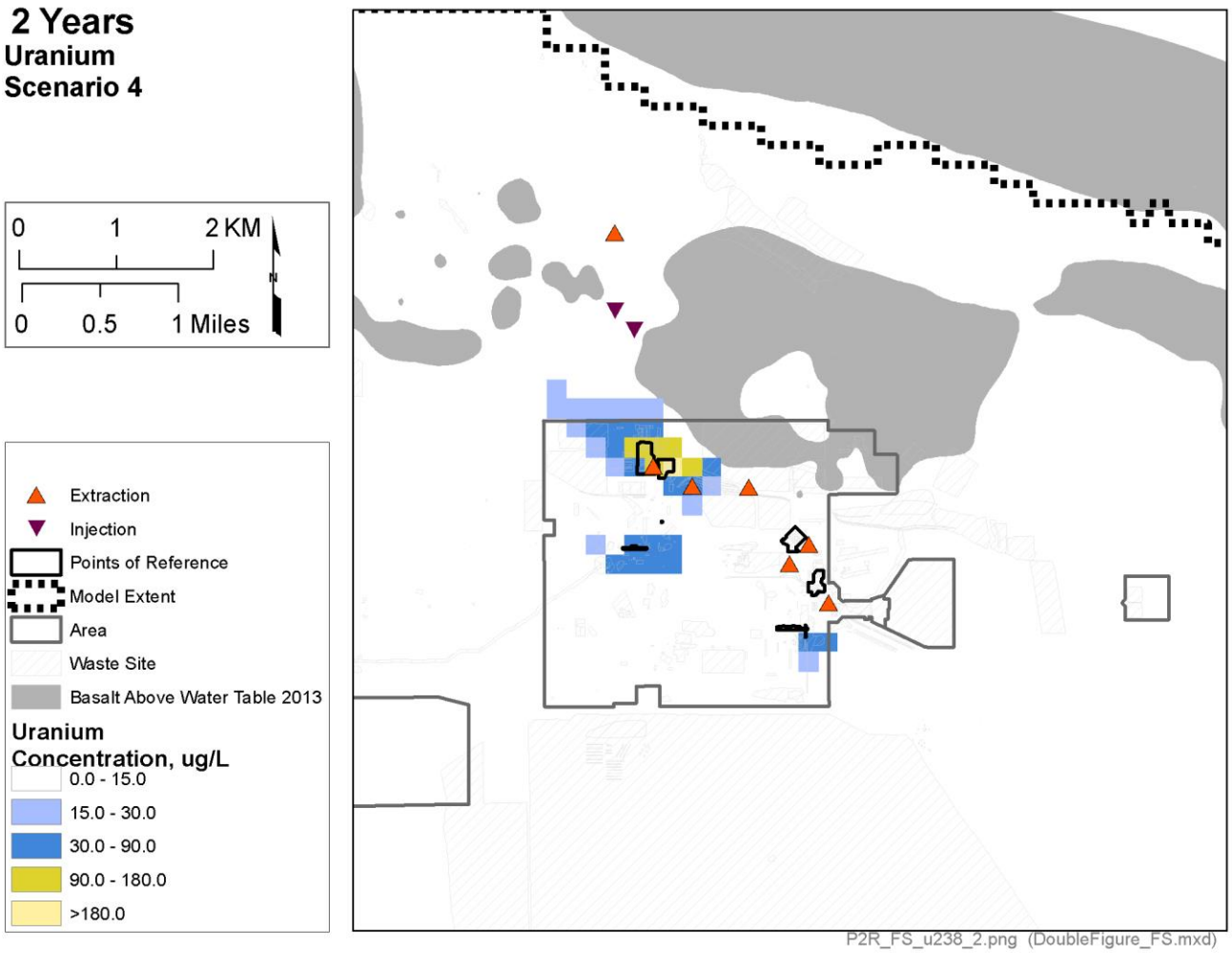

Figure B-185 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 4 simulation.

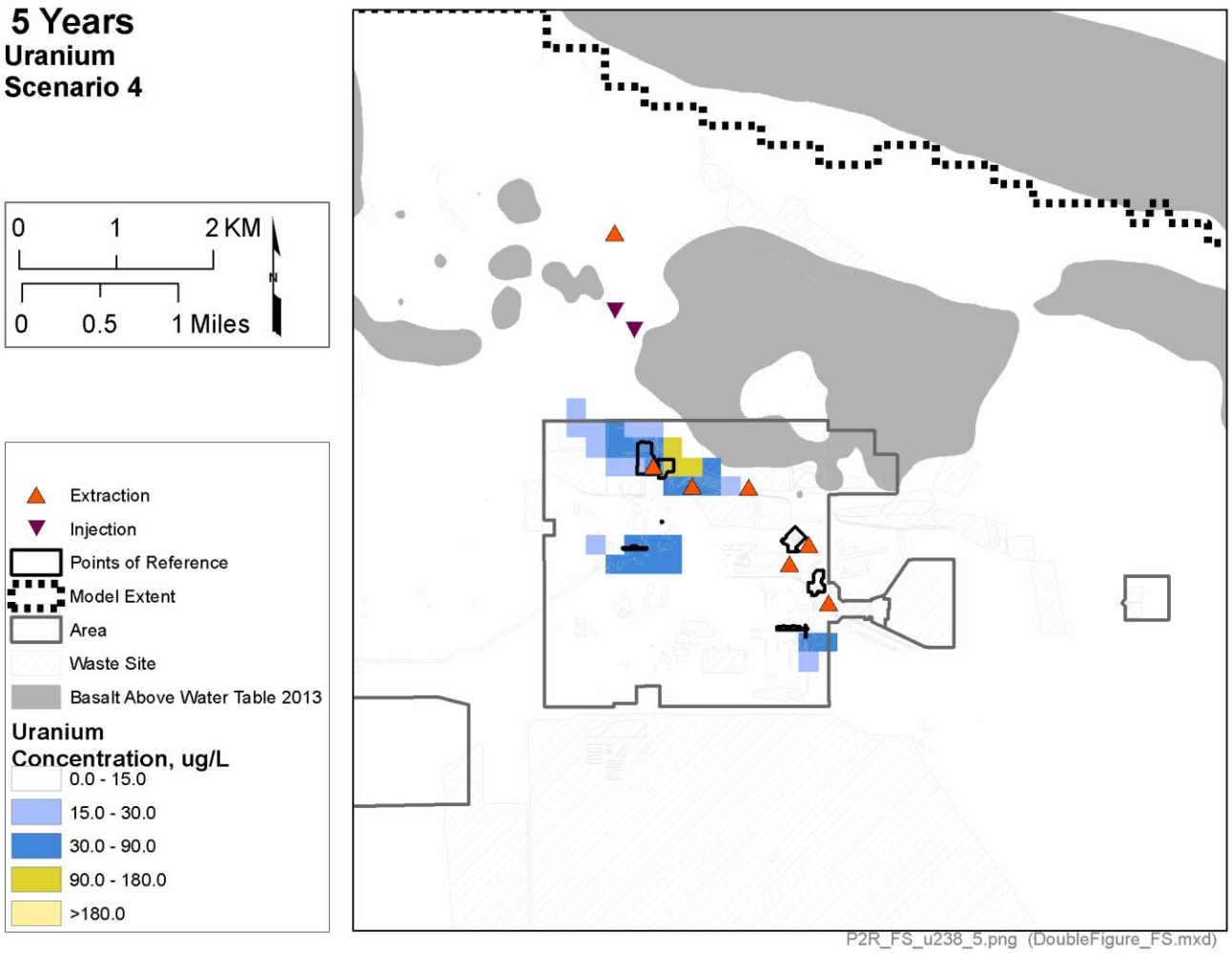

Figure B-186 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 4 simulation.

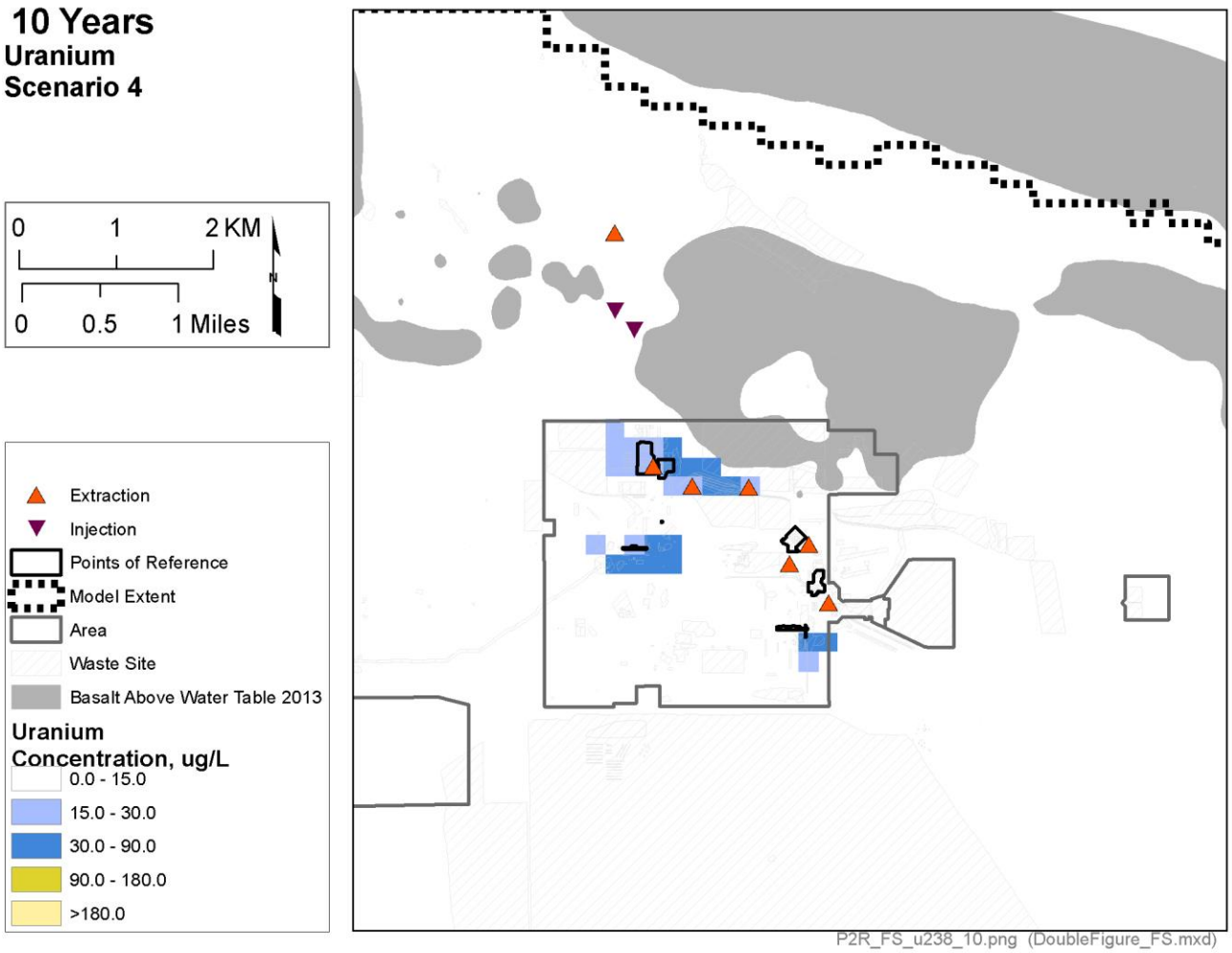

Figure B-187 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 4 simulation.

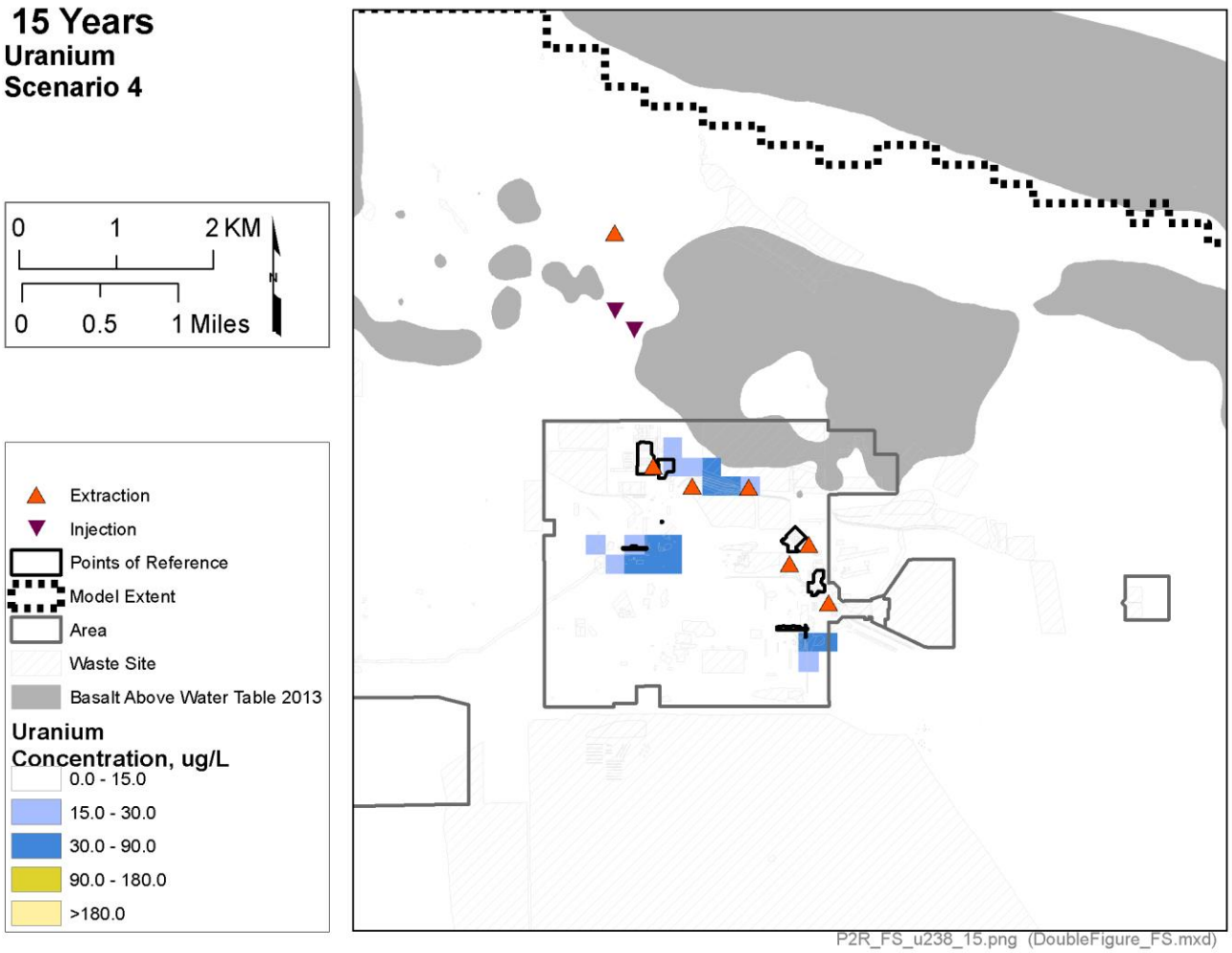

Figure B-188 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 4 simulation.

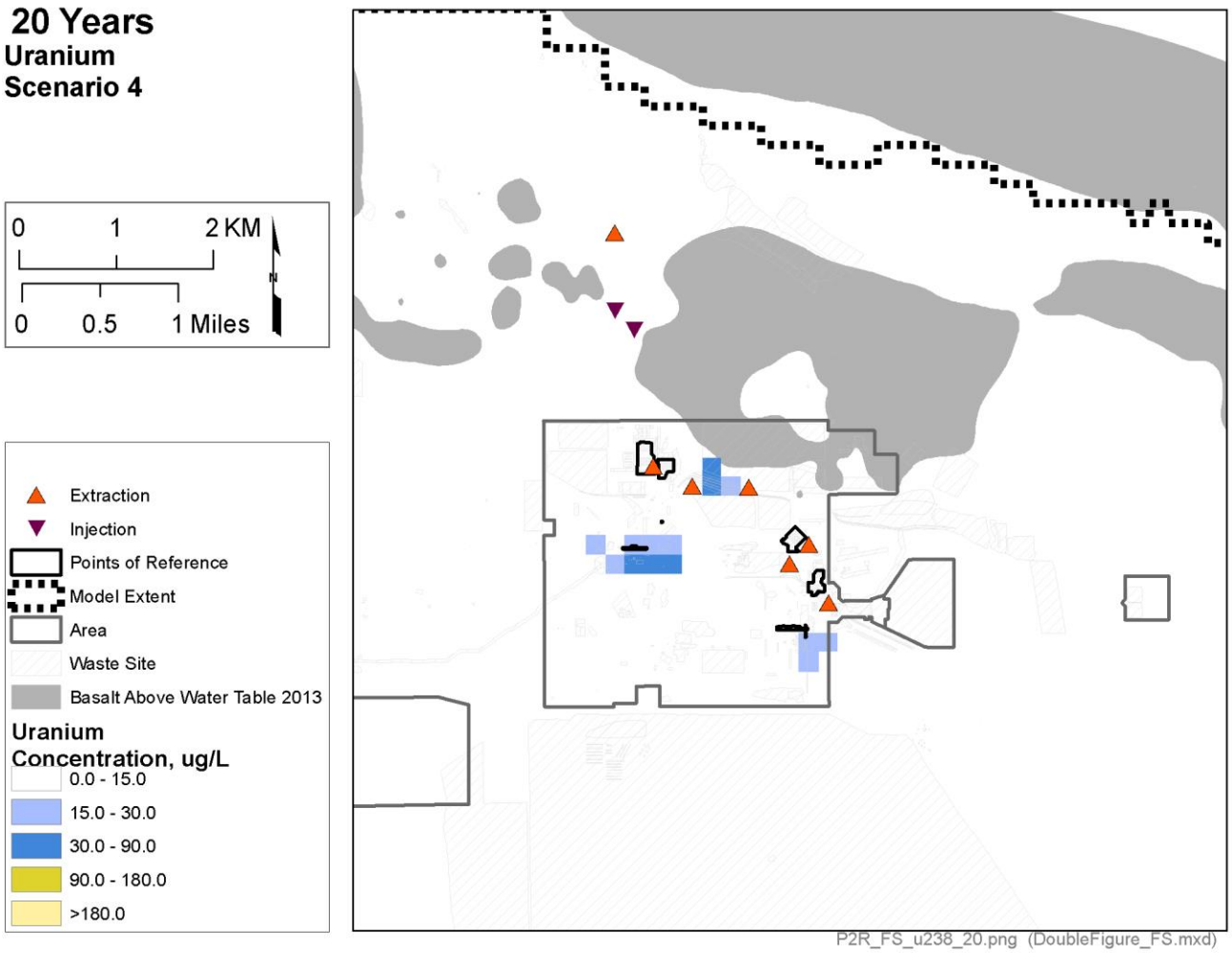

Figure B-189 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 4 simulation.

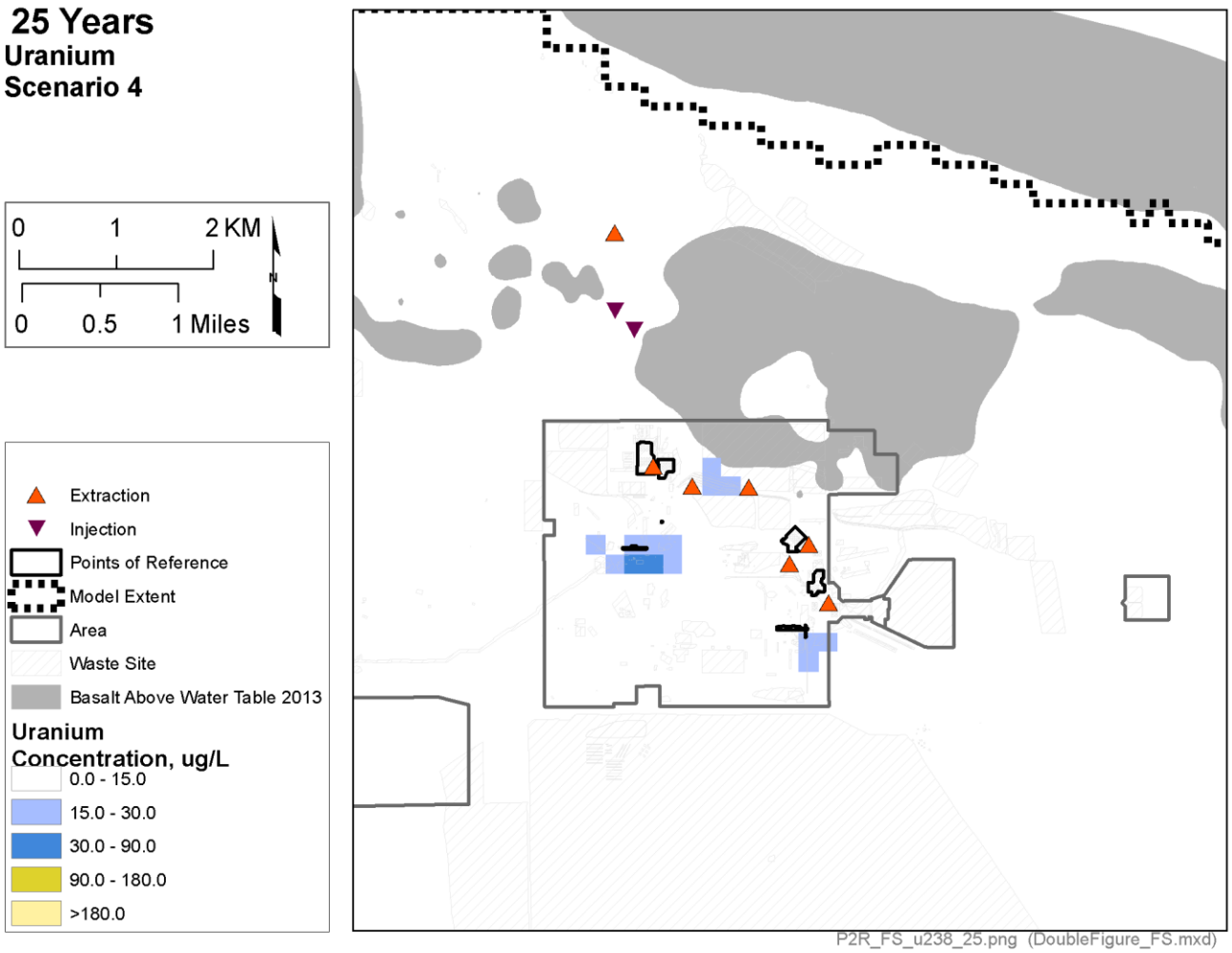

Figure B-190 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 4 simulation.

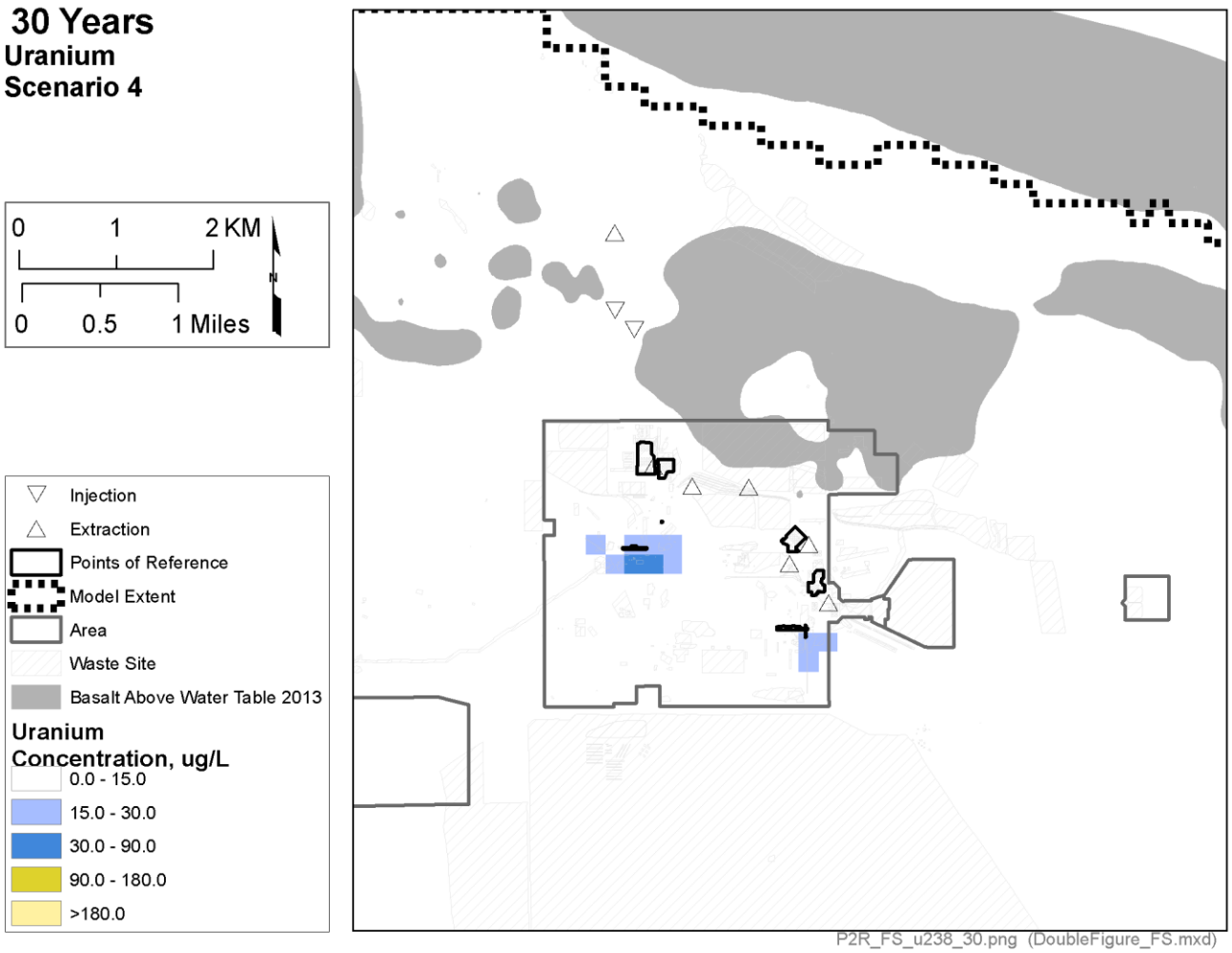

Figure B-191 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 4 simulation.

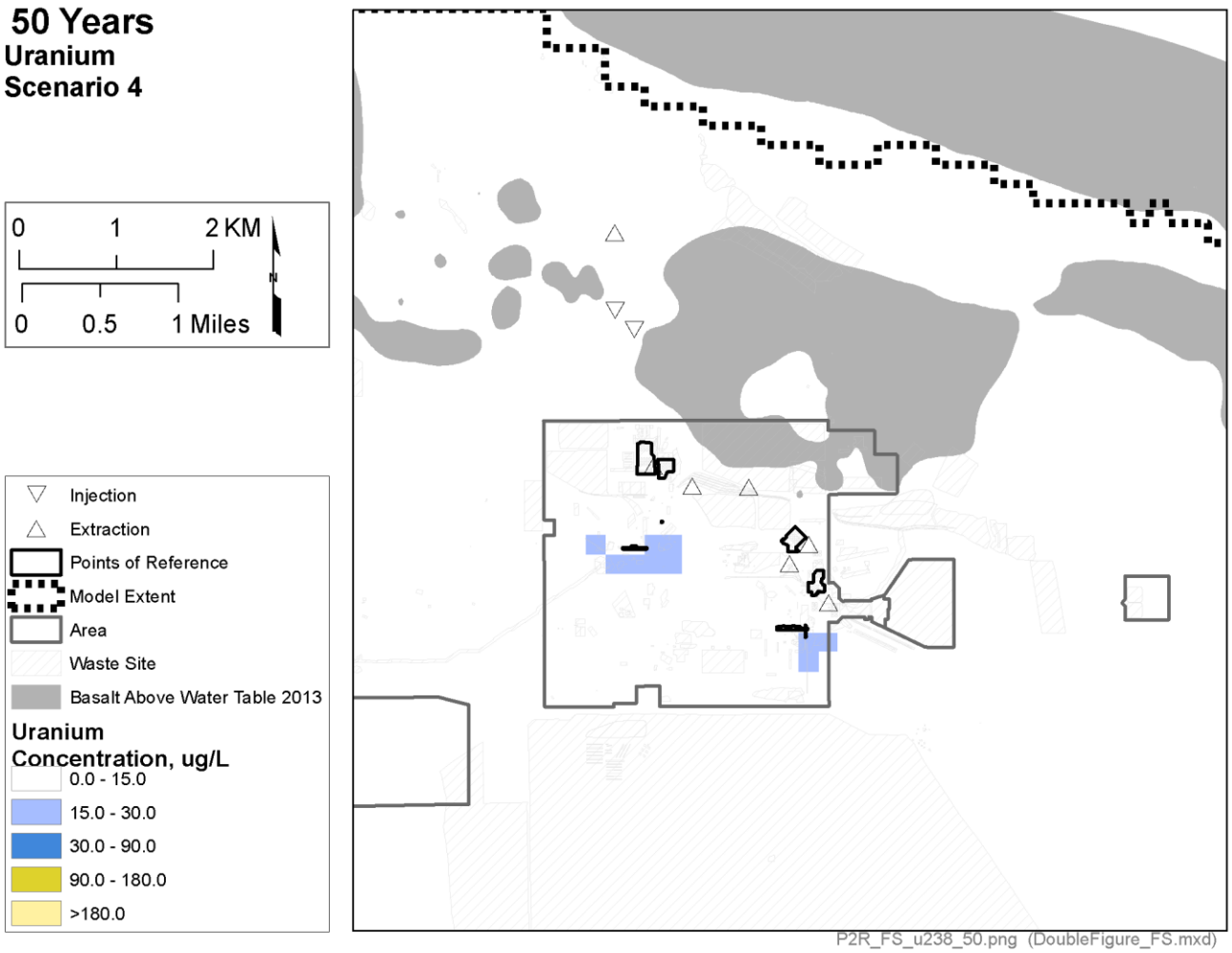

Figure B-192 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 4 simulation.

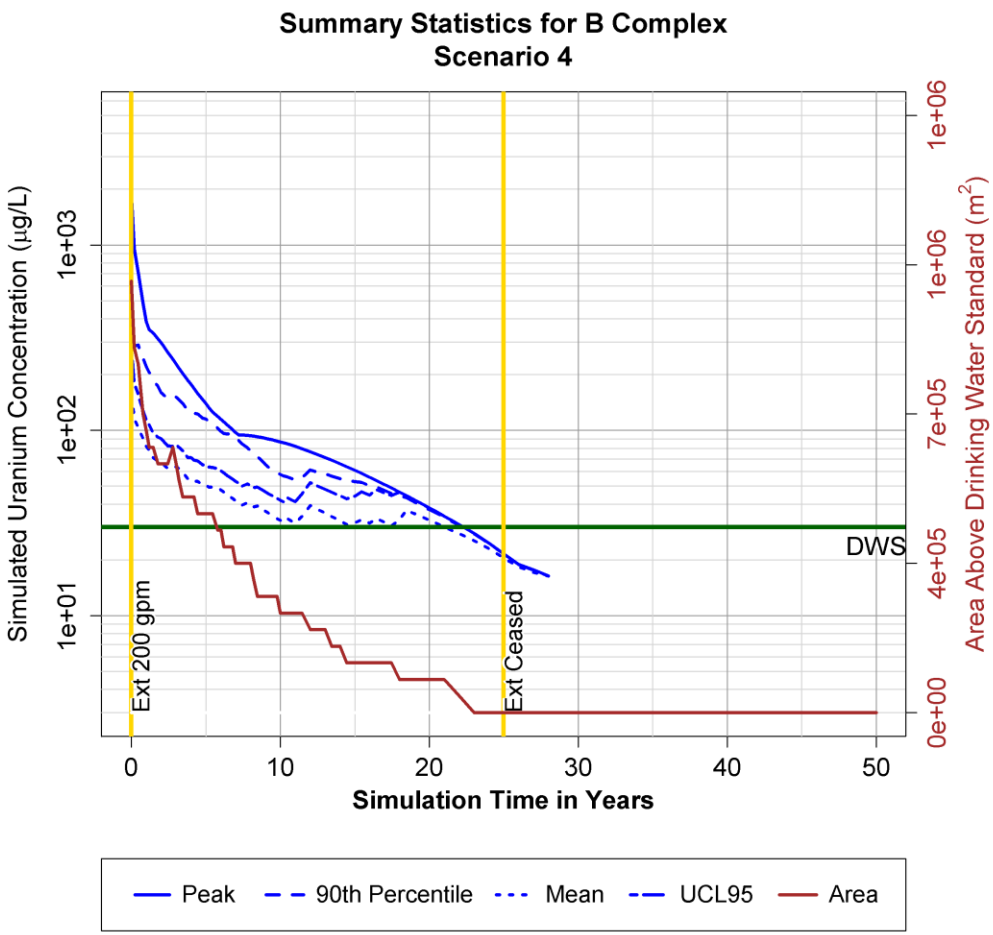

Figure B-193 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

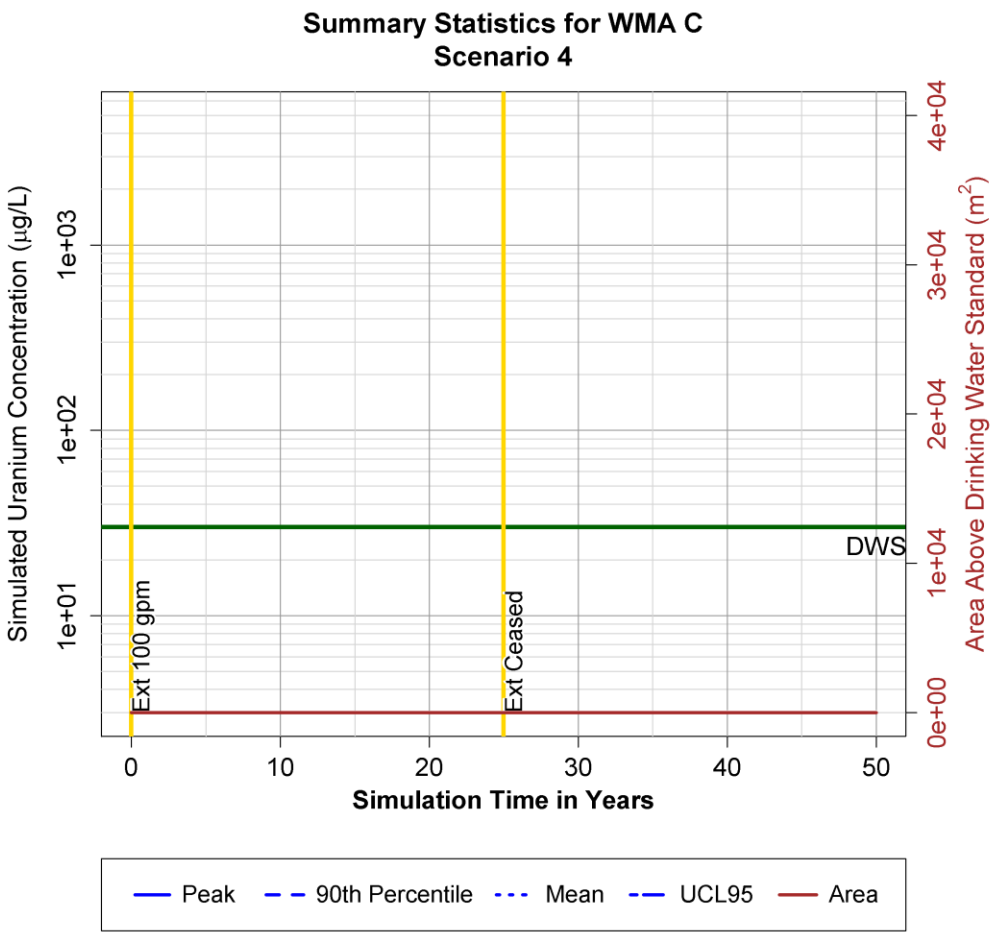

Figure B-194 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

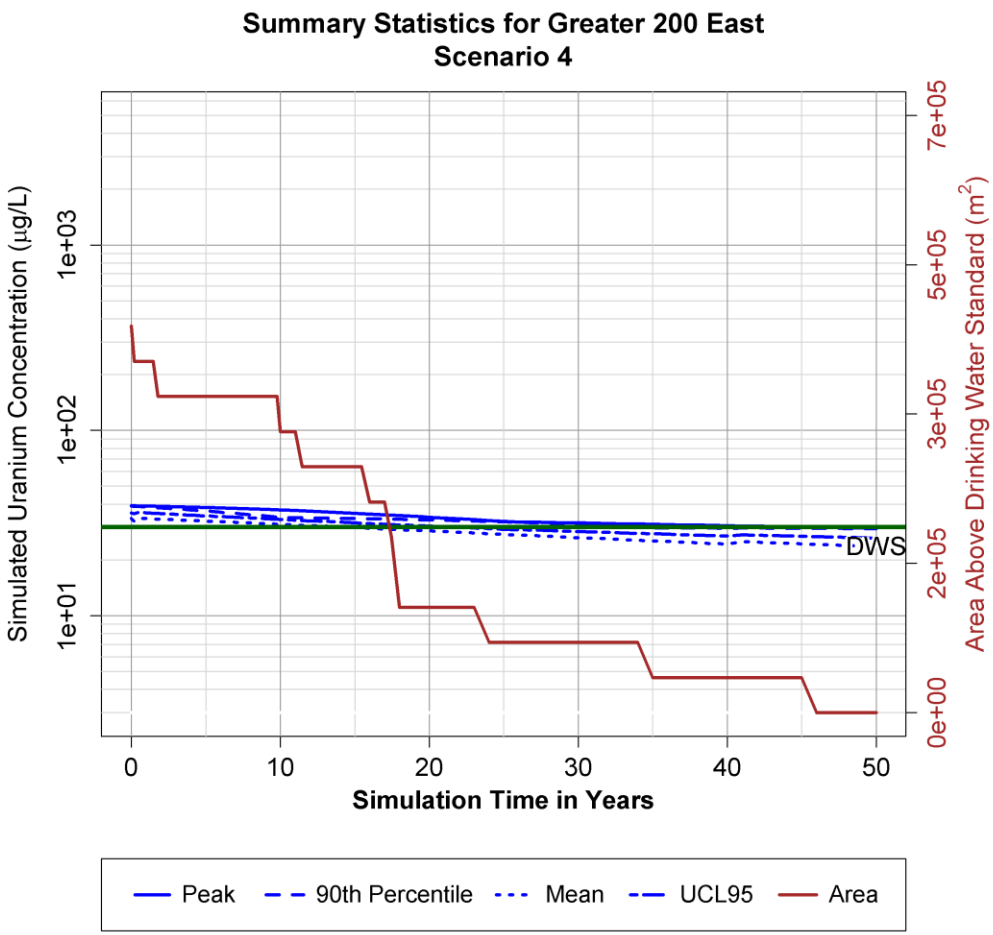

Figure B-195 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

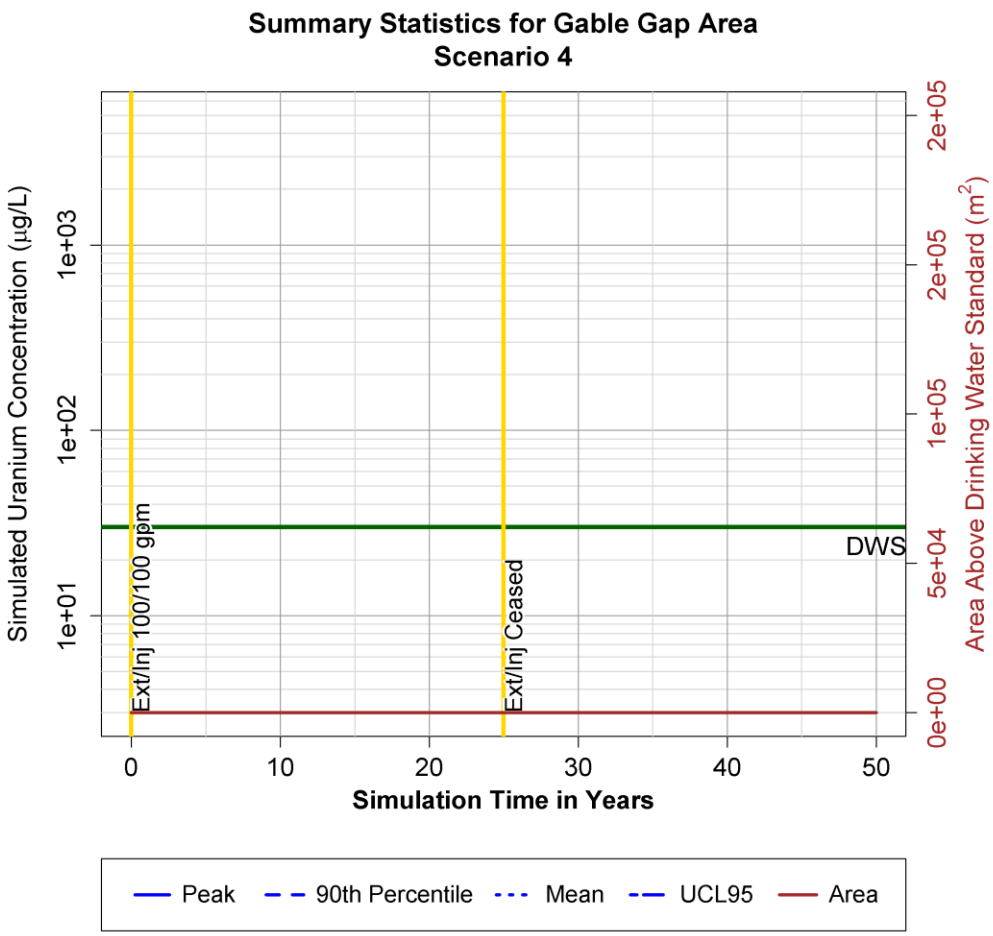

Figure B-196 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation.

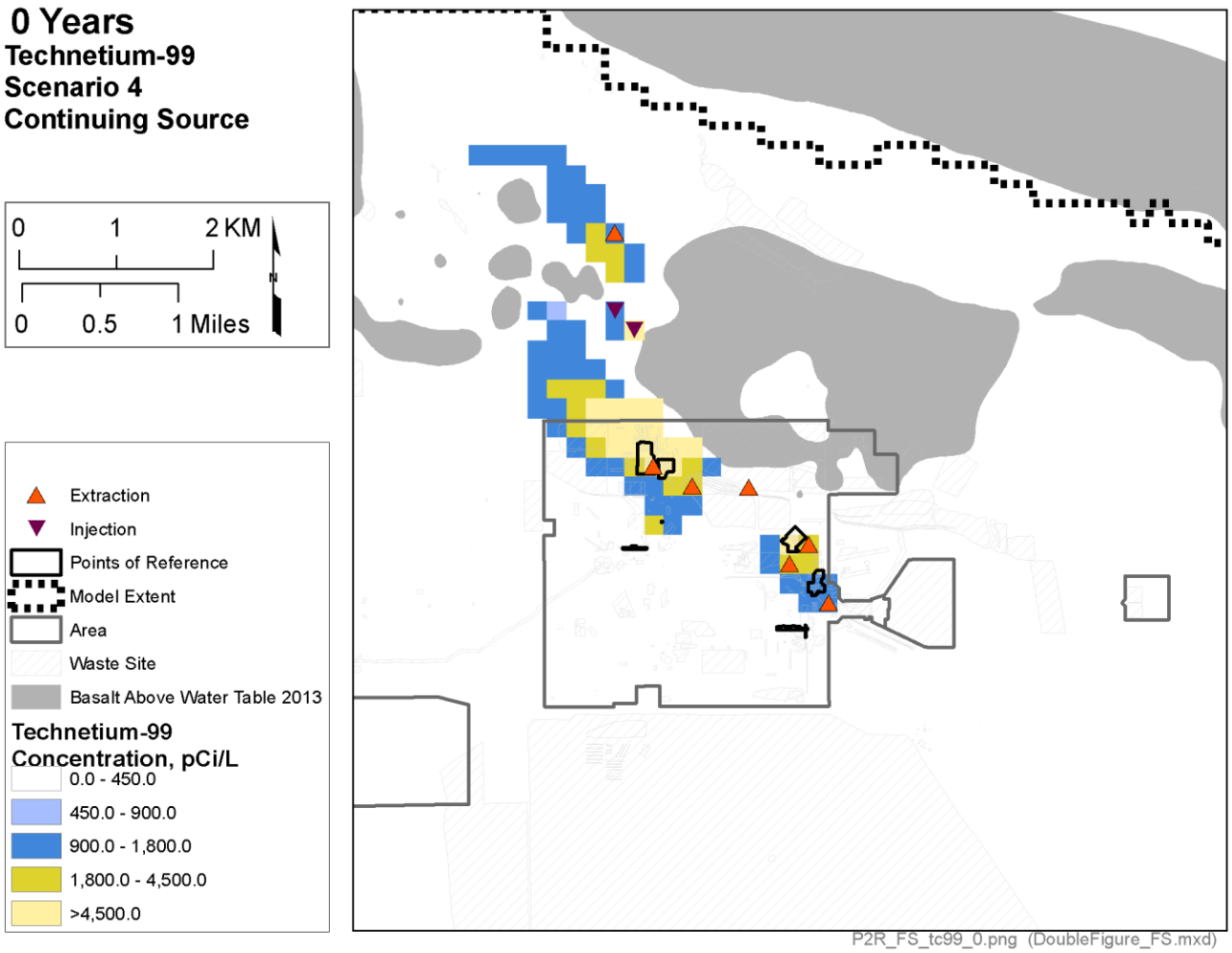

Figure B-197 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 4 simulation with a continuing source term.

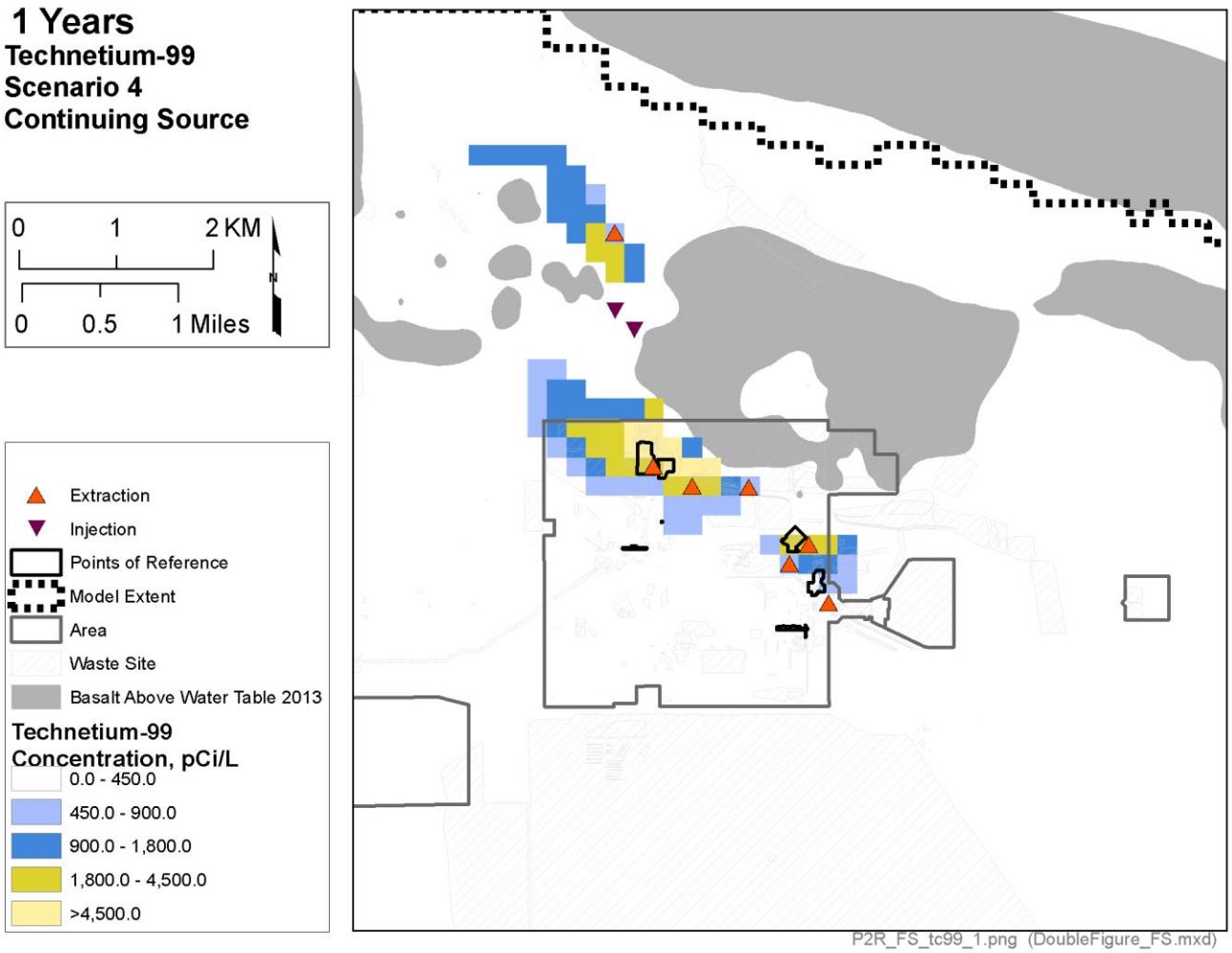

Figure B-198 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 4 simulation with a continuing source term.

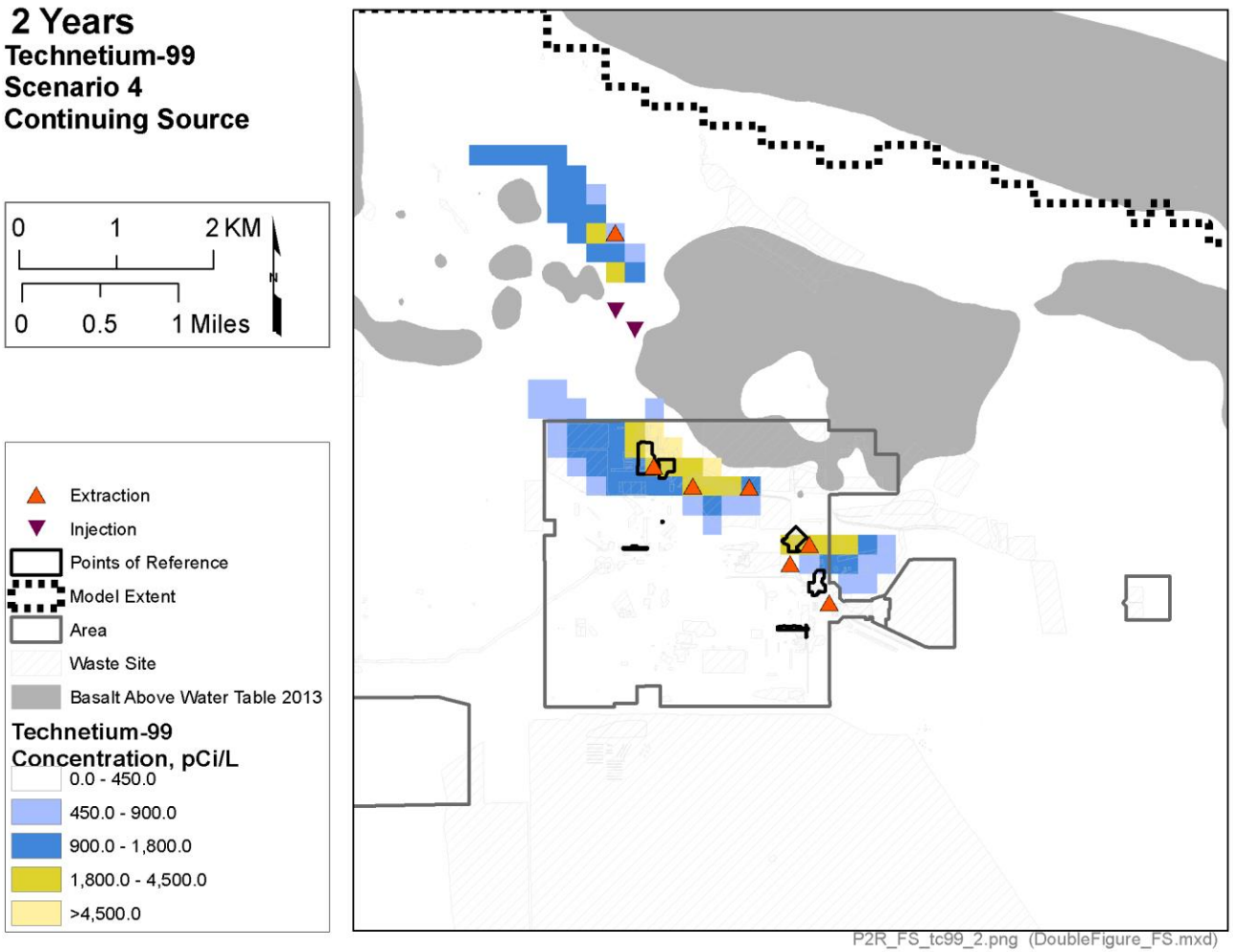

Figure B-199 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 4 simulation with a continuing source term.

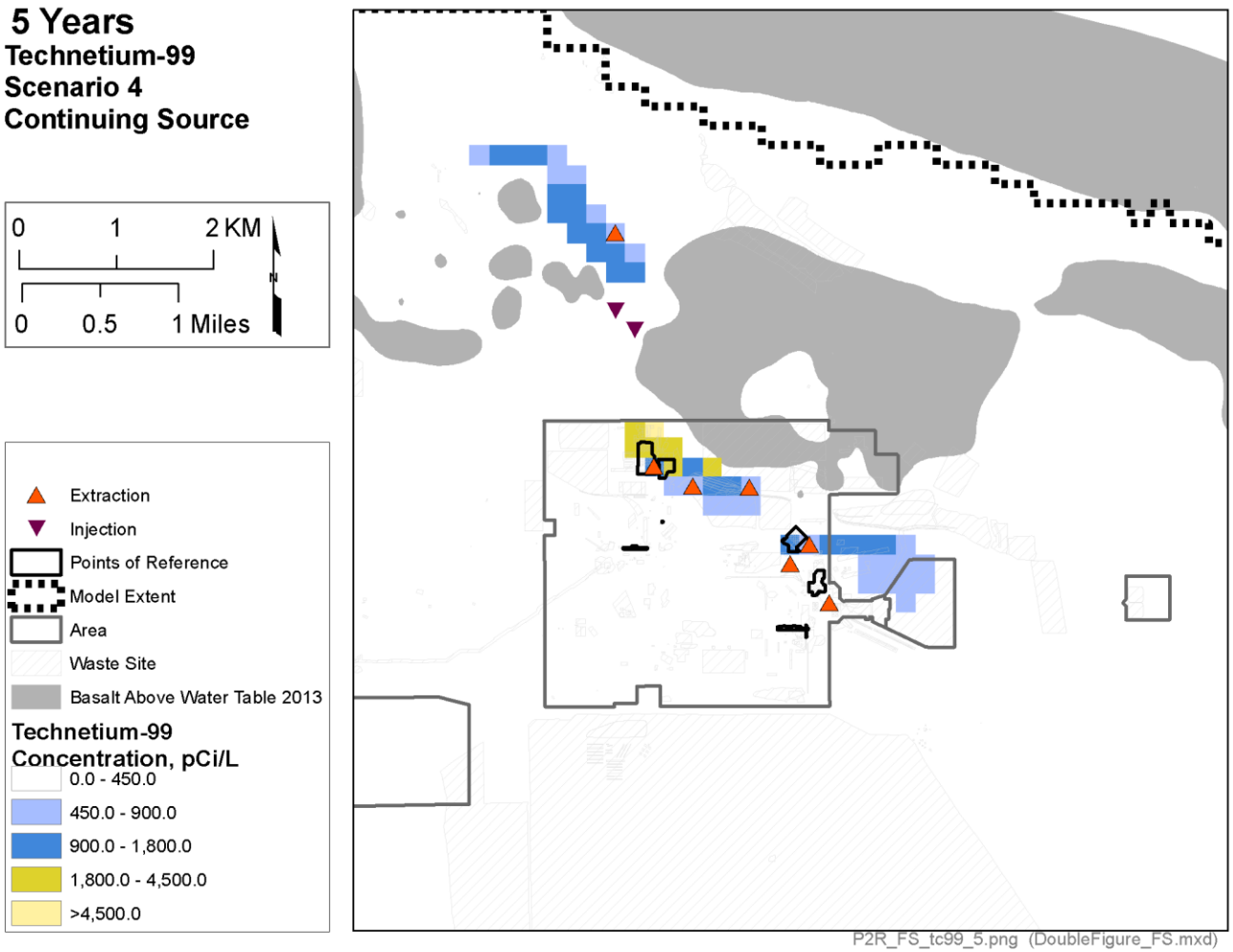

Figure B-200 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 4 simulation with a continuing source term.

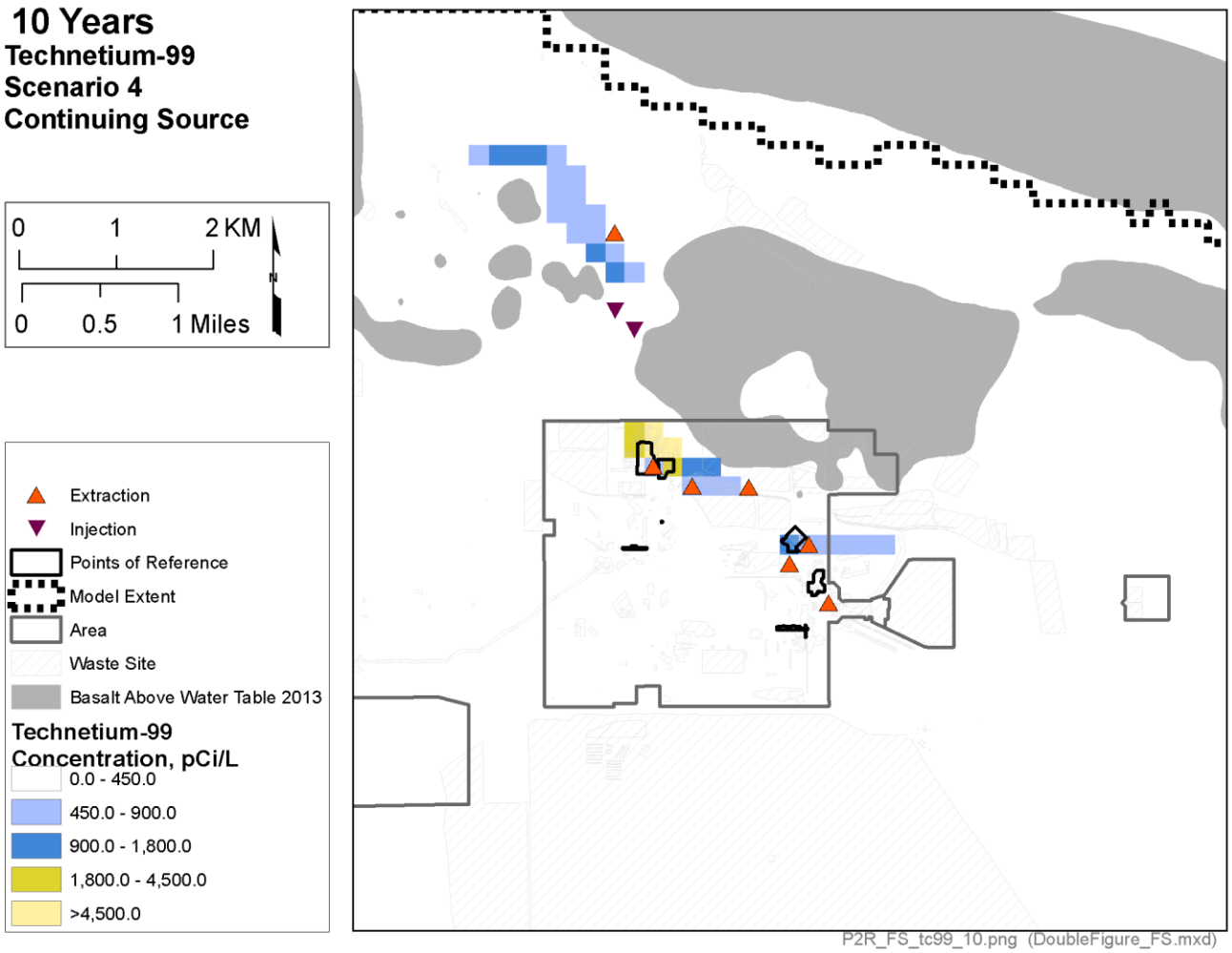

Figure B-201 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 4 simulation with a continuing source term.

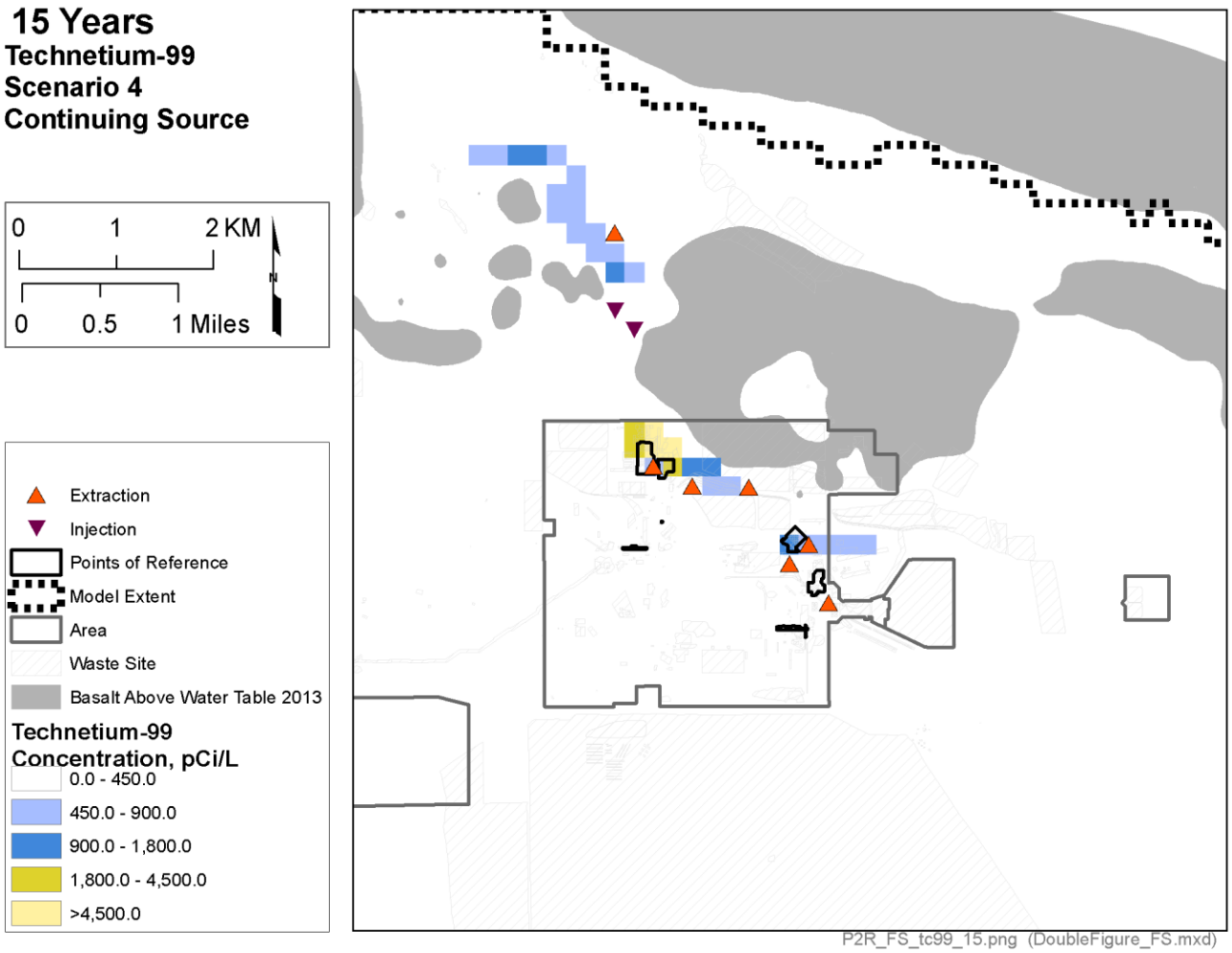

Figure B-202 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 4 simulation with a continuing source term.

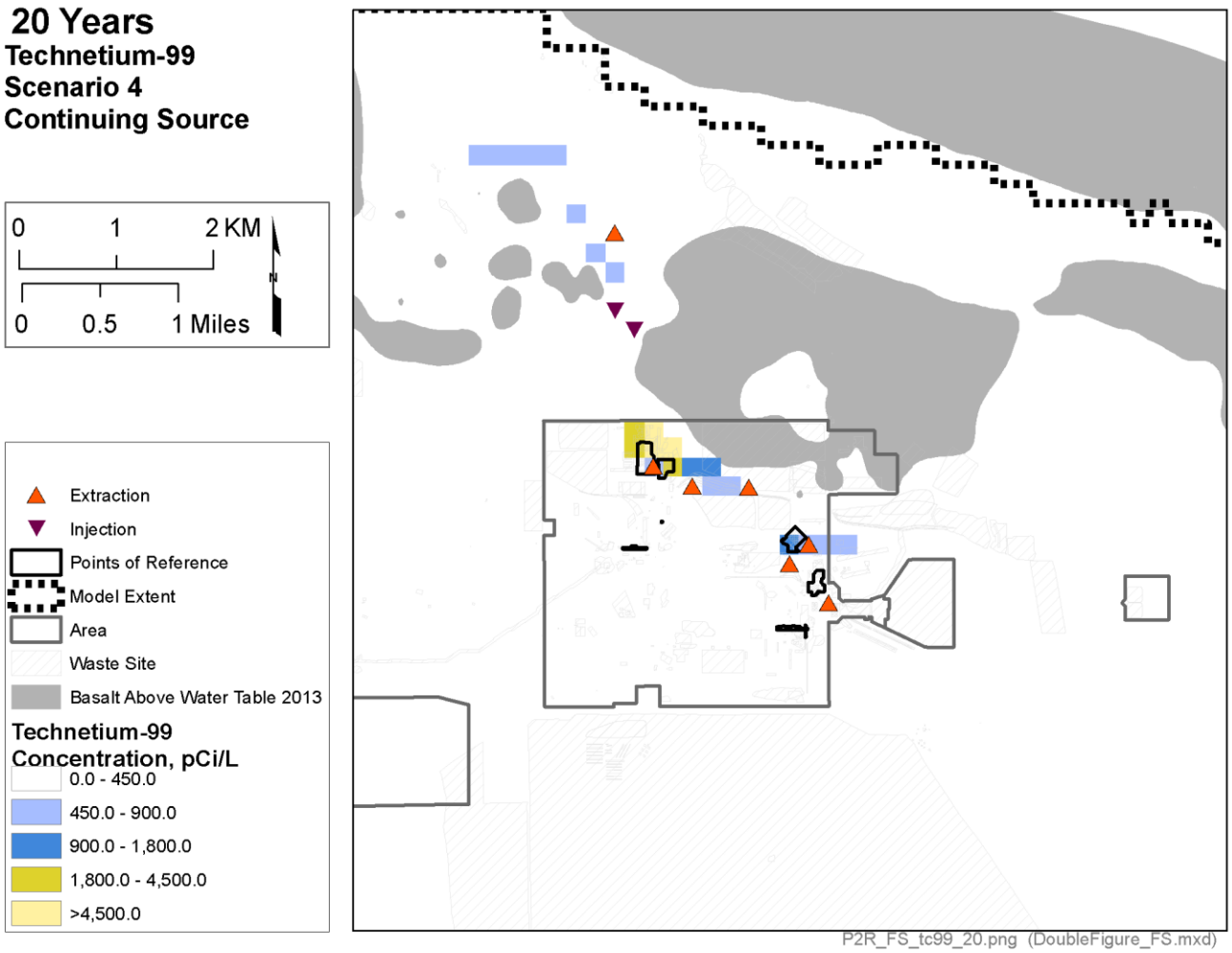

Figure B-203 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 4 simulation with a continuing source term.

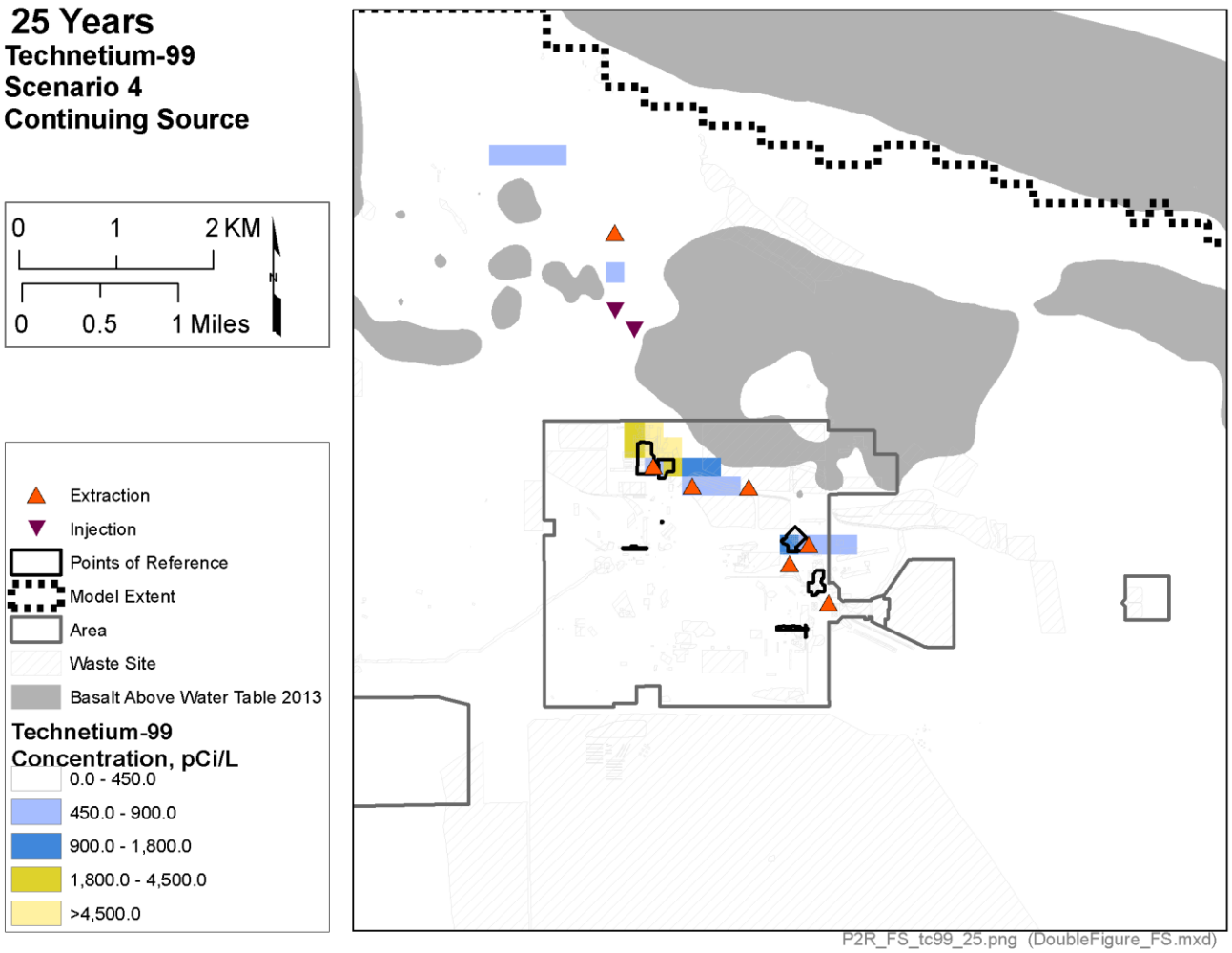

Figure B-204 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 4 simulation with a continuing source term.

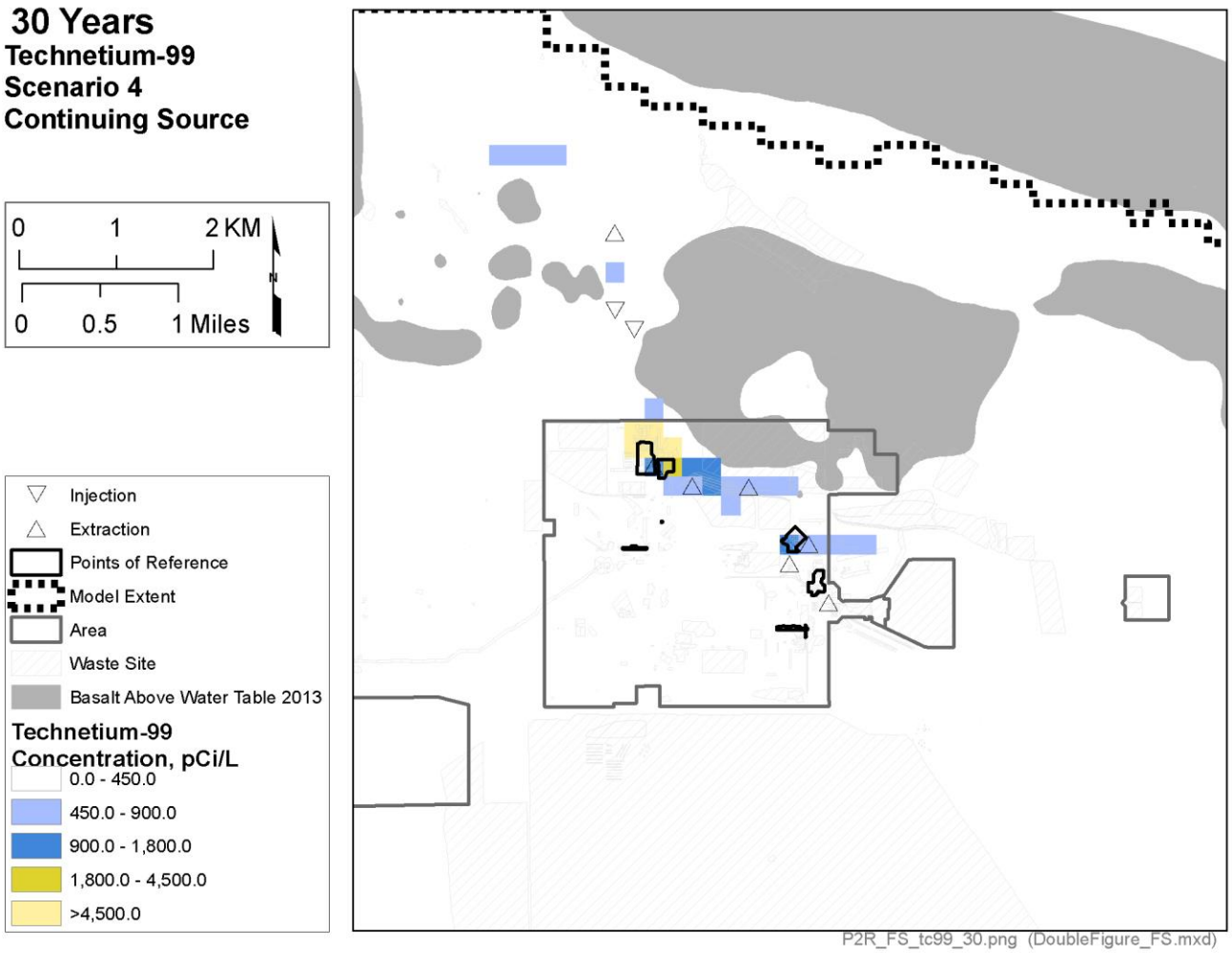

Figure B-205 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 4 simulation with a continuing source term.

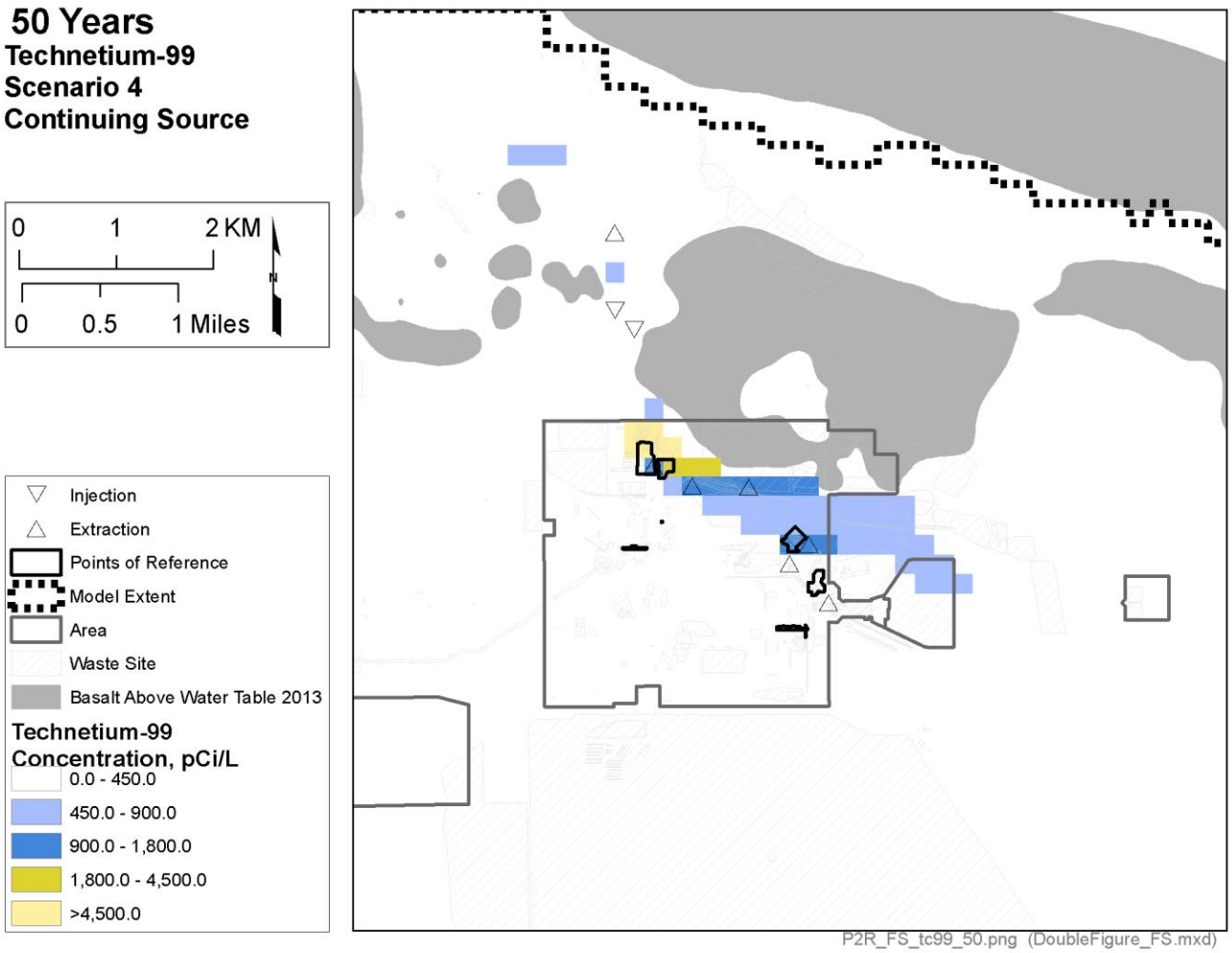

Figure B-206 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 4 simulation with a continuing source term.

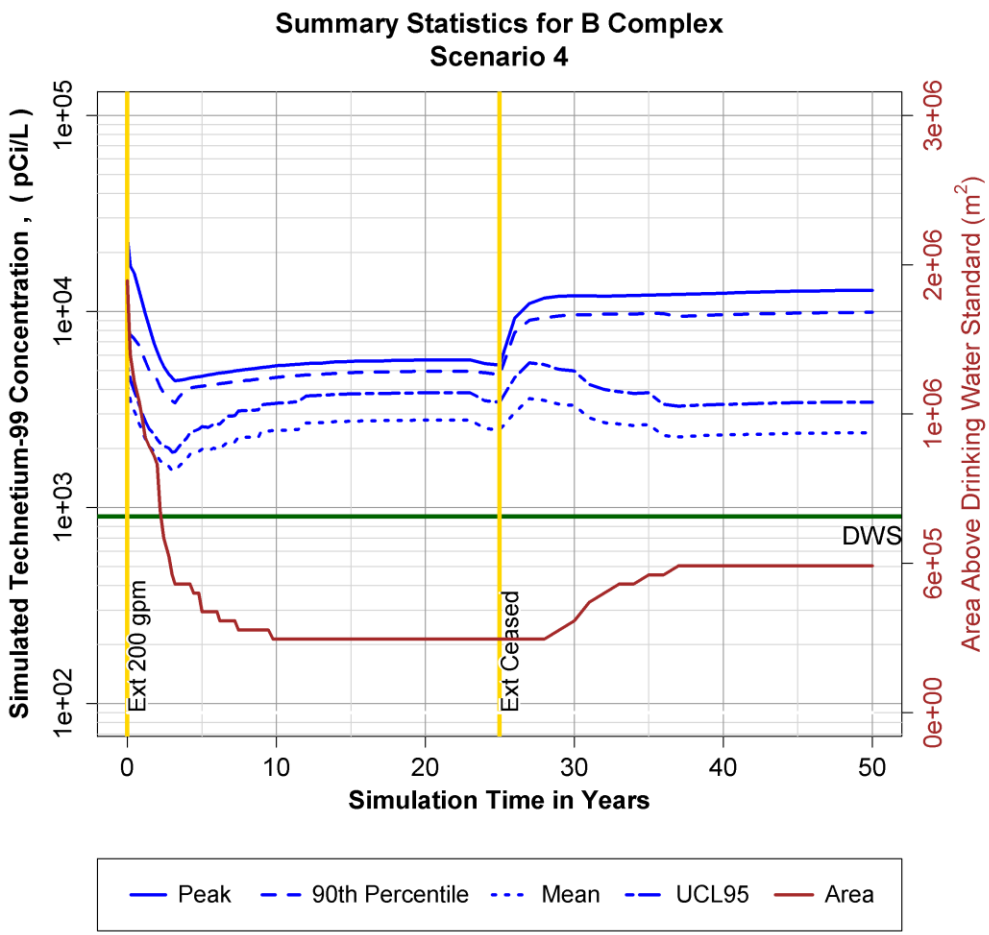

Figure B-207 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

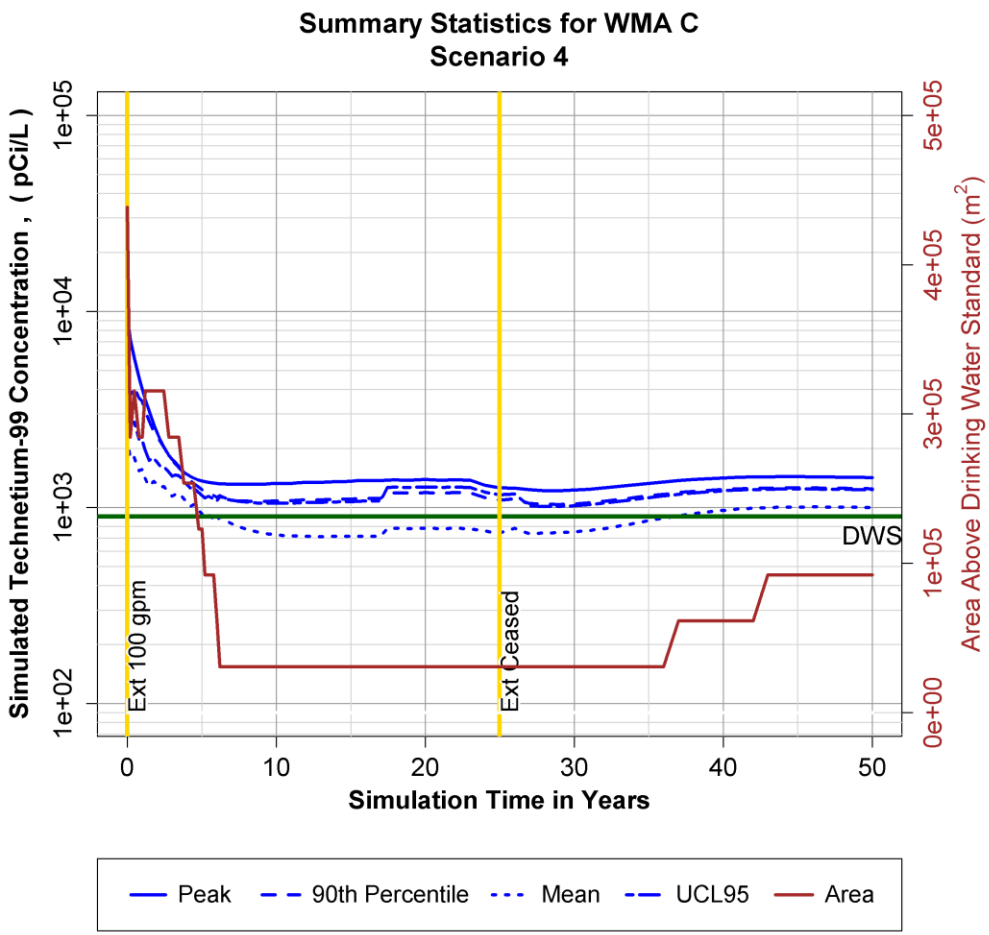

Figure B-208 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

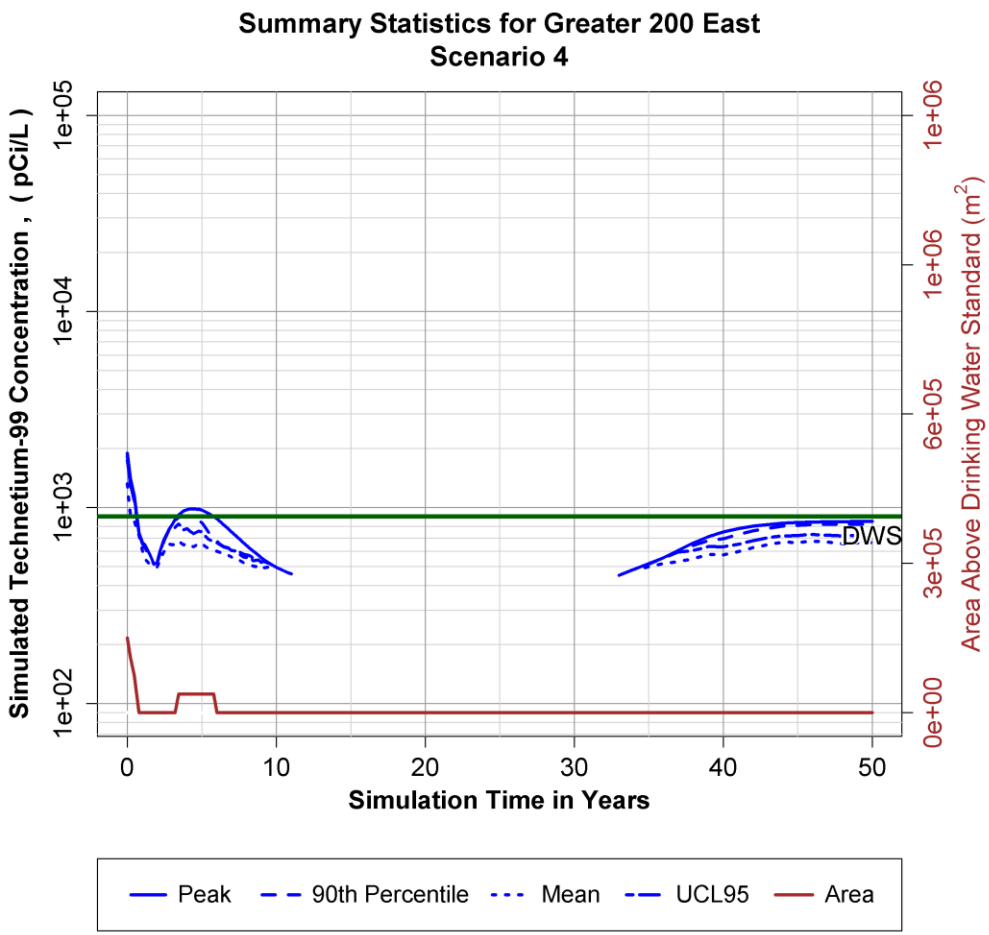

Figure B-209 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

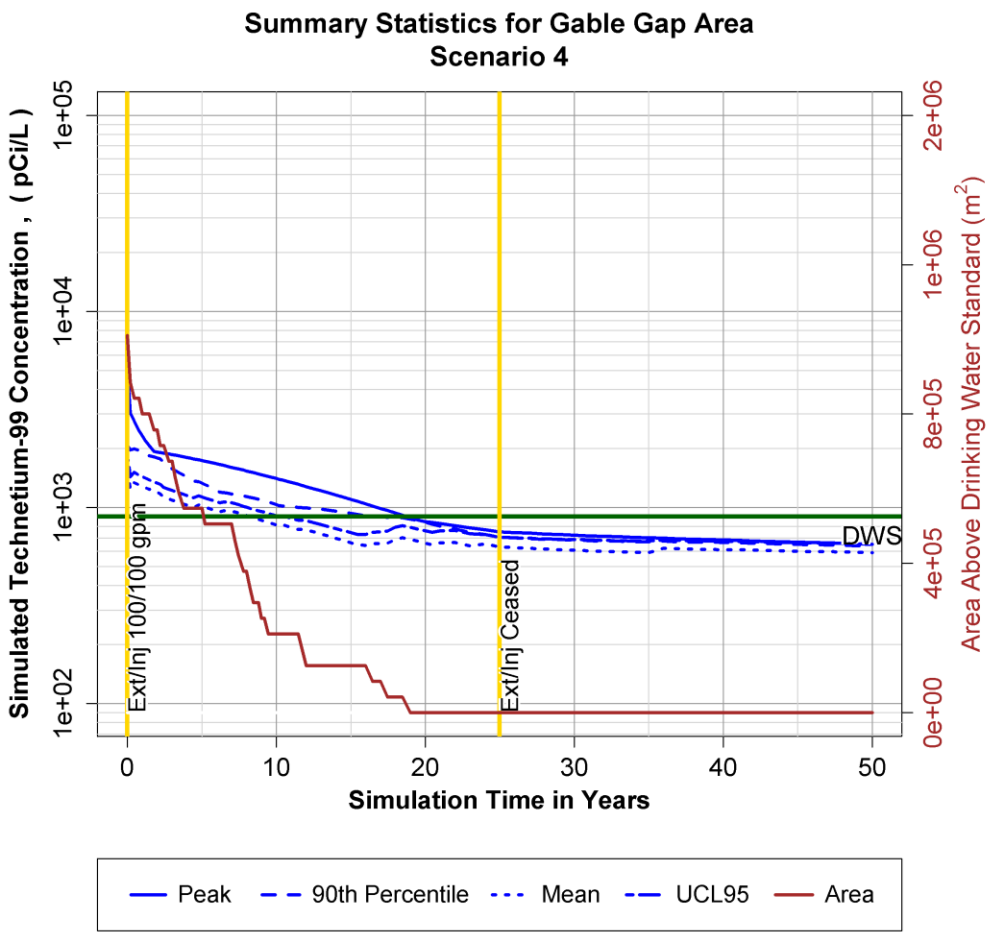

Figure B-210 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 4 simulation with a continuing source term.

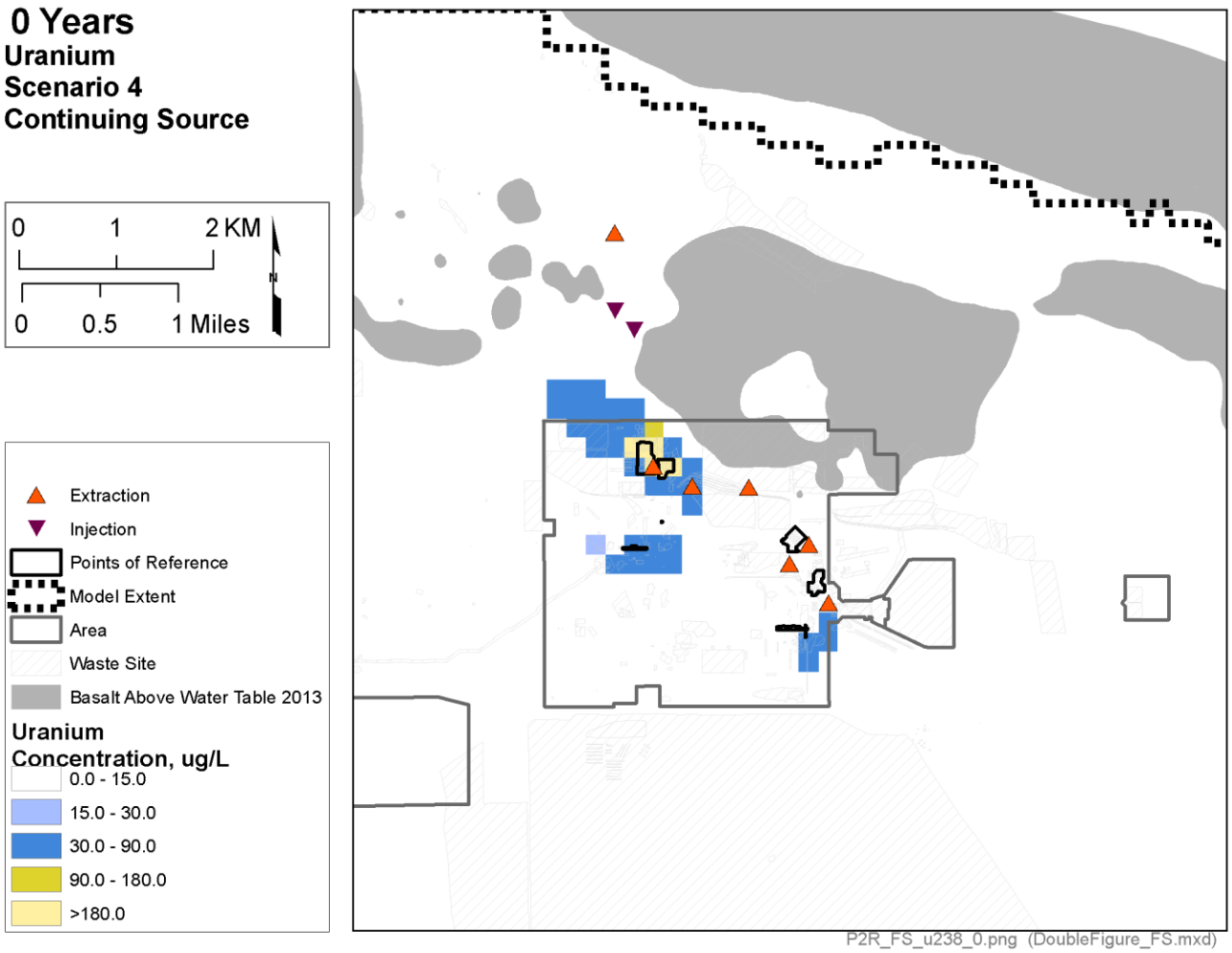

Figure B-211 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 4 simulation with a continuing source term.

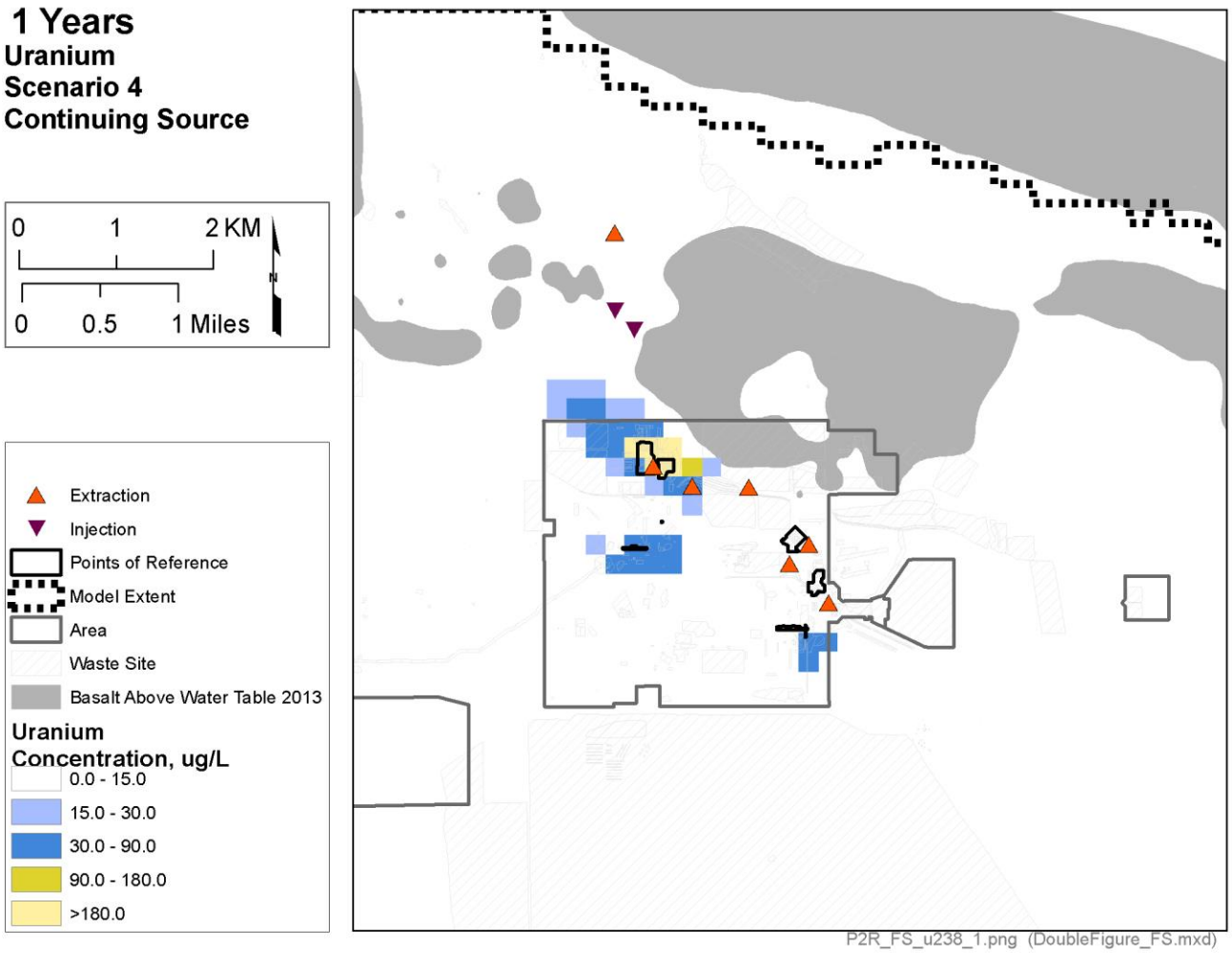

Figure B-212 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 4 simulation with a continuing source term.

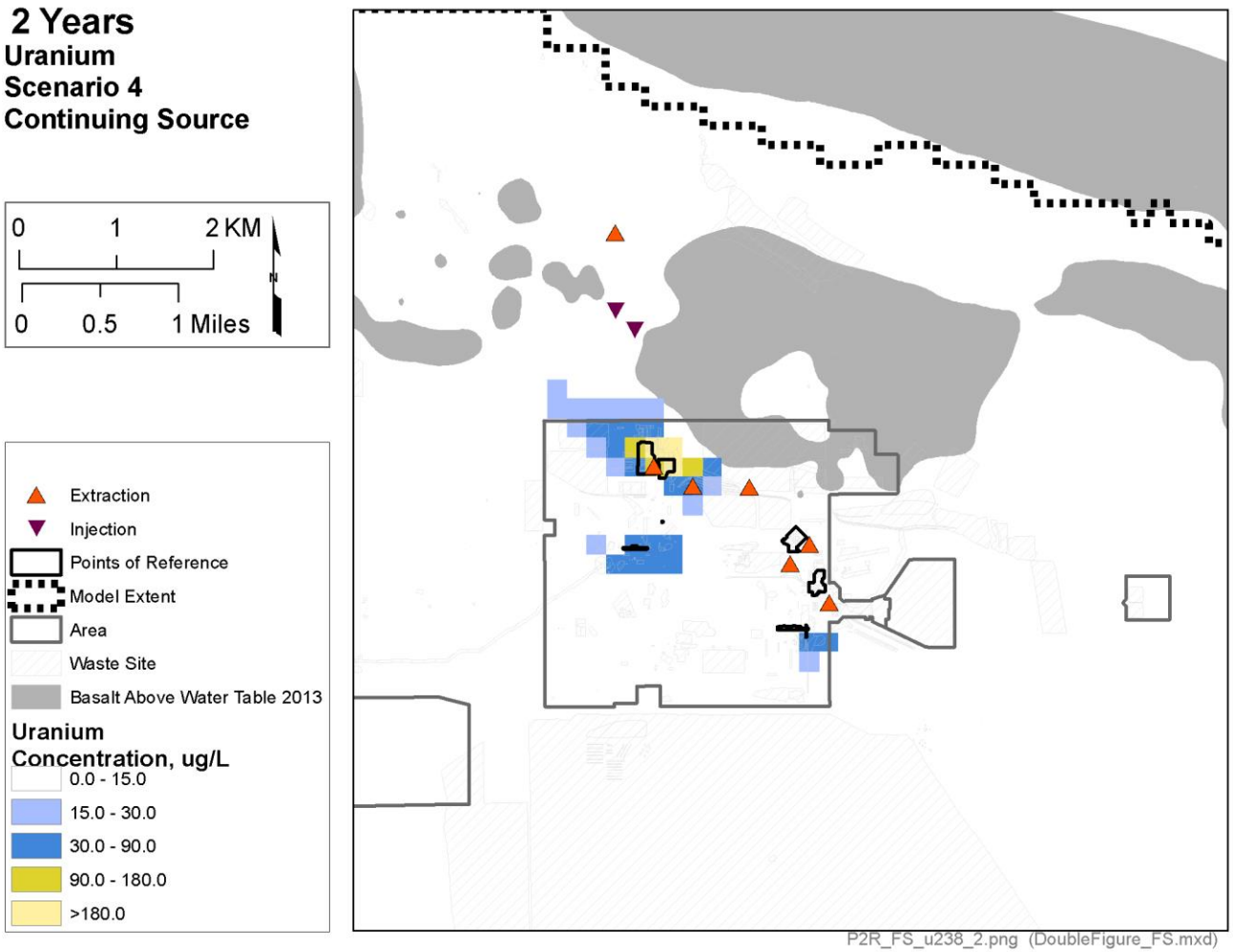

Figure B-213 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 4 simulation with a continuing source term.

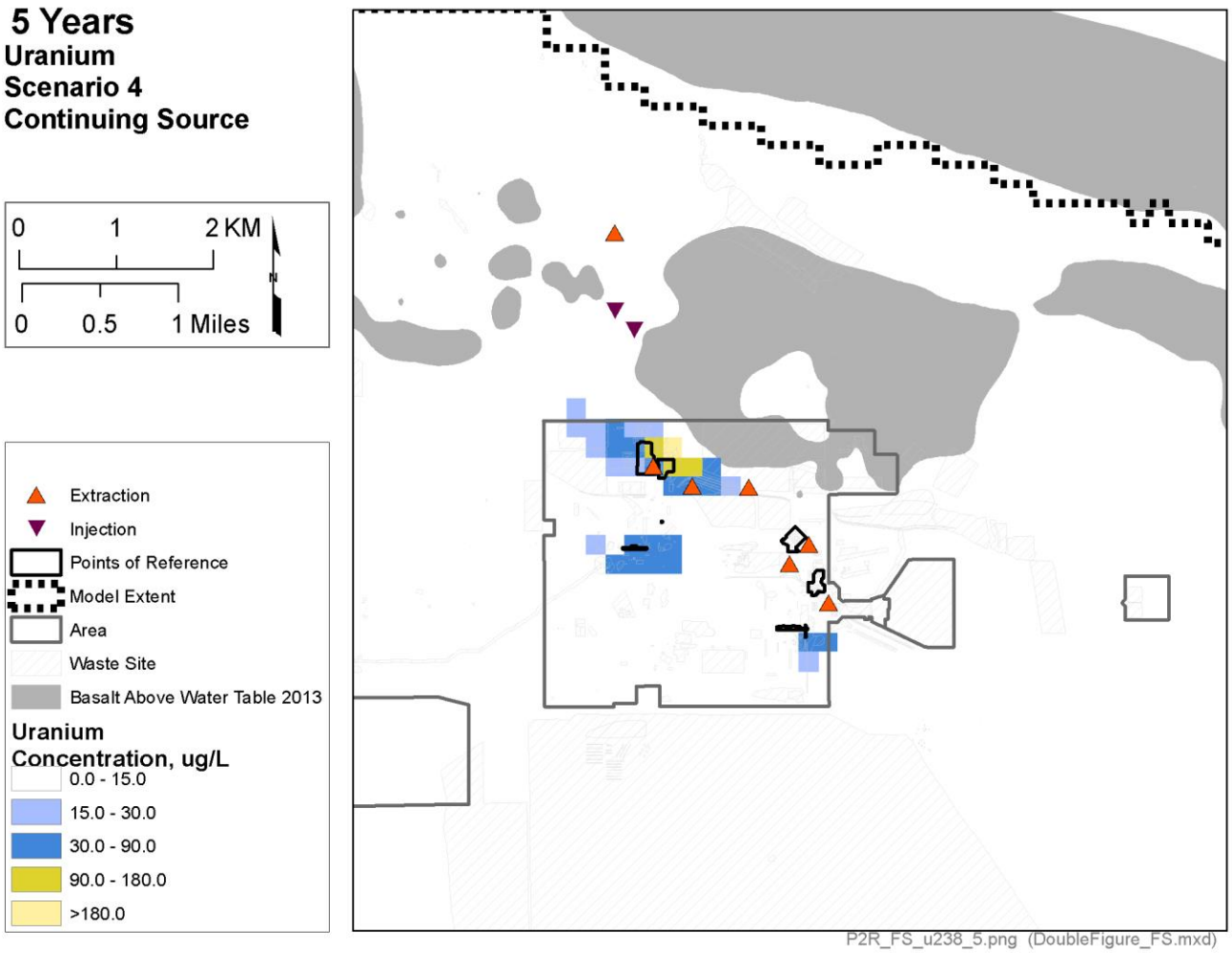

Figure B-214 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 4 simulation with a continuing source term.

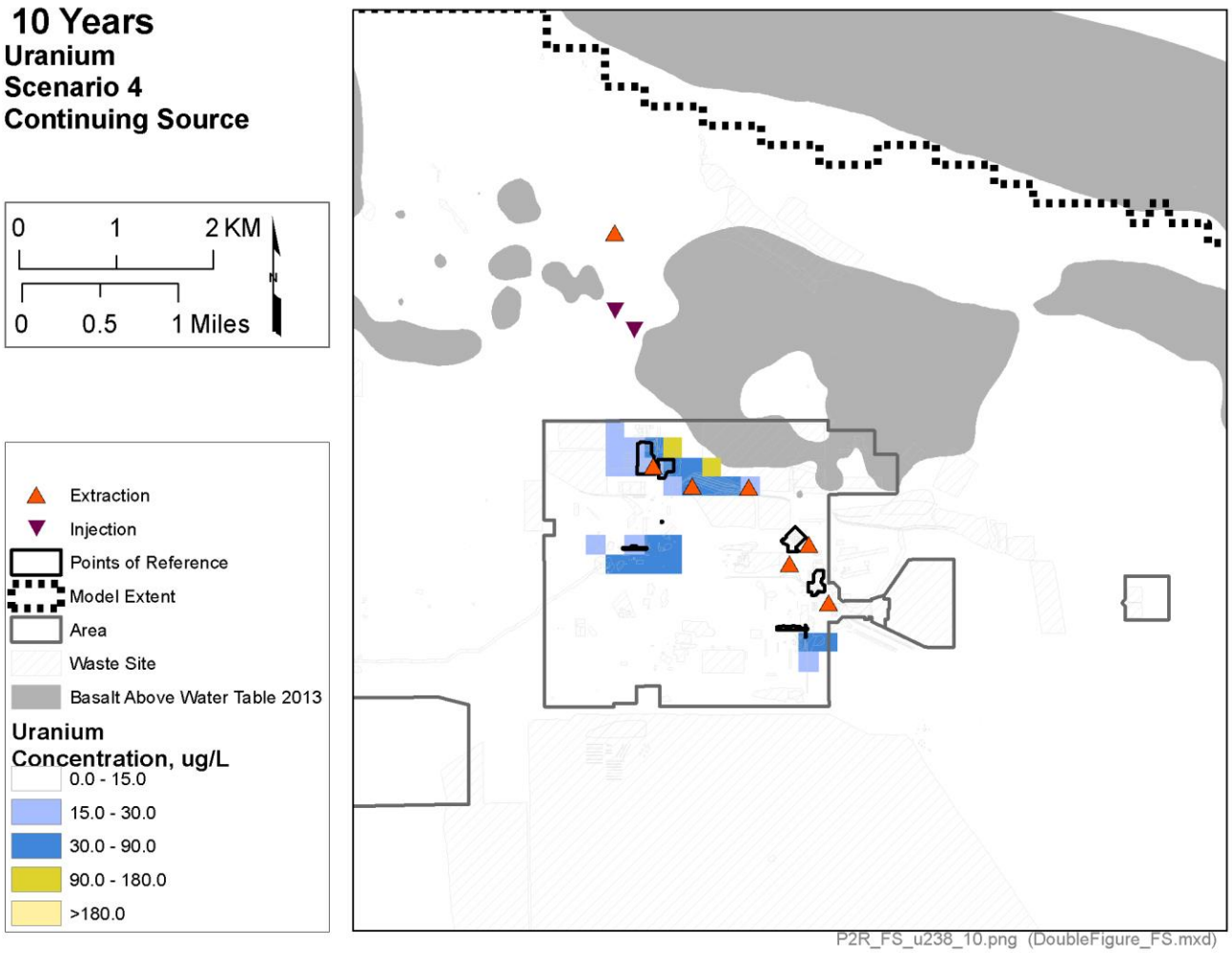

Figure B-215 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 4 simulation with a continuing source term.

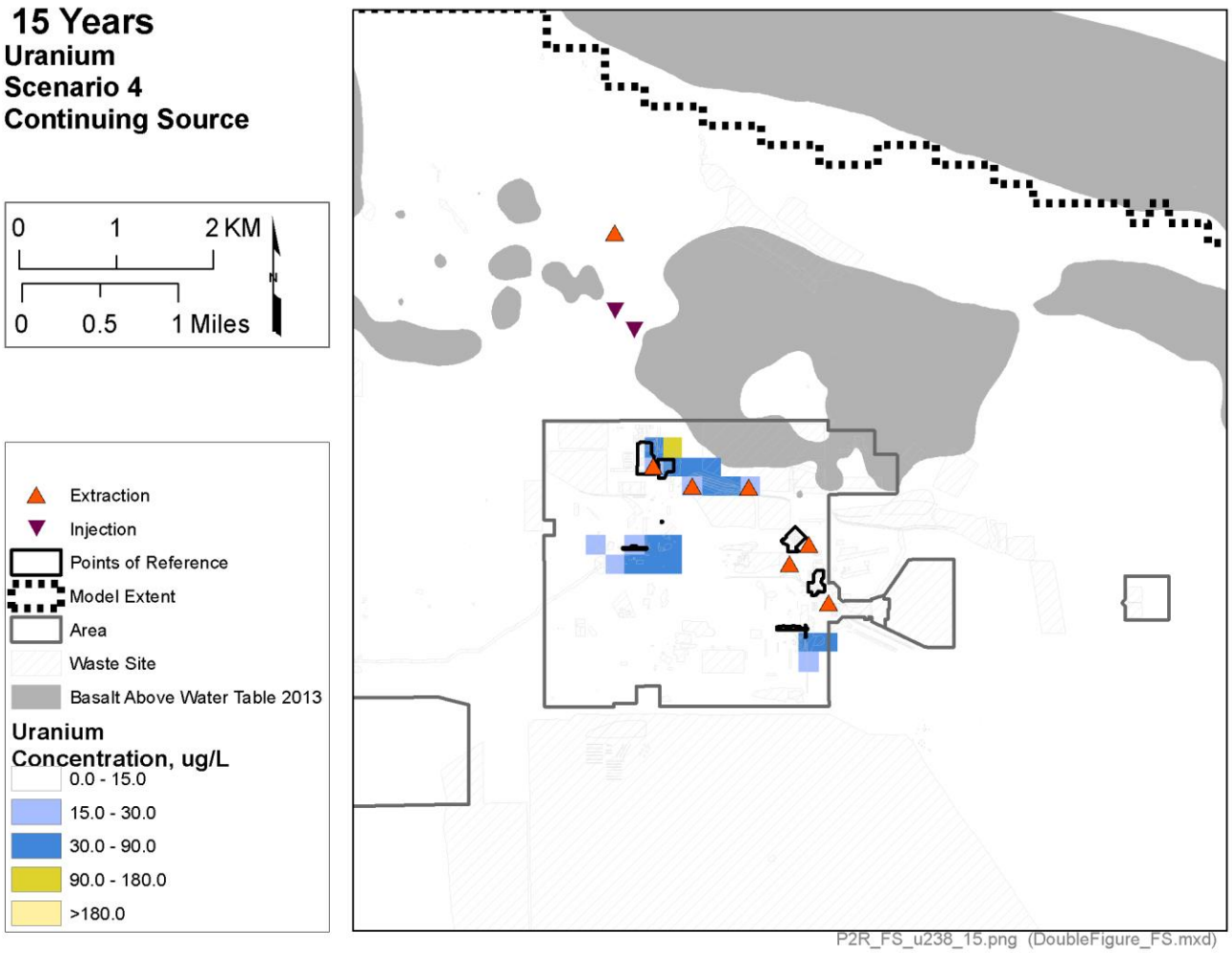

Figure B-216 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 4 simulation with a continuing source term.

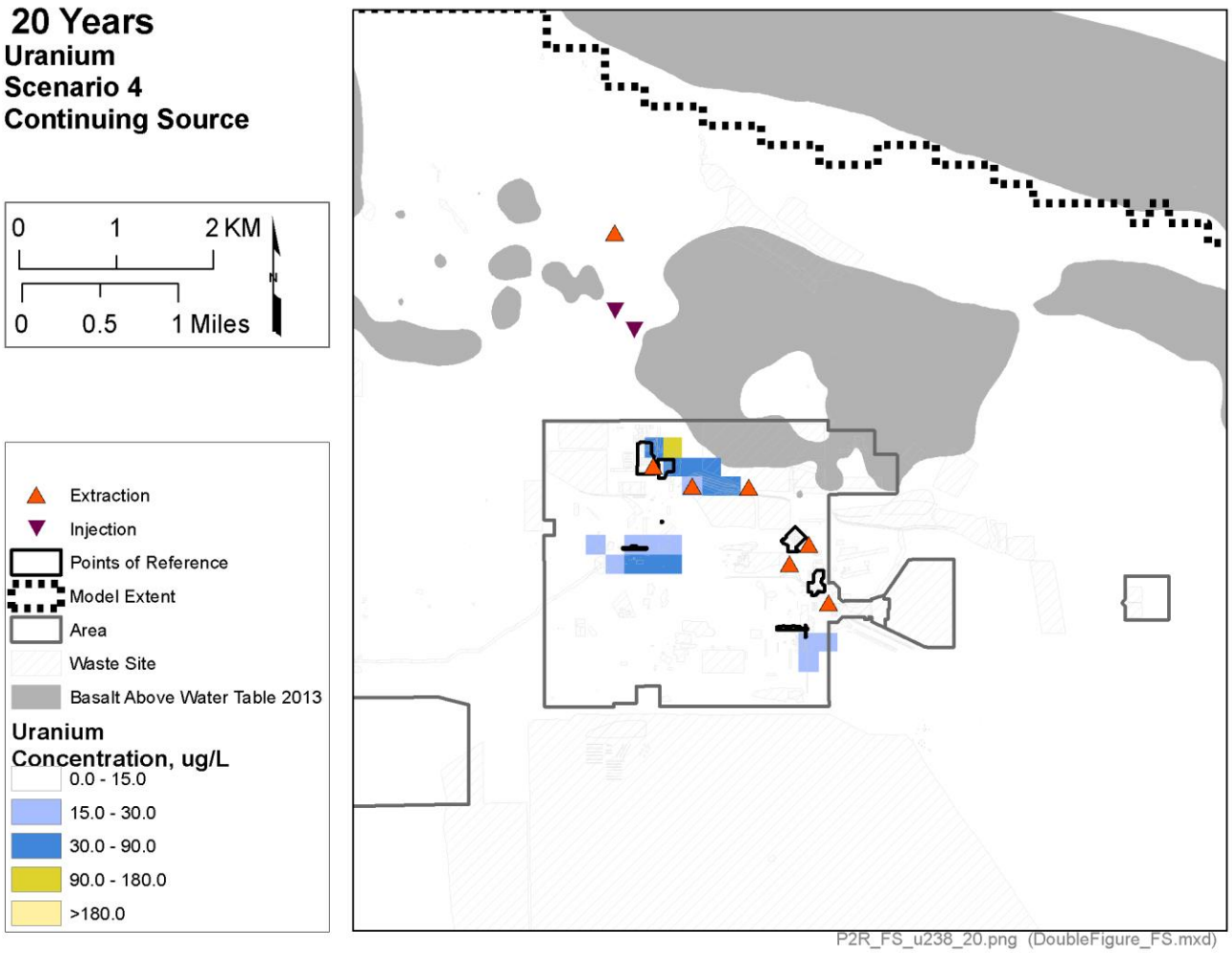

Figure B-217 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 4 simulation with a continuing source term.

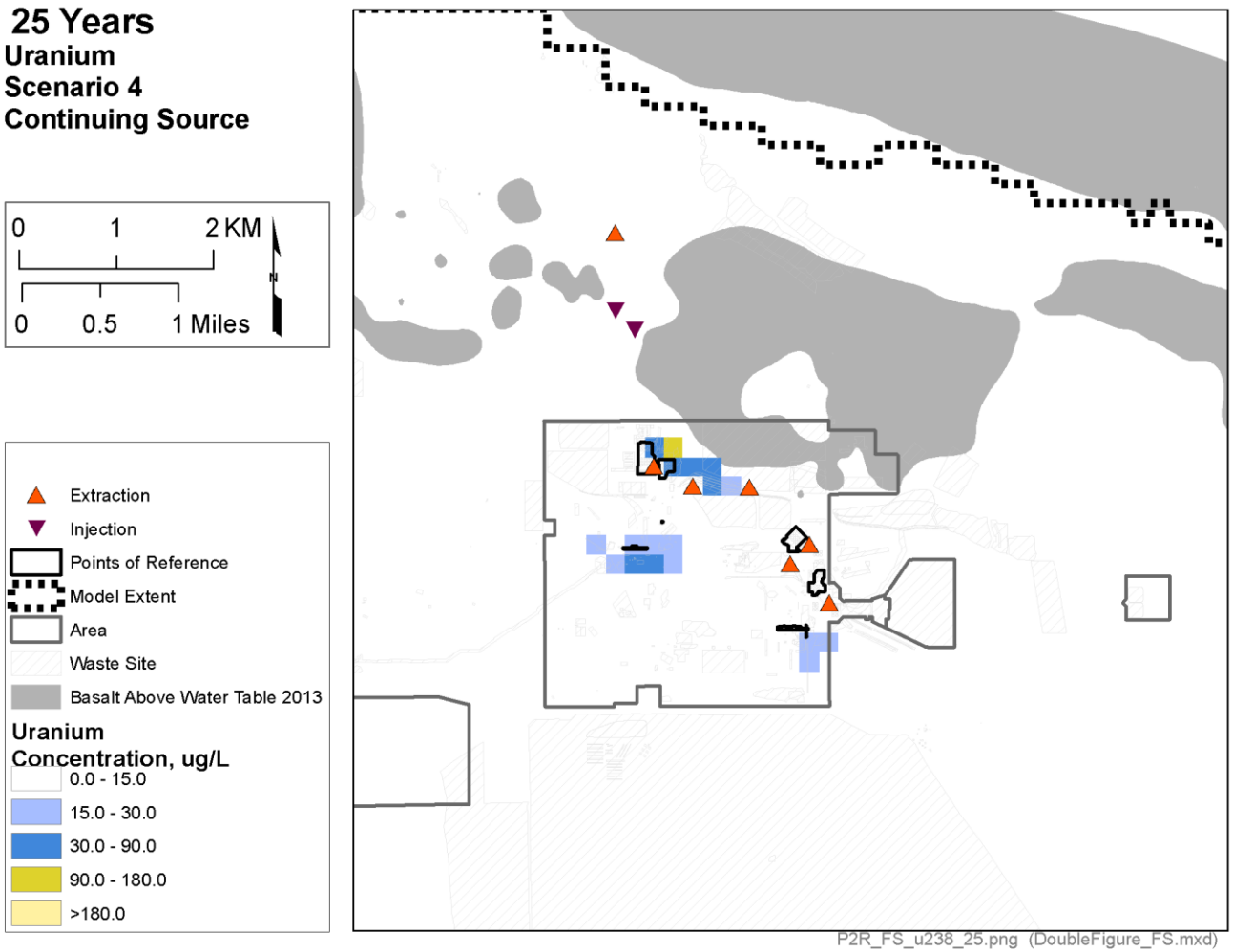

Figure B-218 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 4 simulation with a continuing source term.

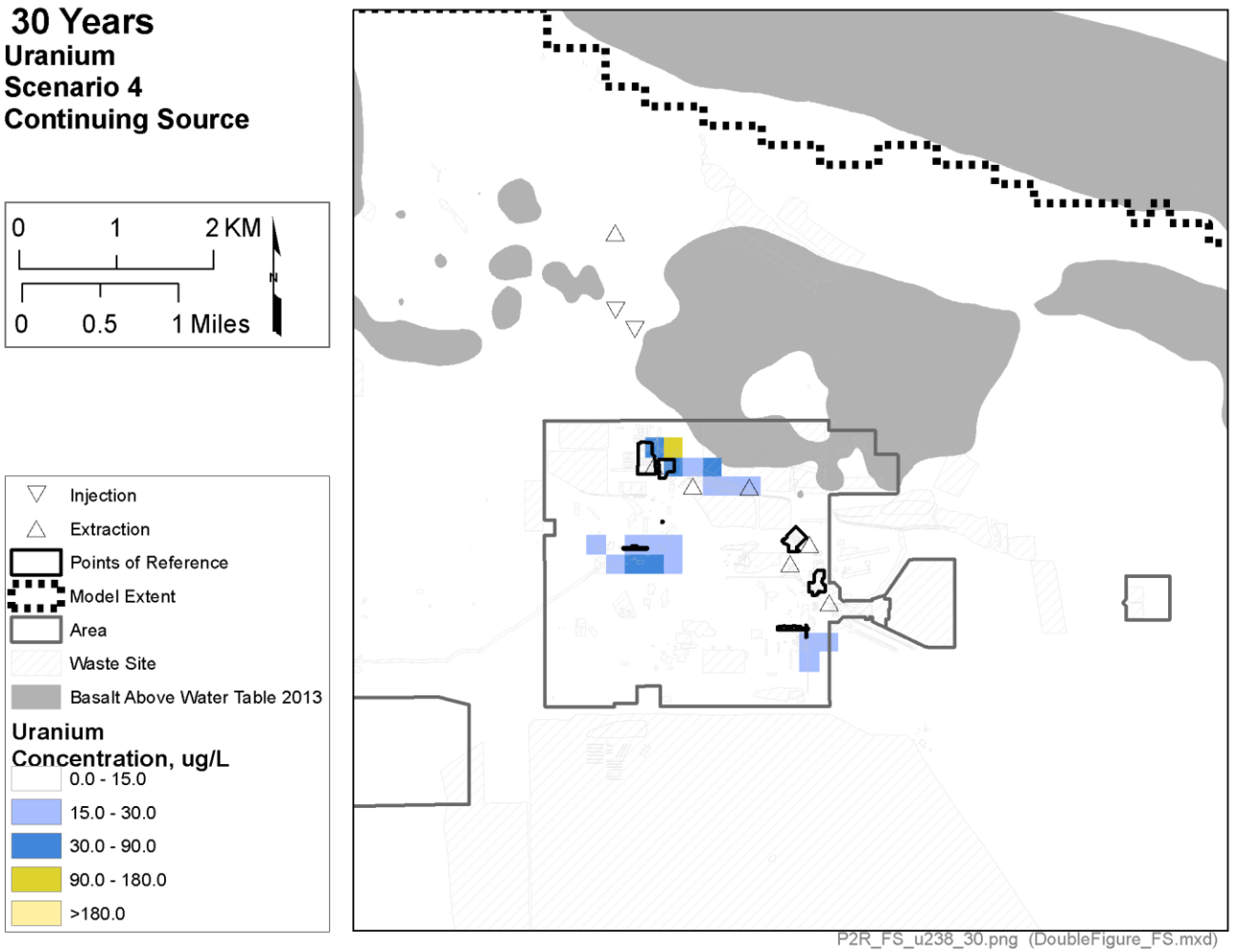

Figure B-219 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 4 simulation with a continuing source term.

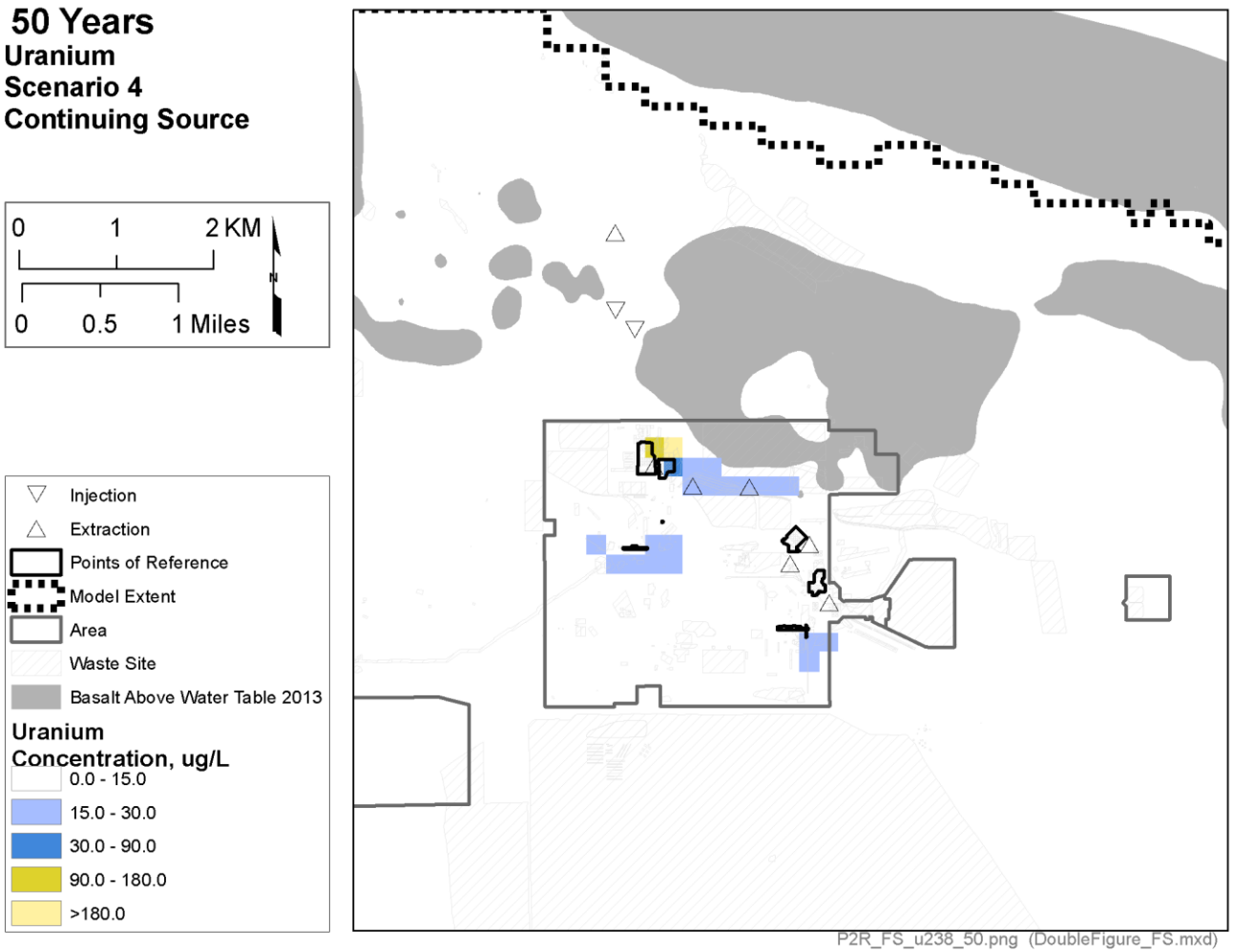

Figure B-220 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 4 simulation with a continuing source term.

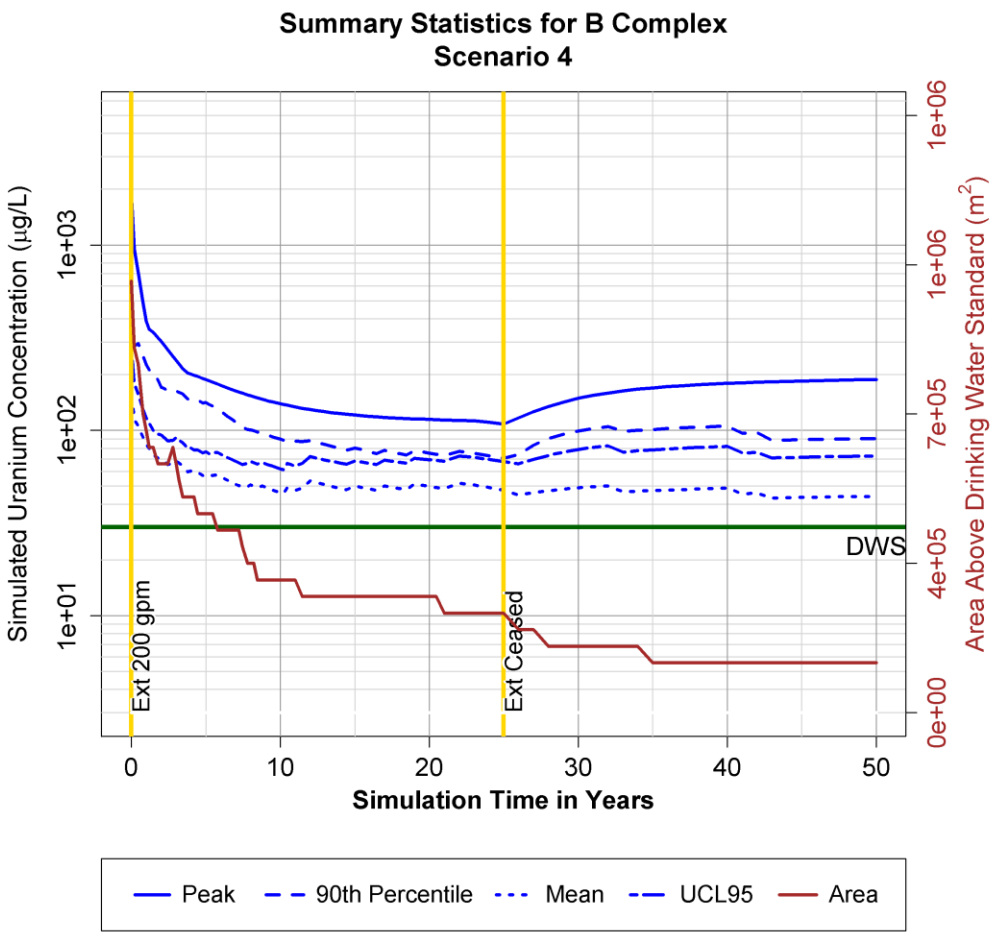

Figure B-221 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

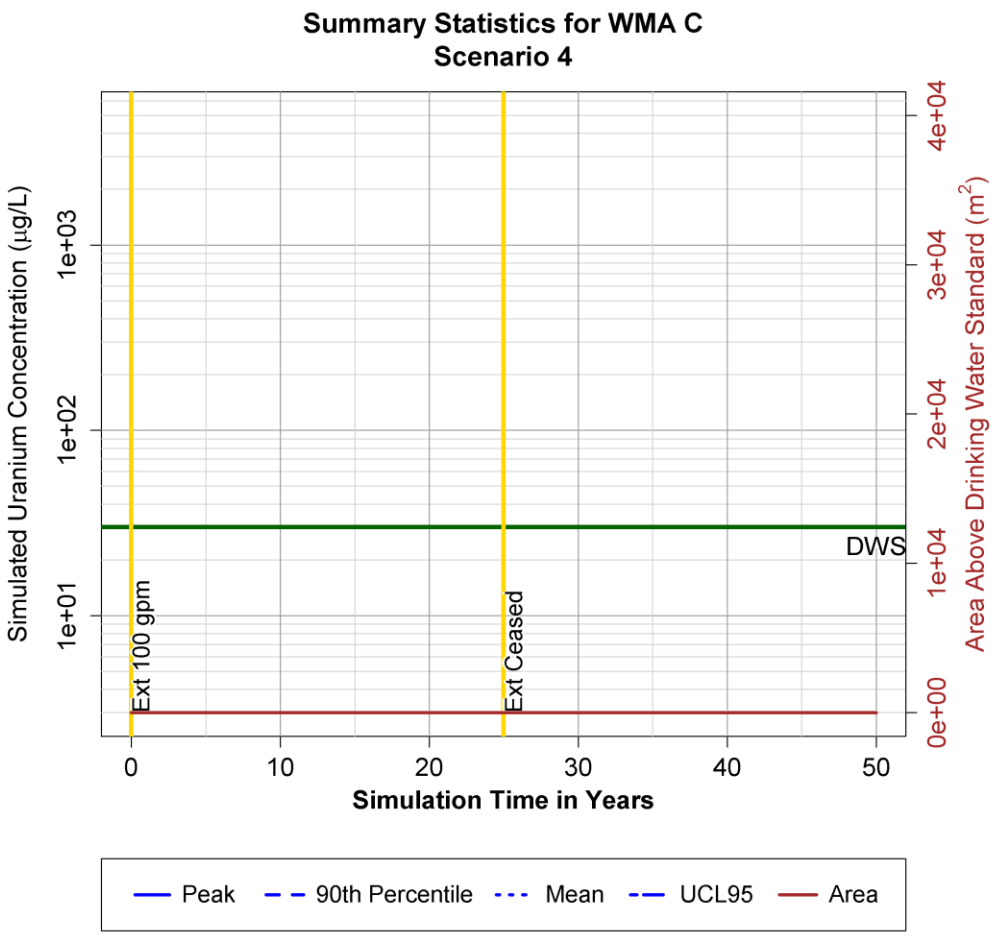

Figure B-222 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

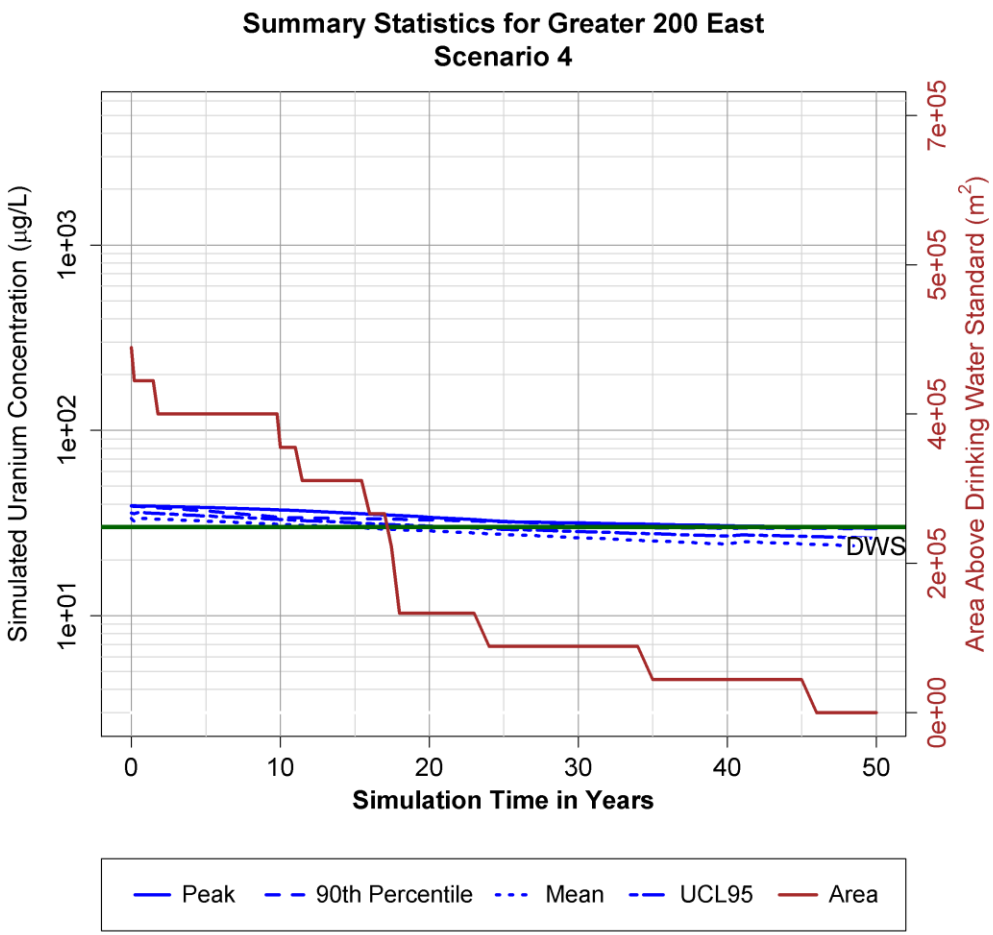

Figure B-223 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

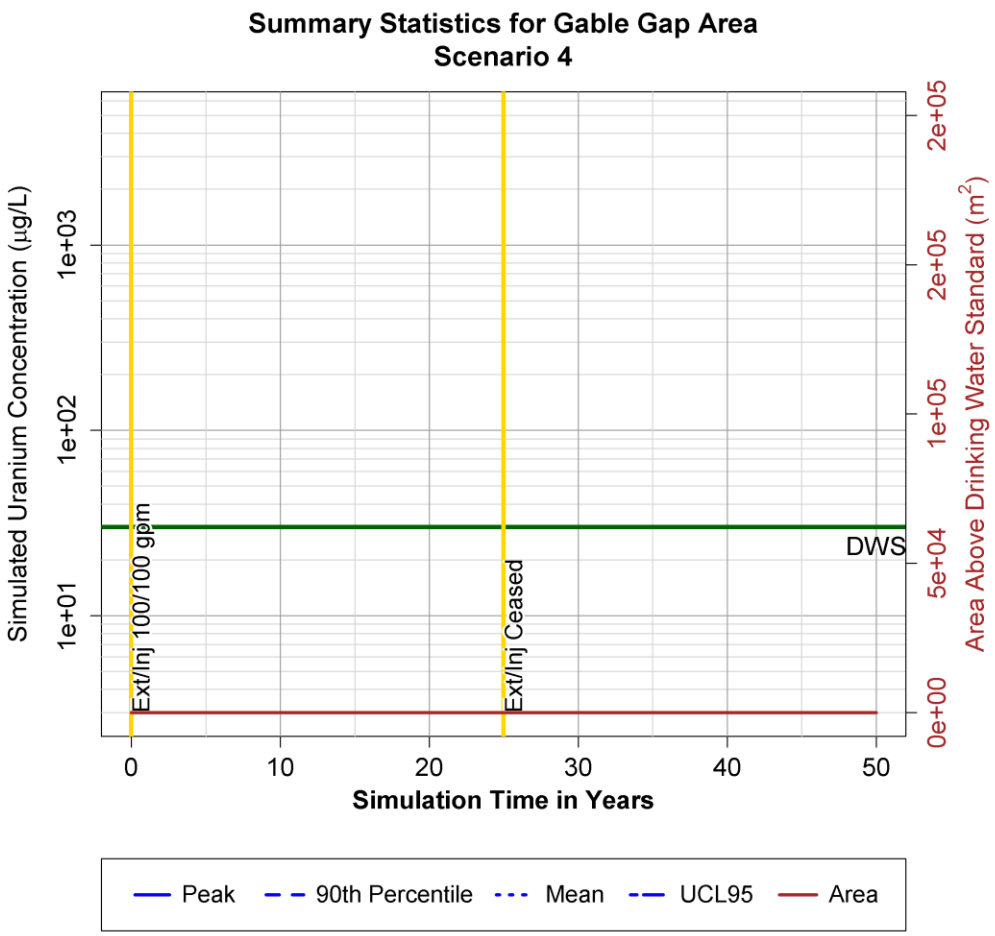

Figure B-224 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 4 simulation with a continuing source term.

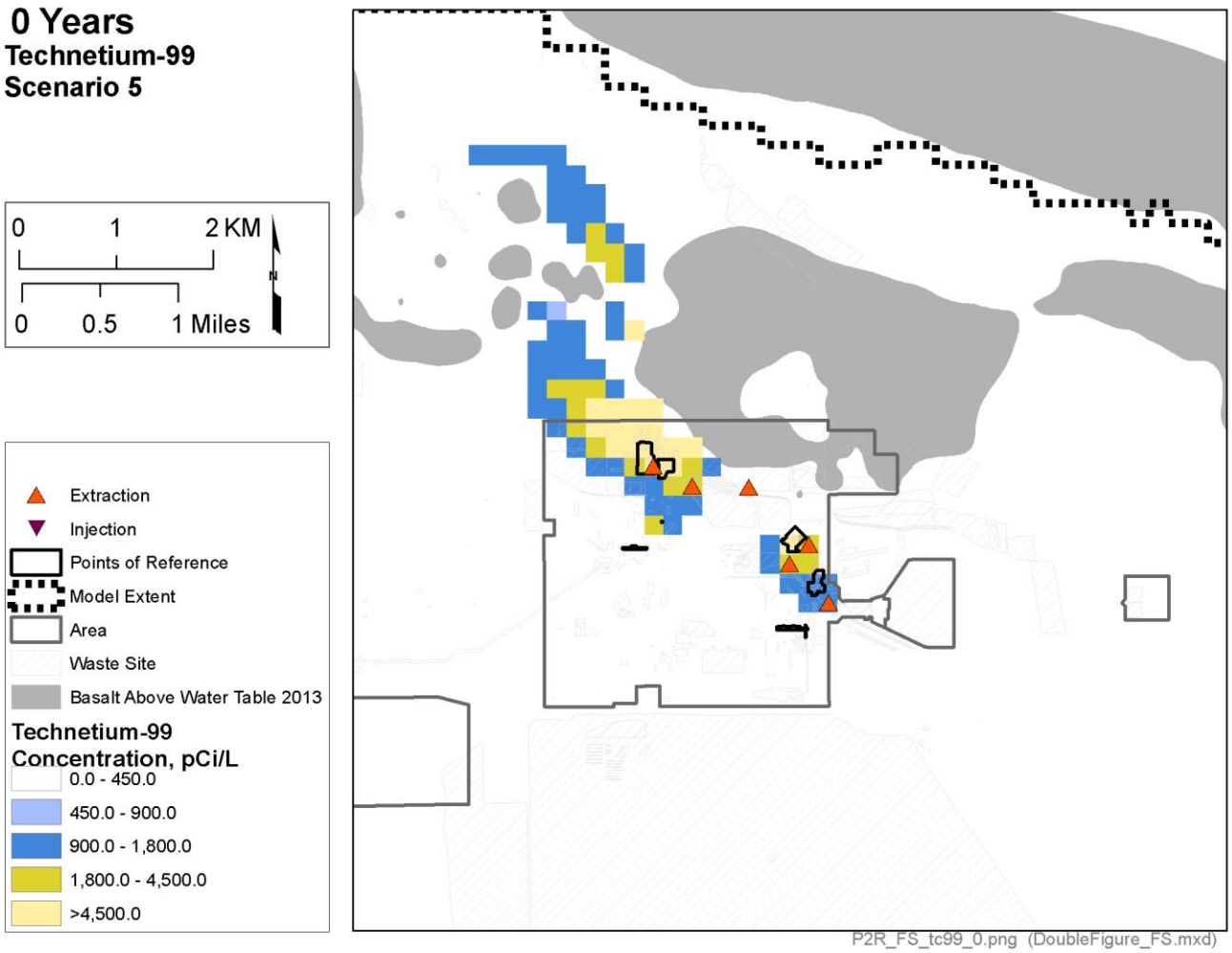

Figure B-225 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 5 simulation.

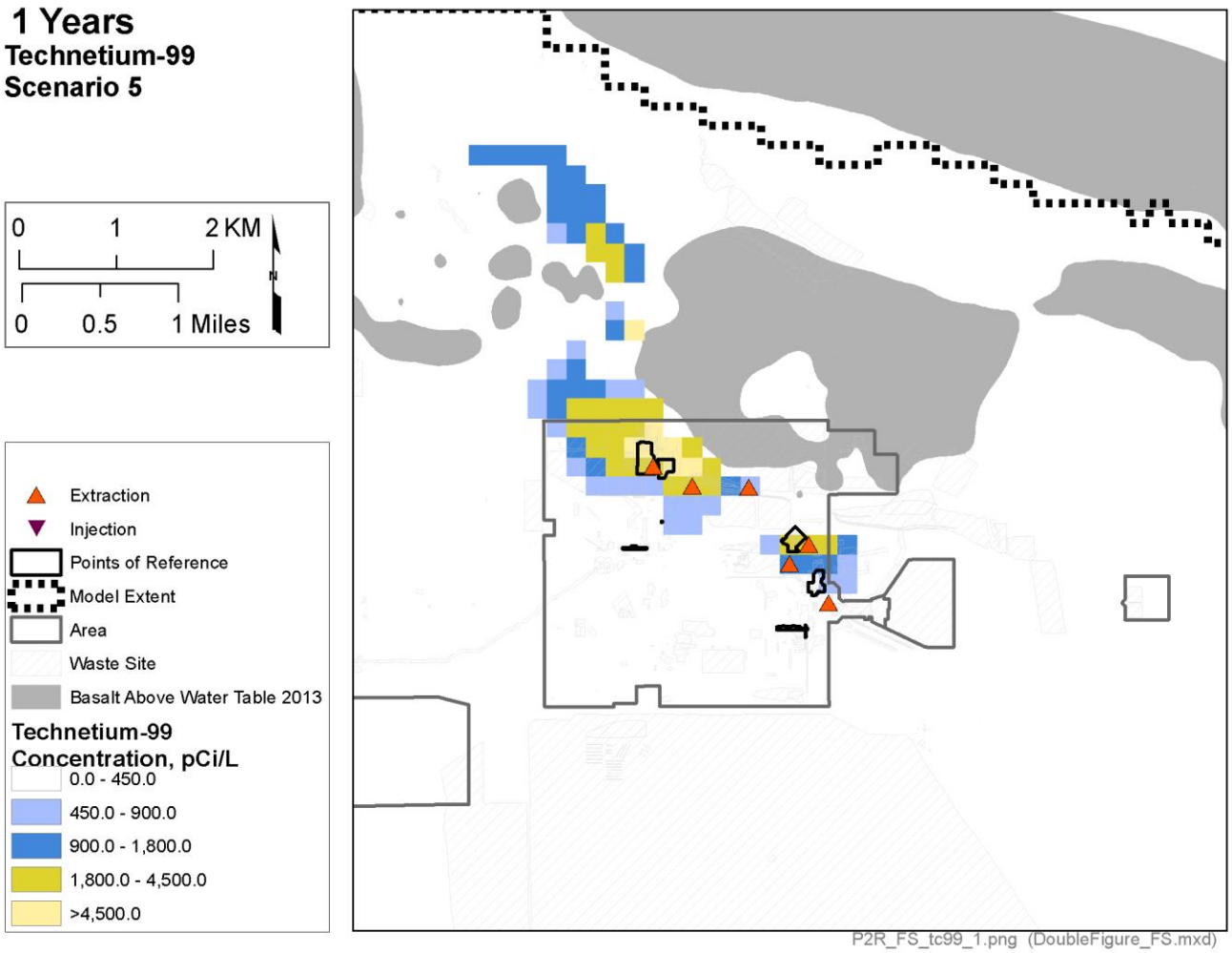

Figure B-226 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 5 simulation.

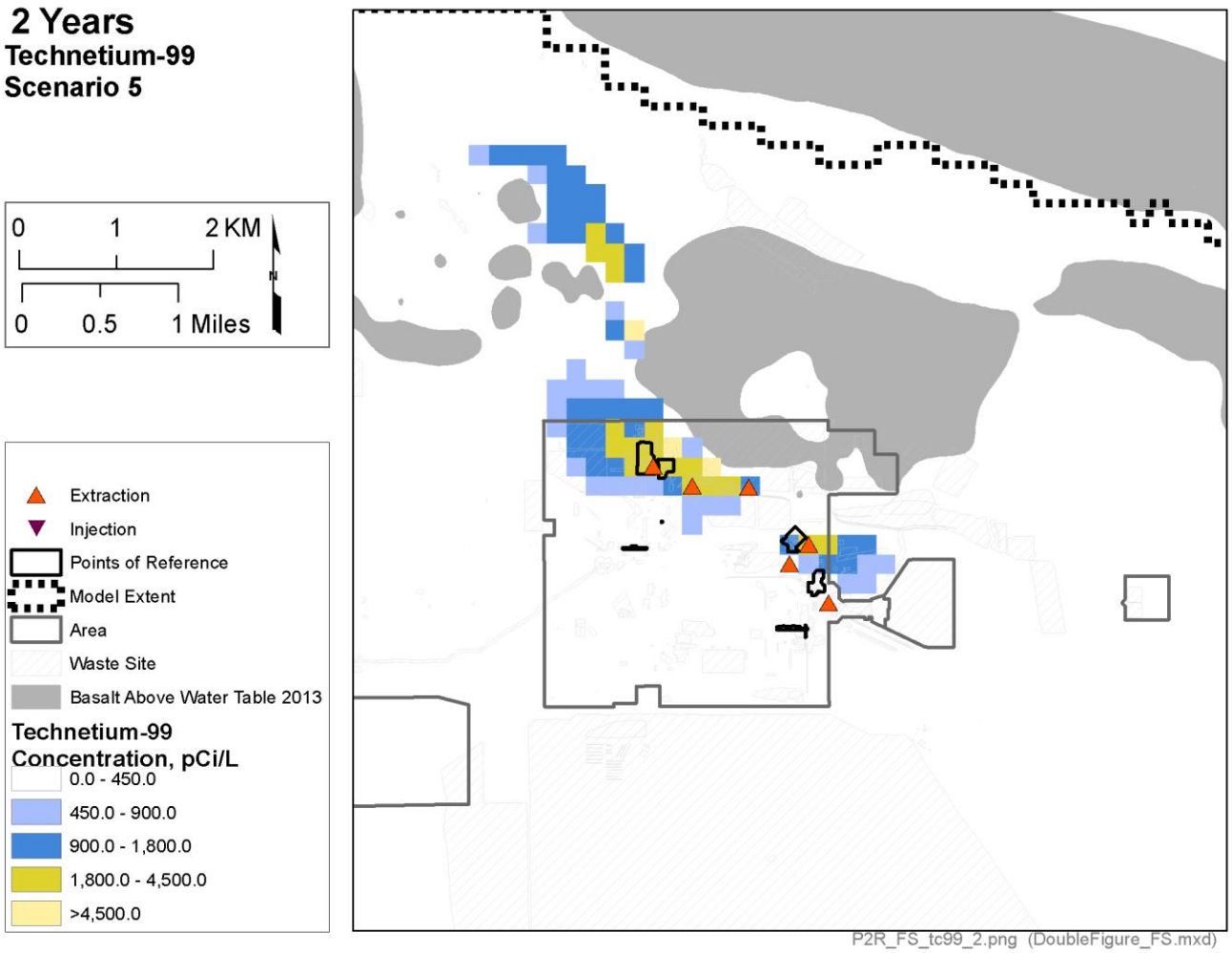

Figure B-227 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 5 simulation.

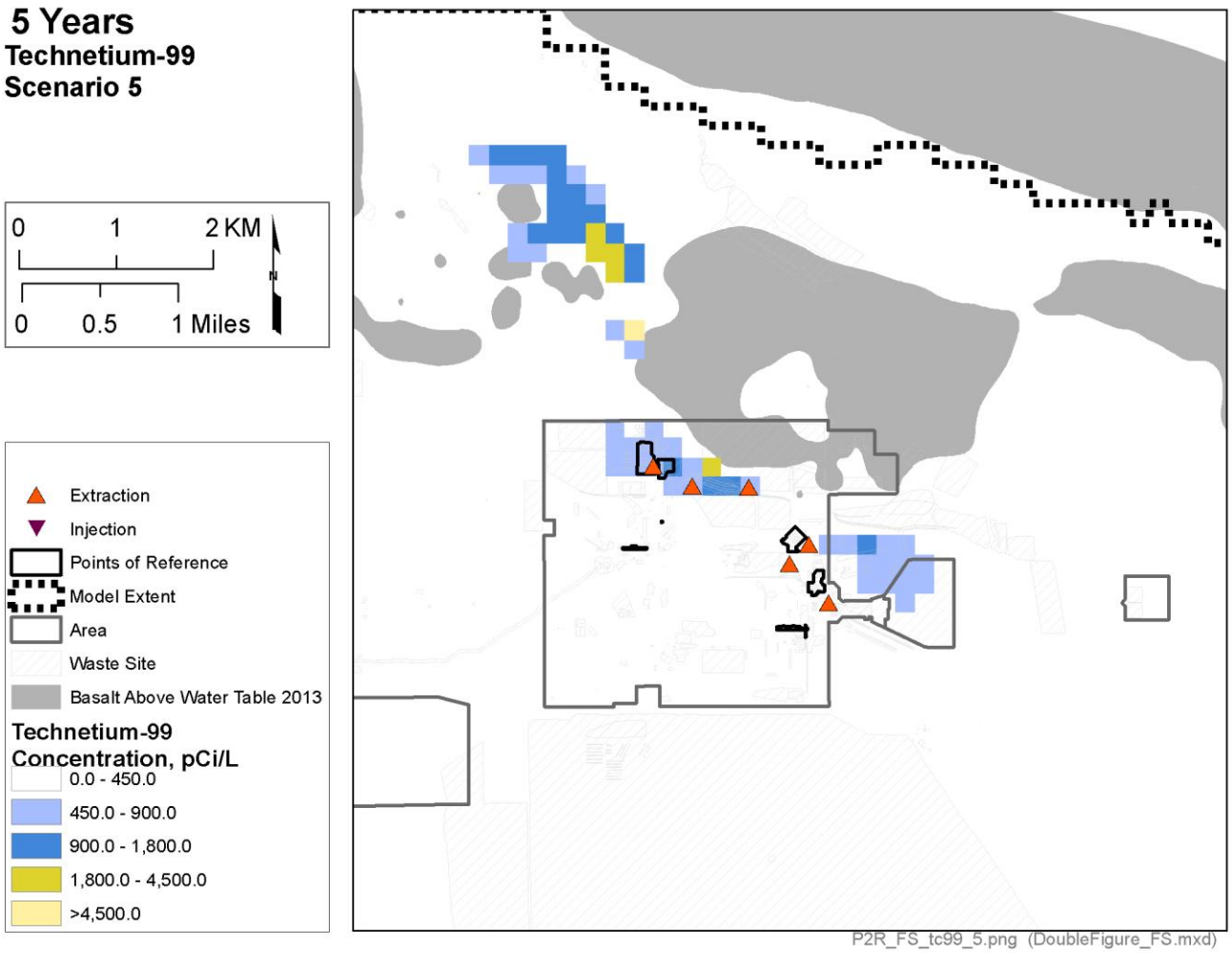

Figure B-228 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 5 simulation.

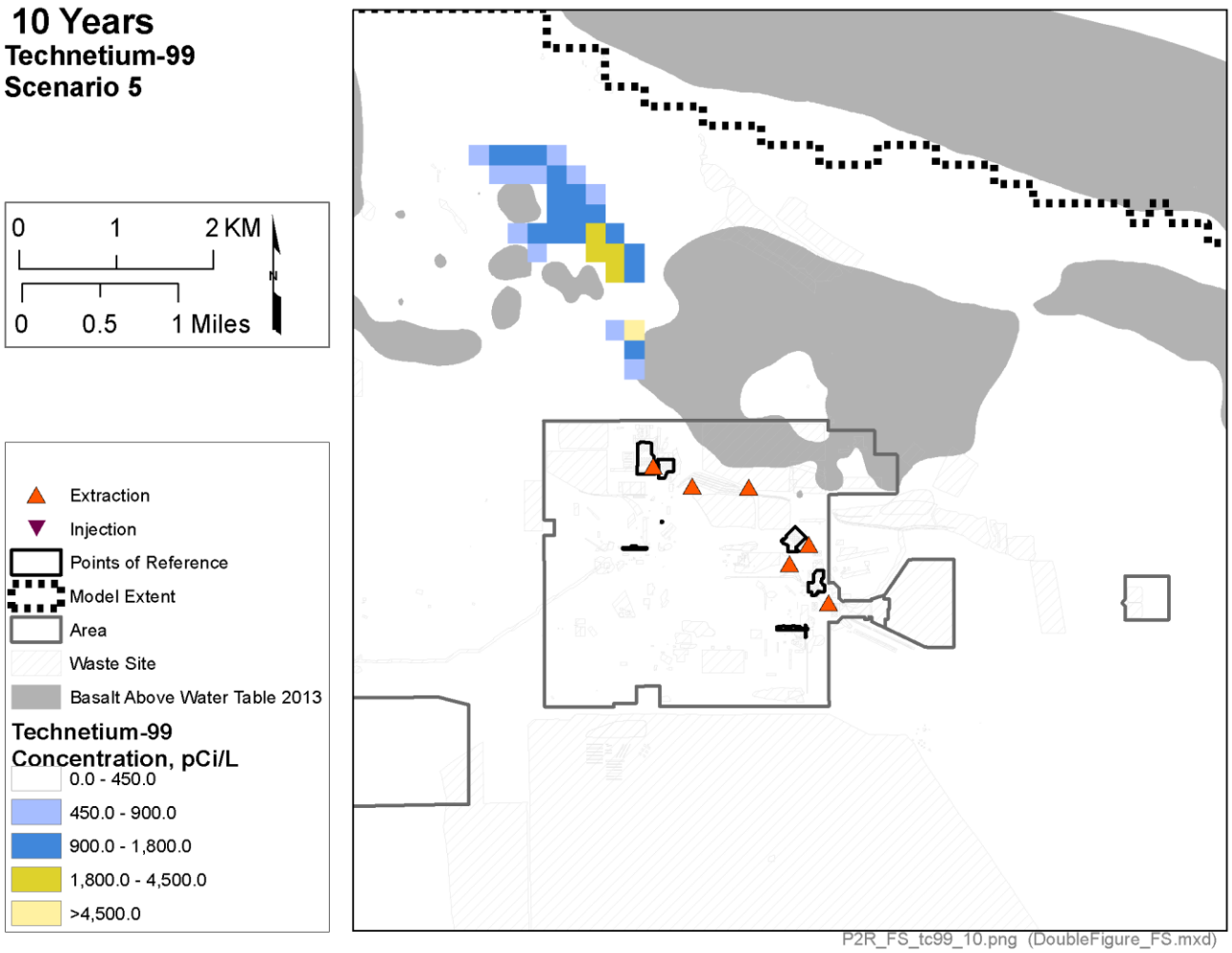

Figure B-229 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 5 simulation.

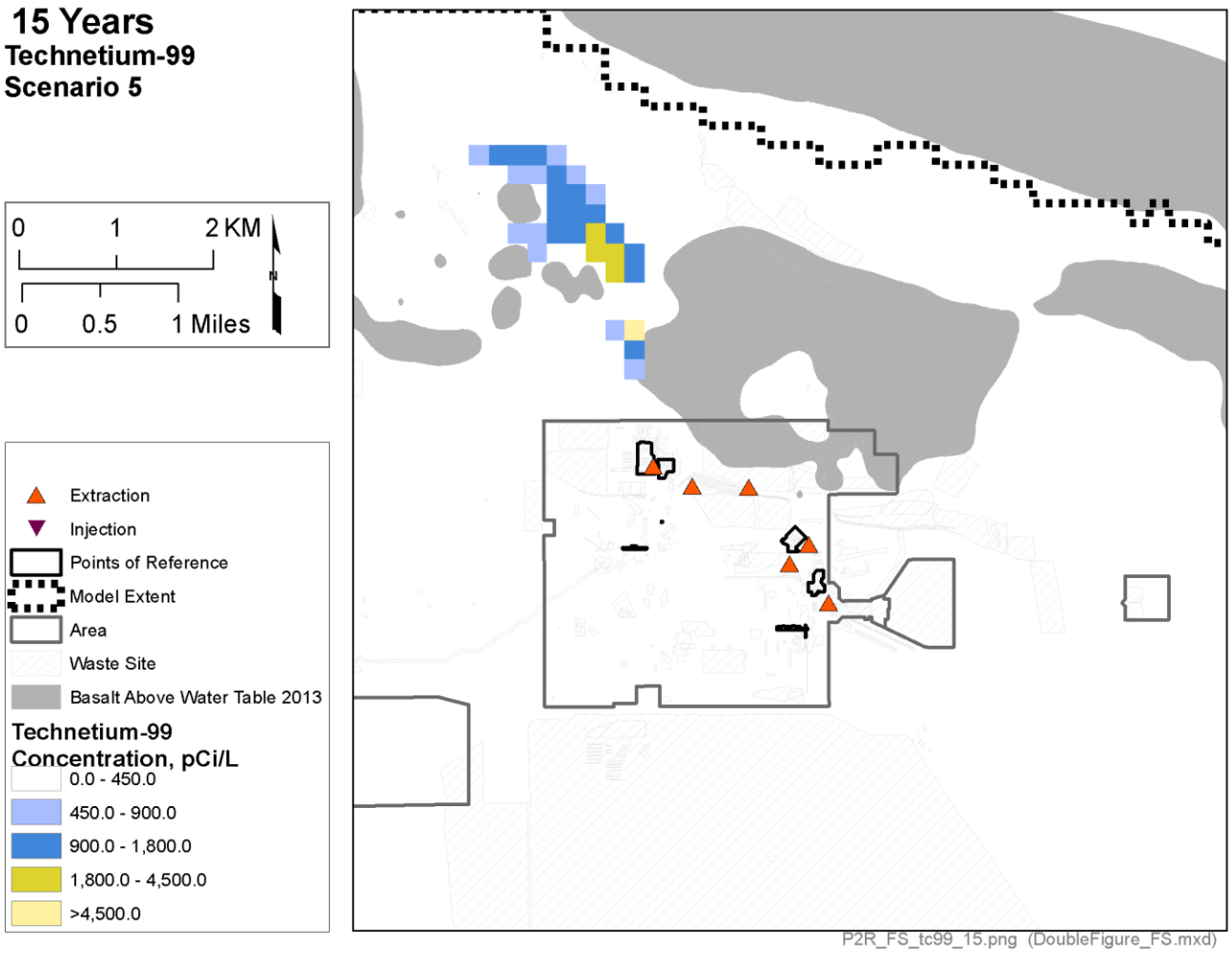

Figure B-230 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 5 simulation.

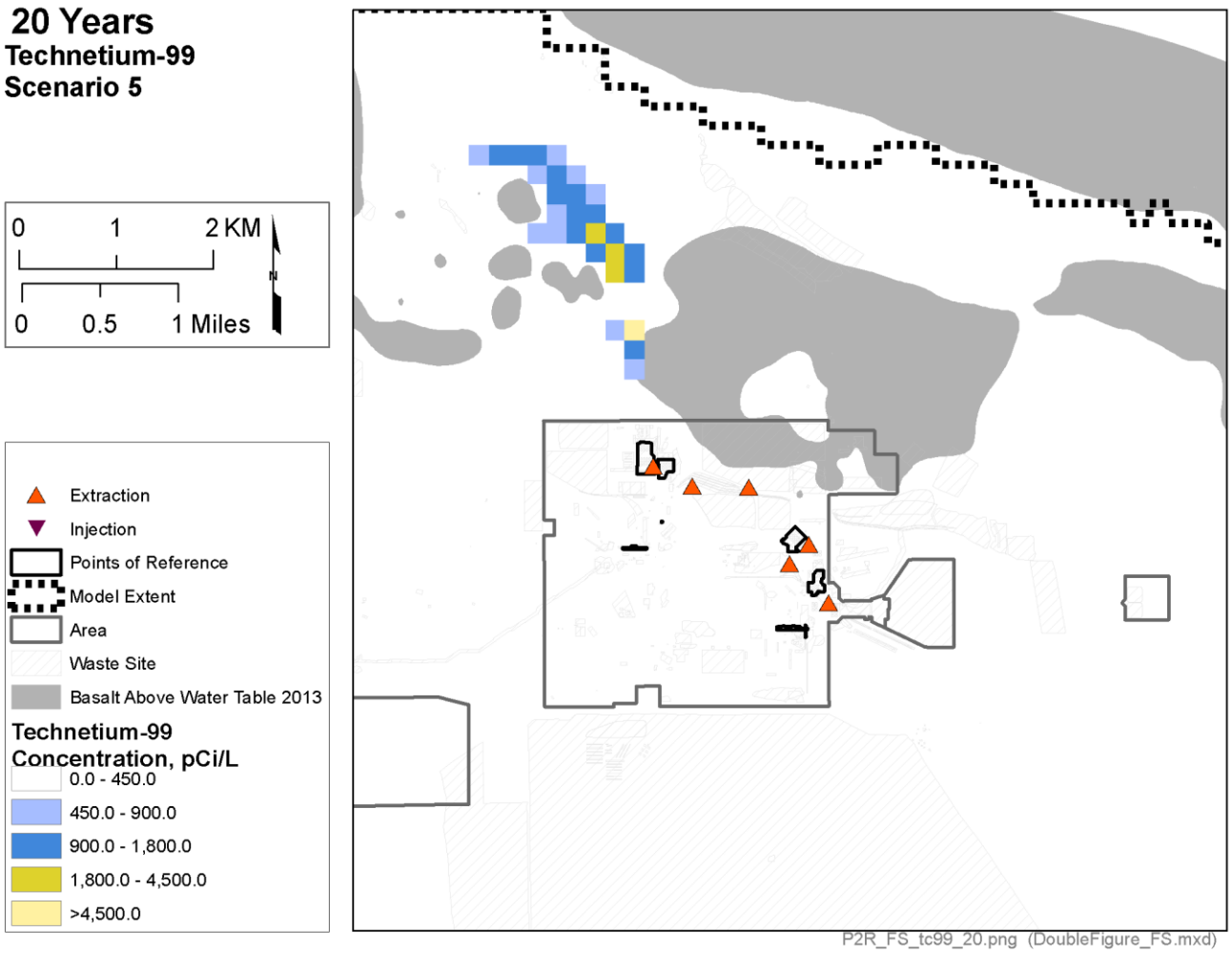

Figure B-231 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 5 simulation.

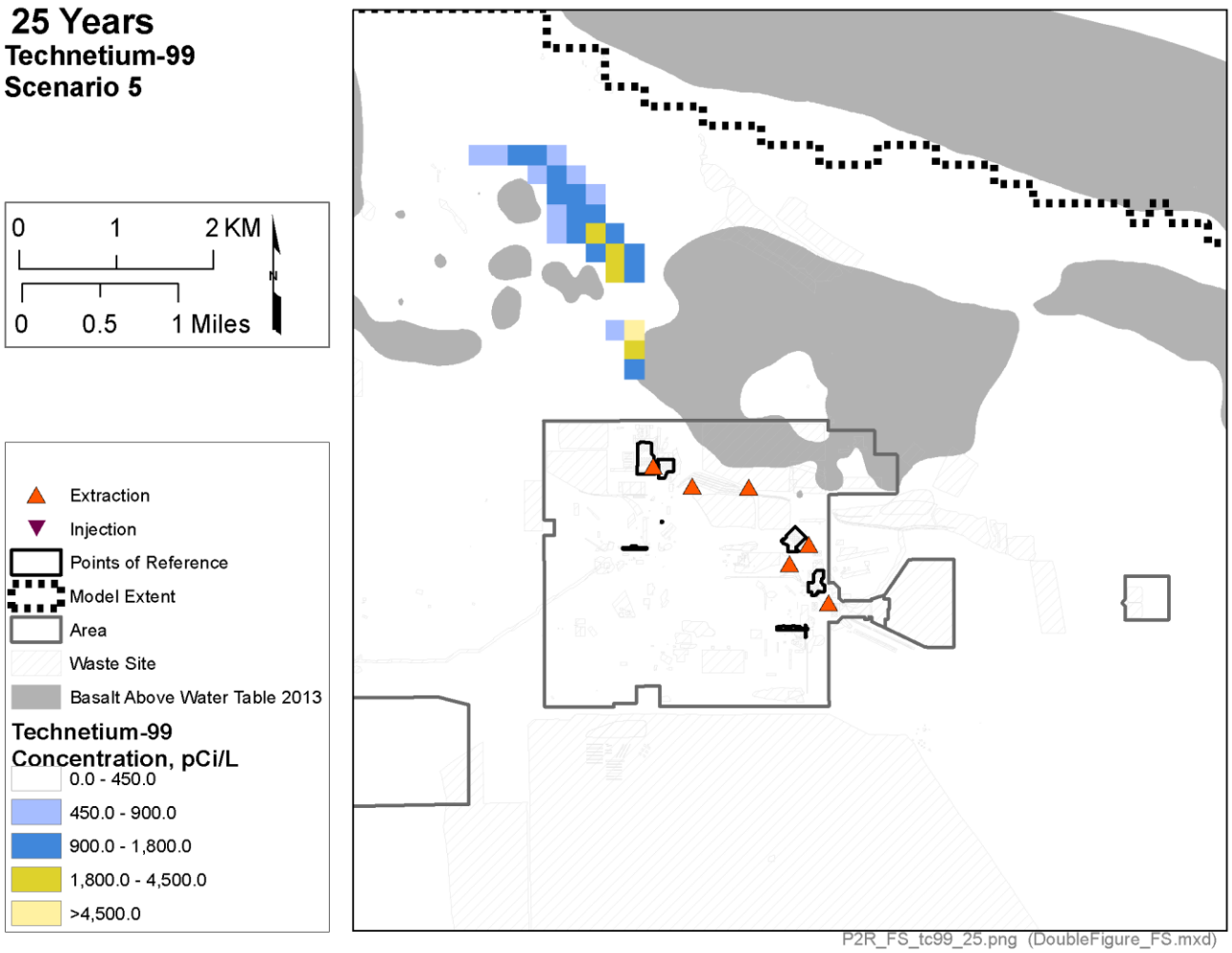

Figure B-232 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 5 simulation.

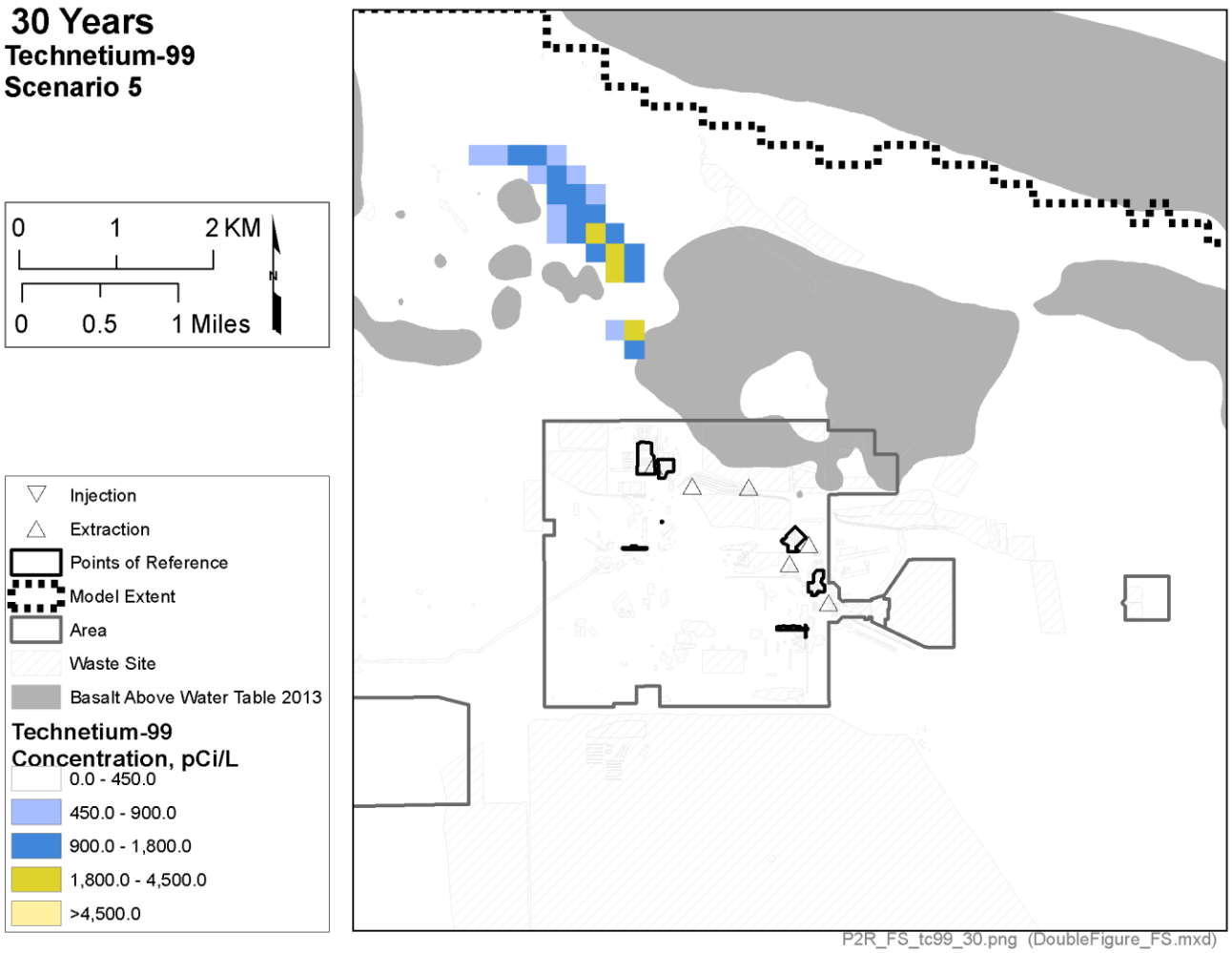

Figure B-233 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 5 simulation.

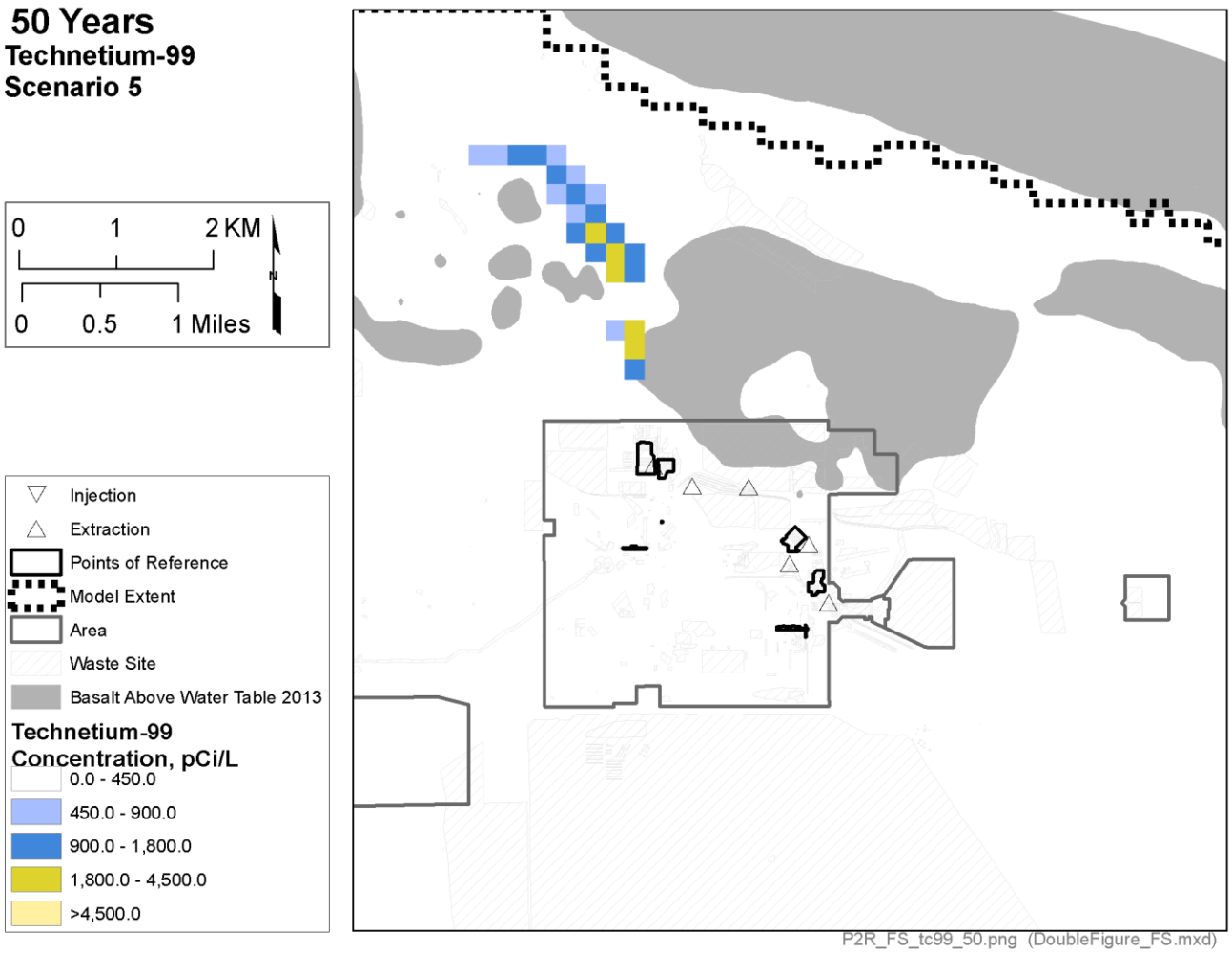

Figure B-234 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 5 simulation.

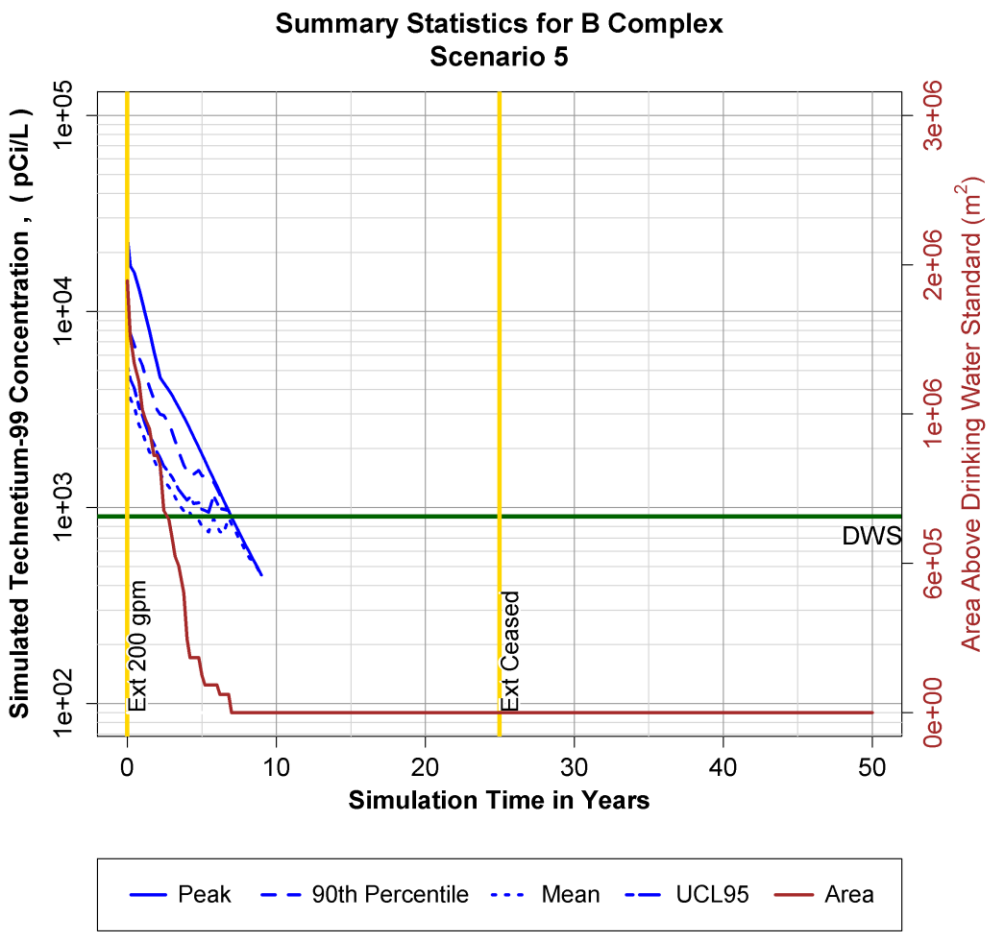

Figure B-235 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

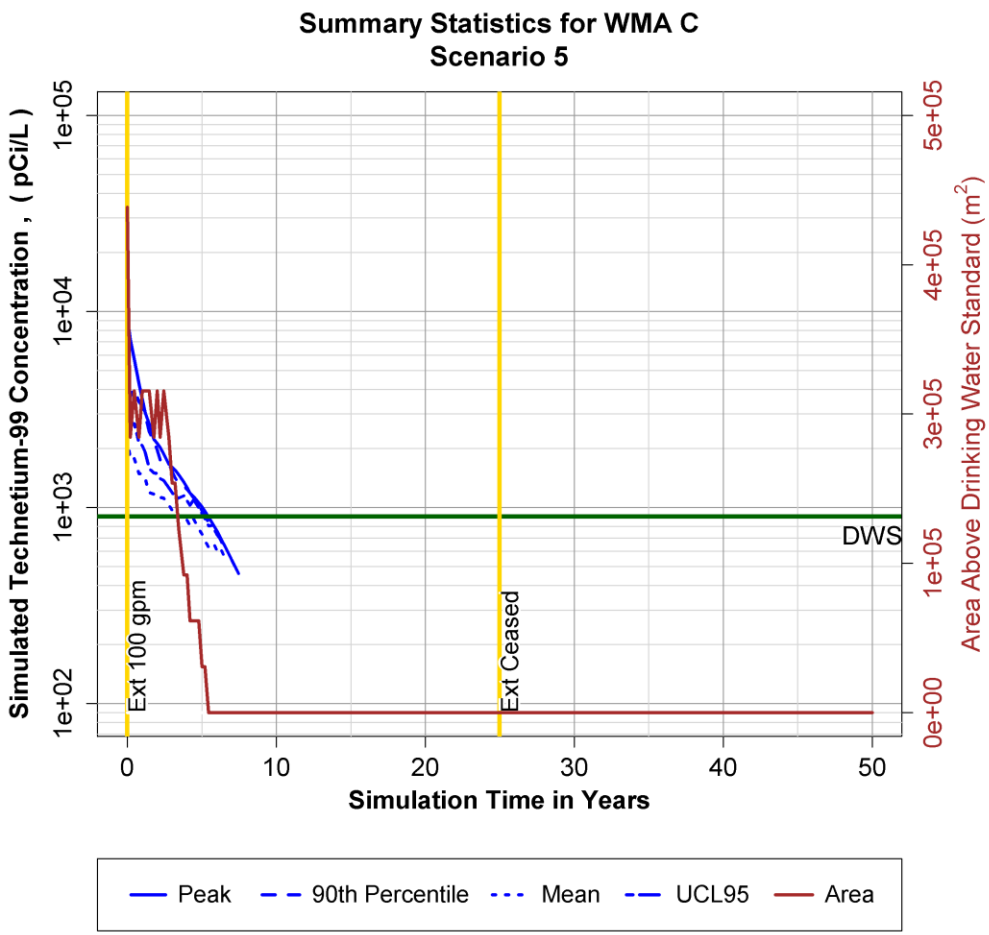

Figure B-236 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

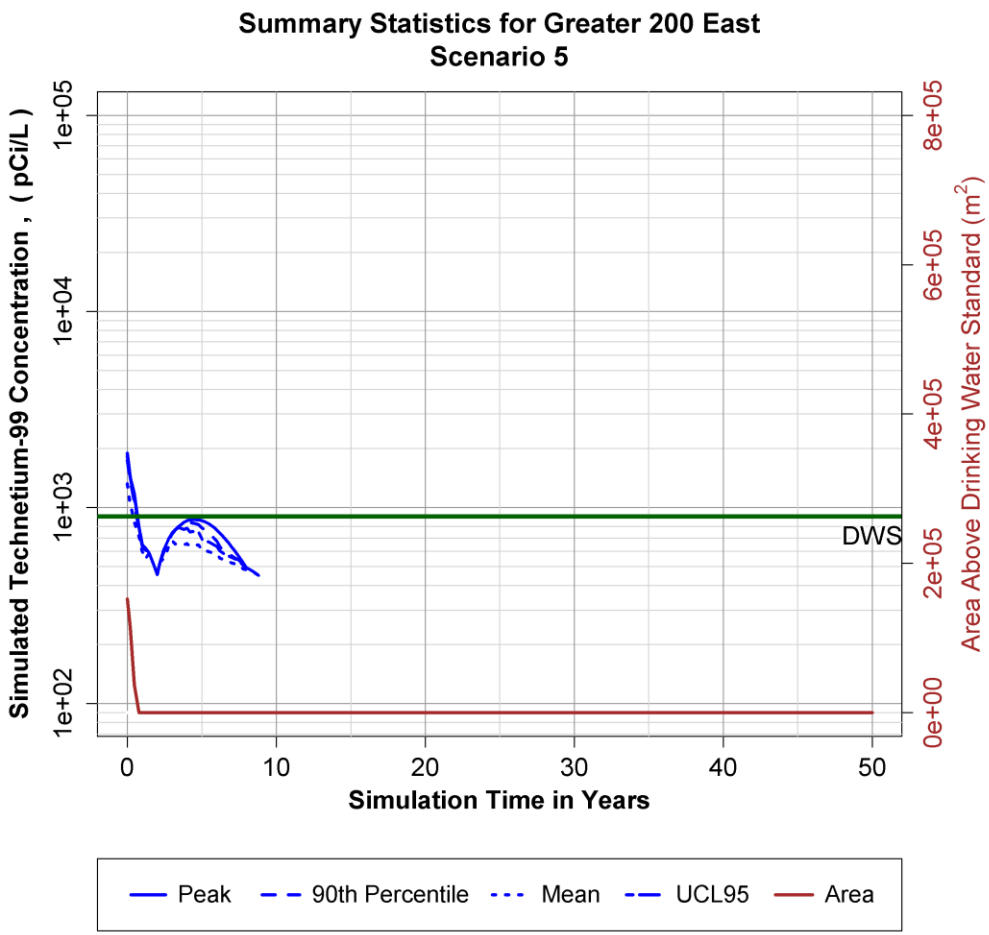

Figure B-237 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

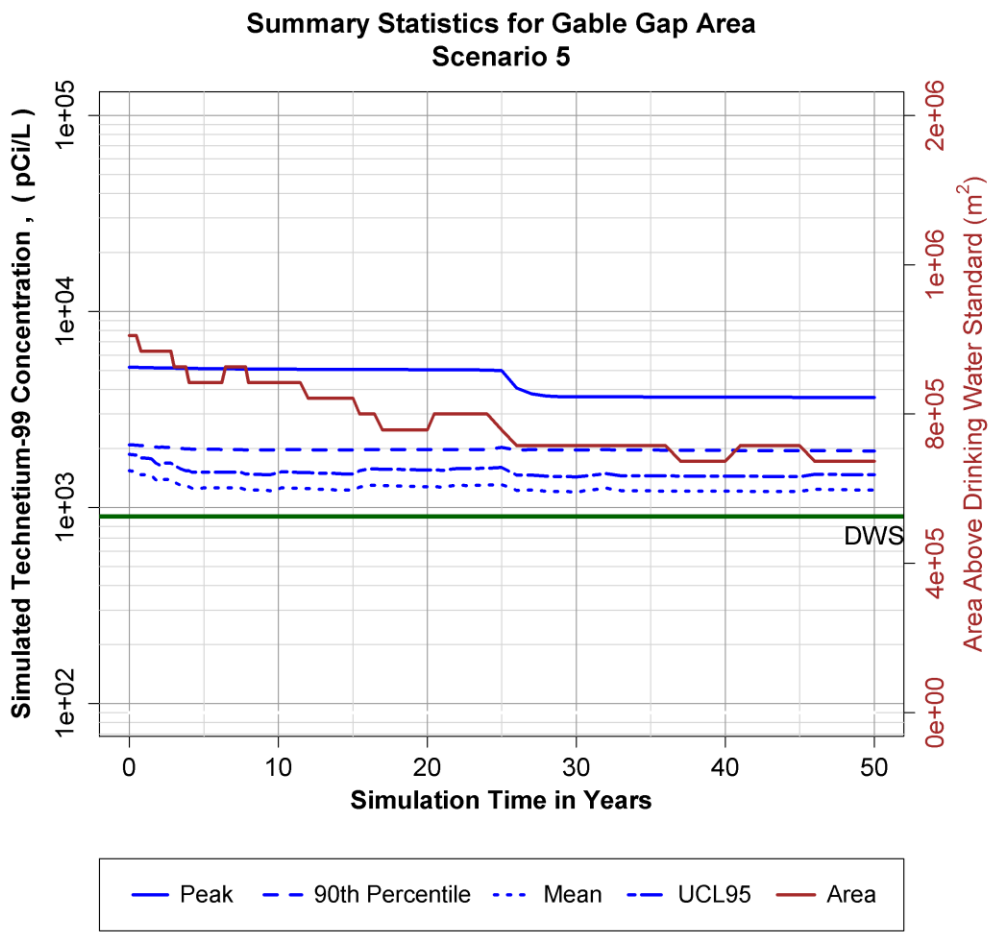

Figure B-238 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation.

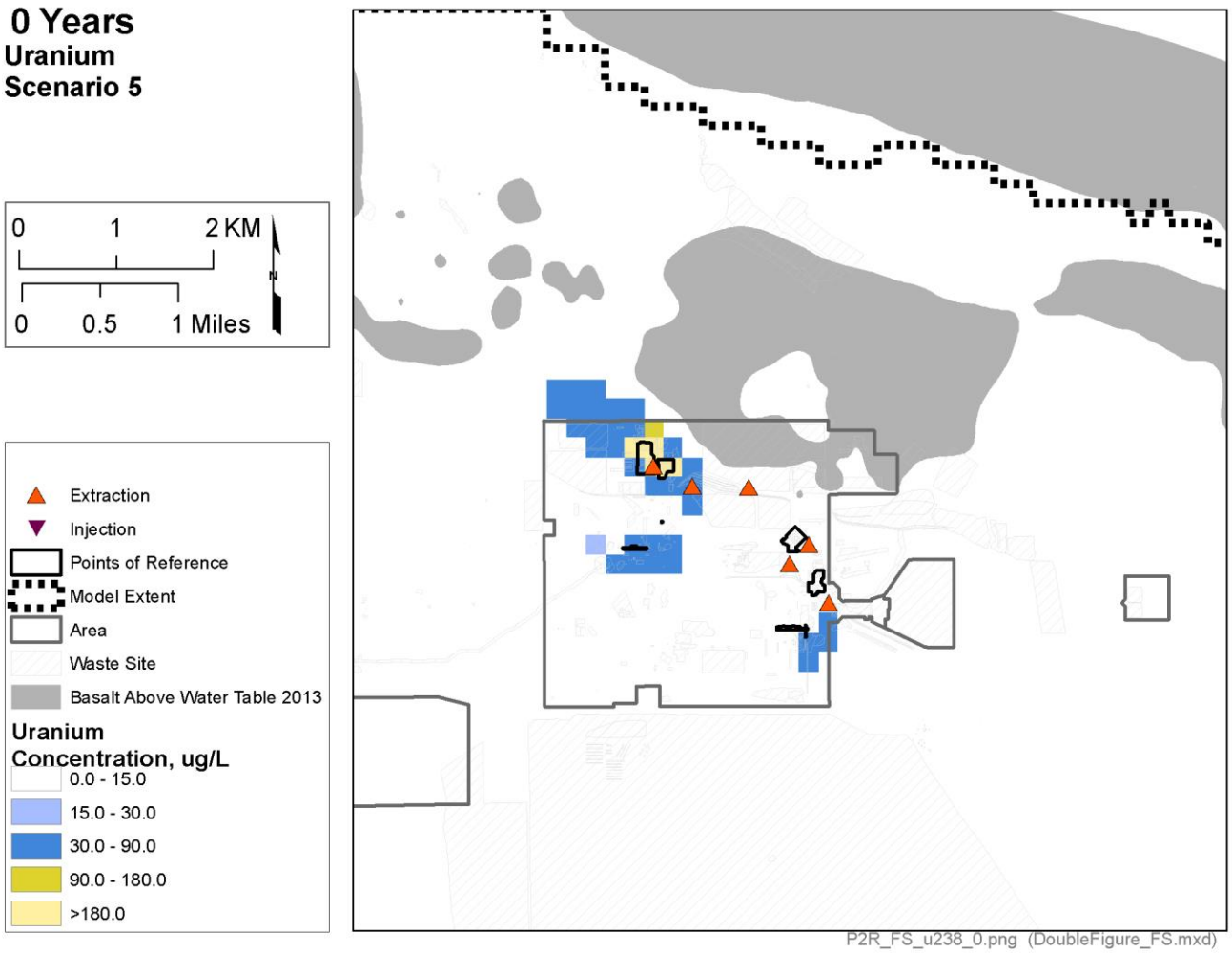

Figure B-239 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 5 simulation.

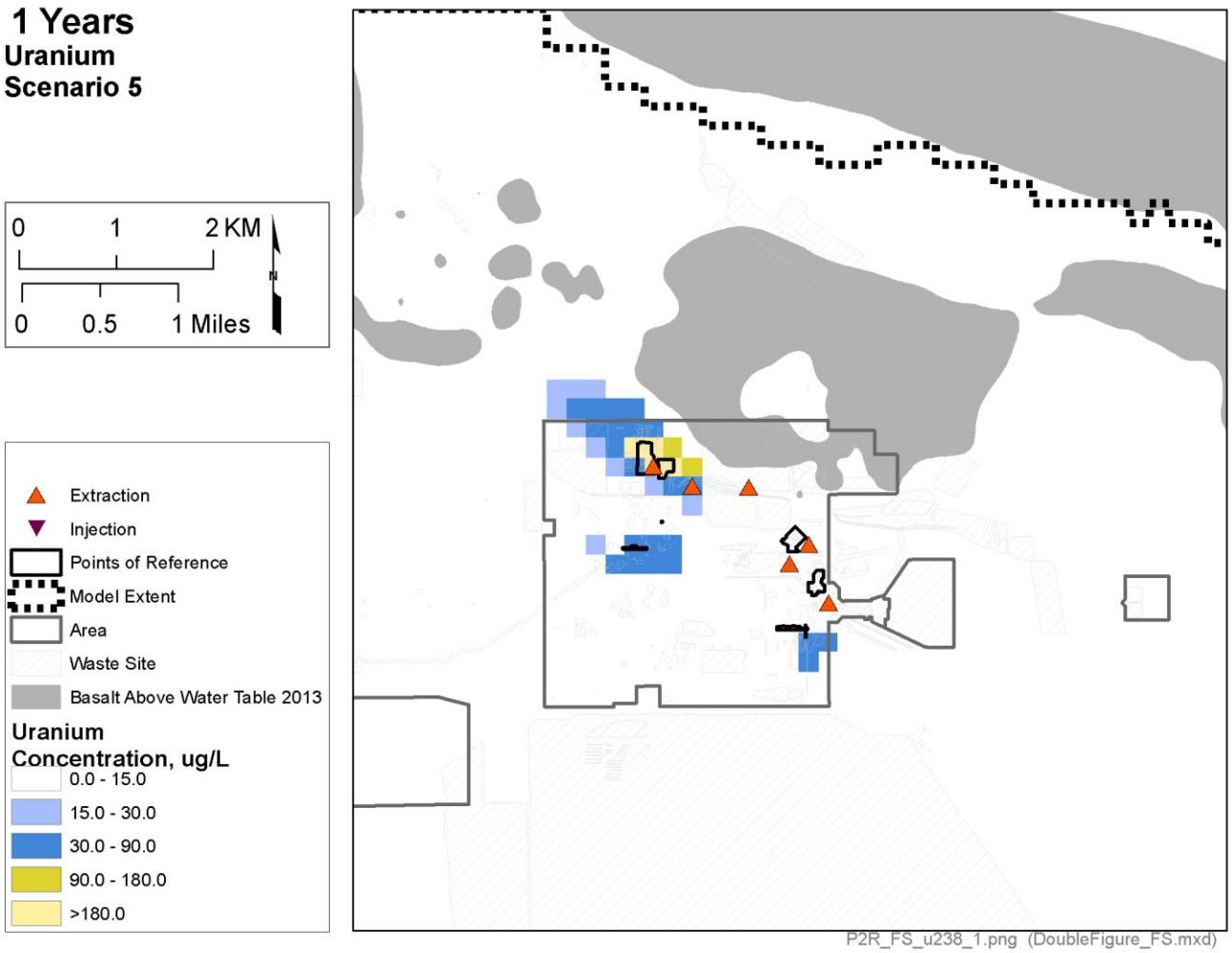

Figure B-240 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 5 simulation.

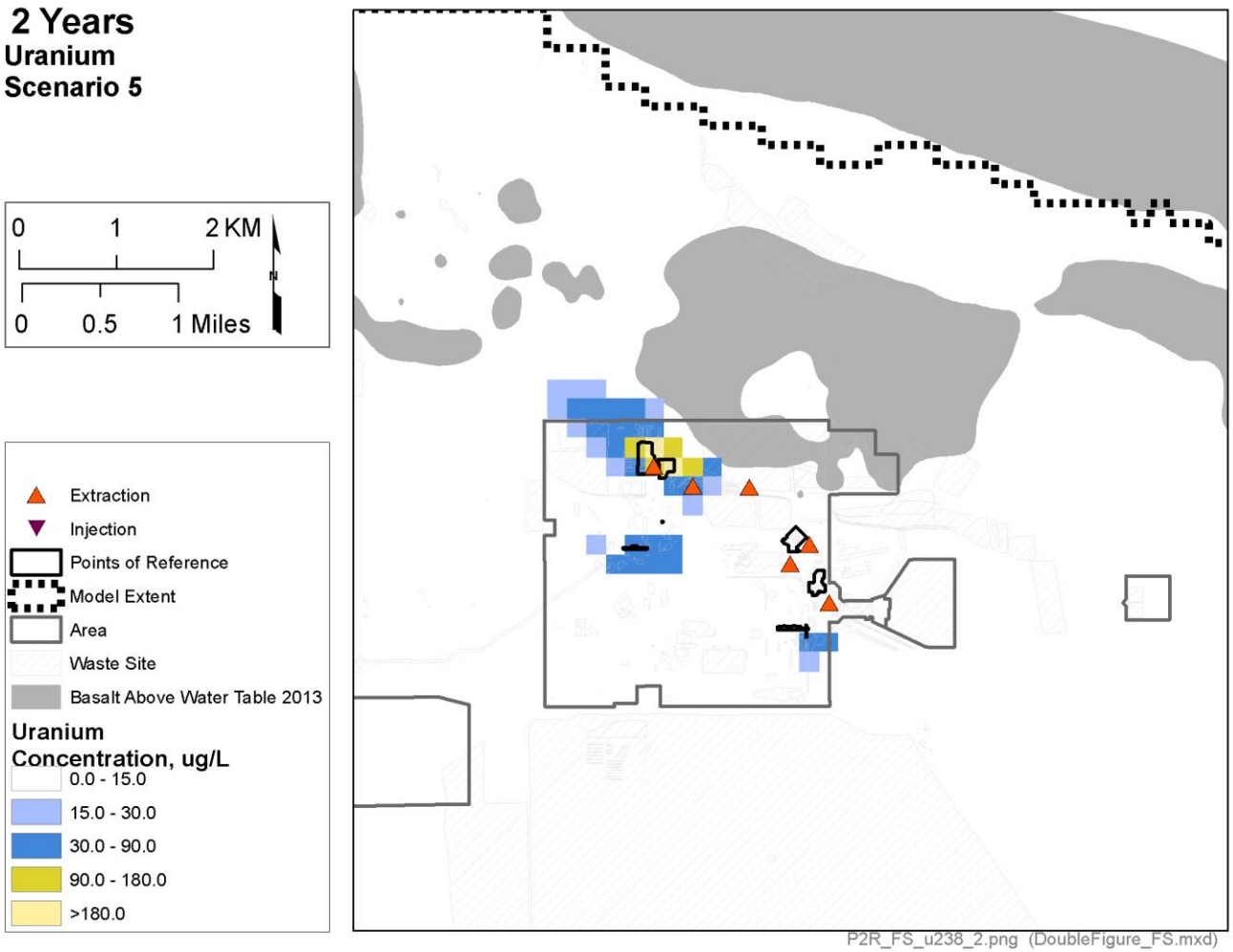

Figure B-241 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 5 simulation.

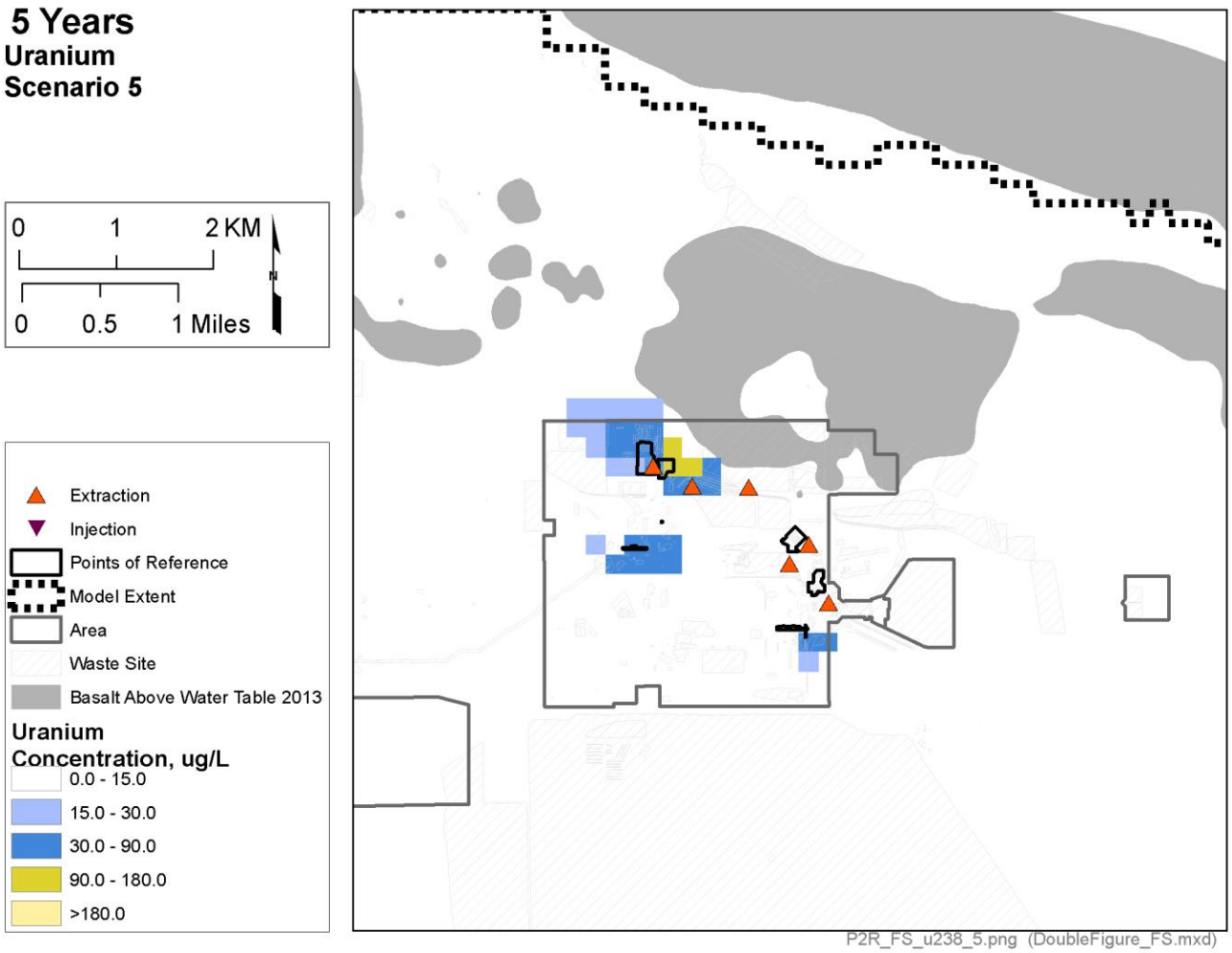

Figure B-242 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 5 simulation.

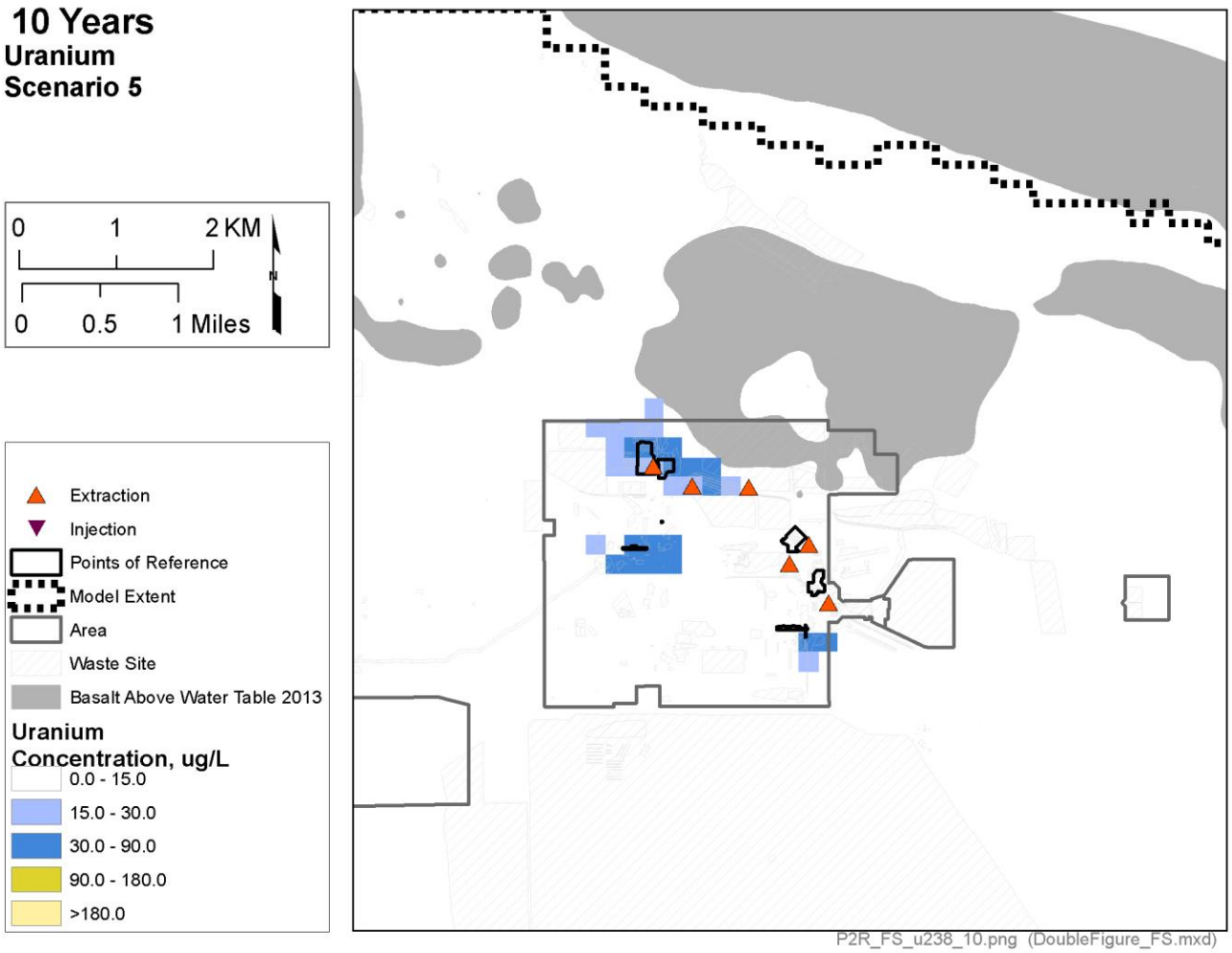

Figure B-243 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 5 simulation.

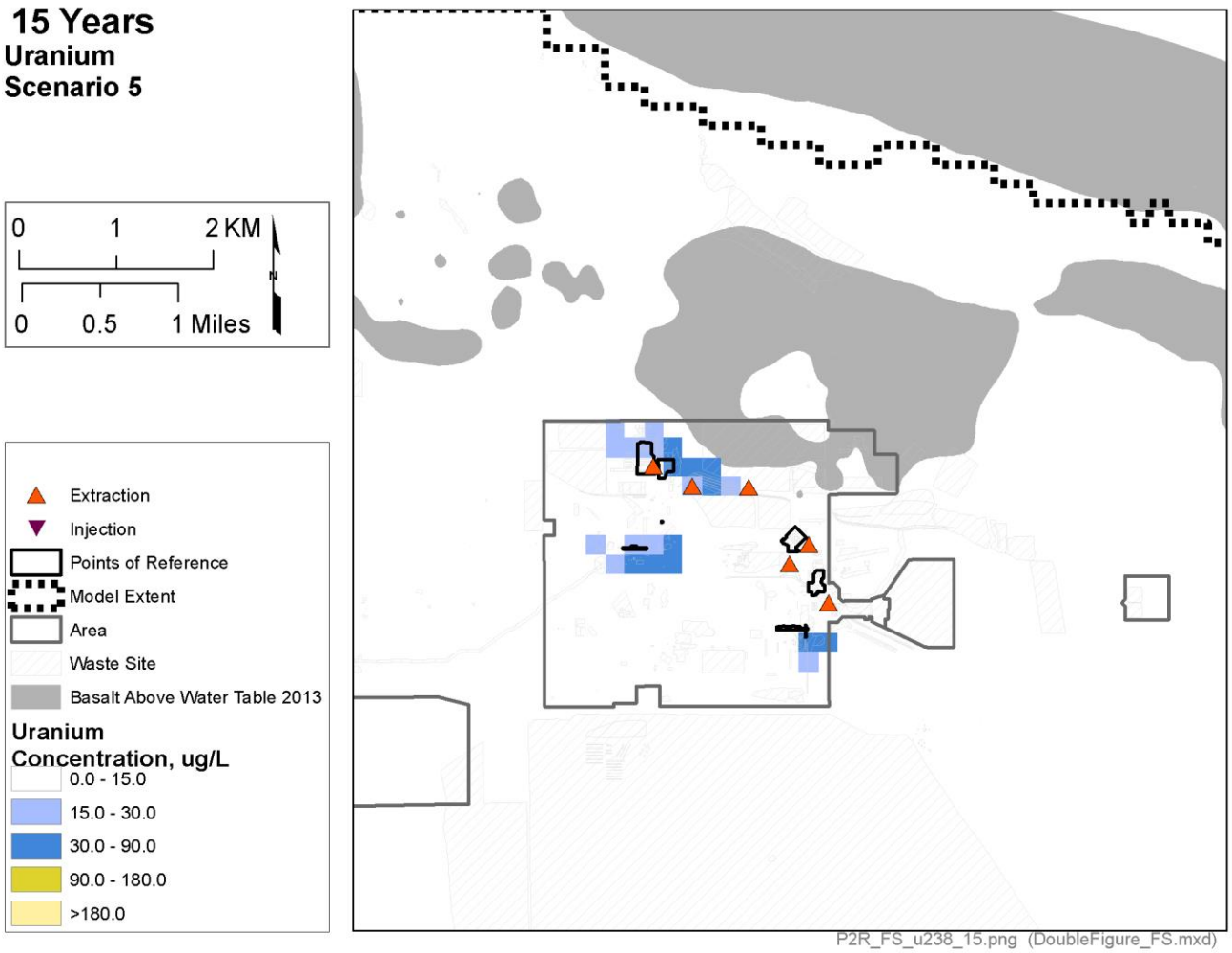

Figure B-244 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 5 simulation.

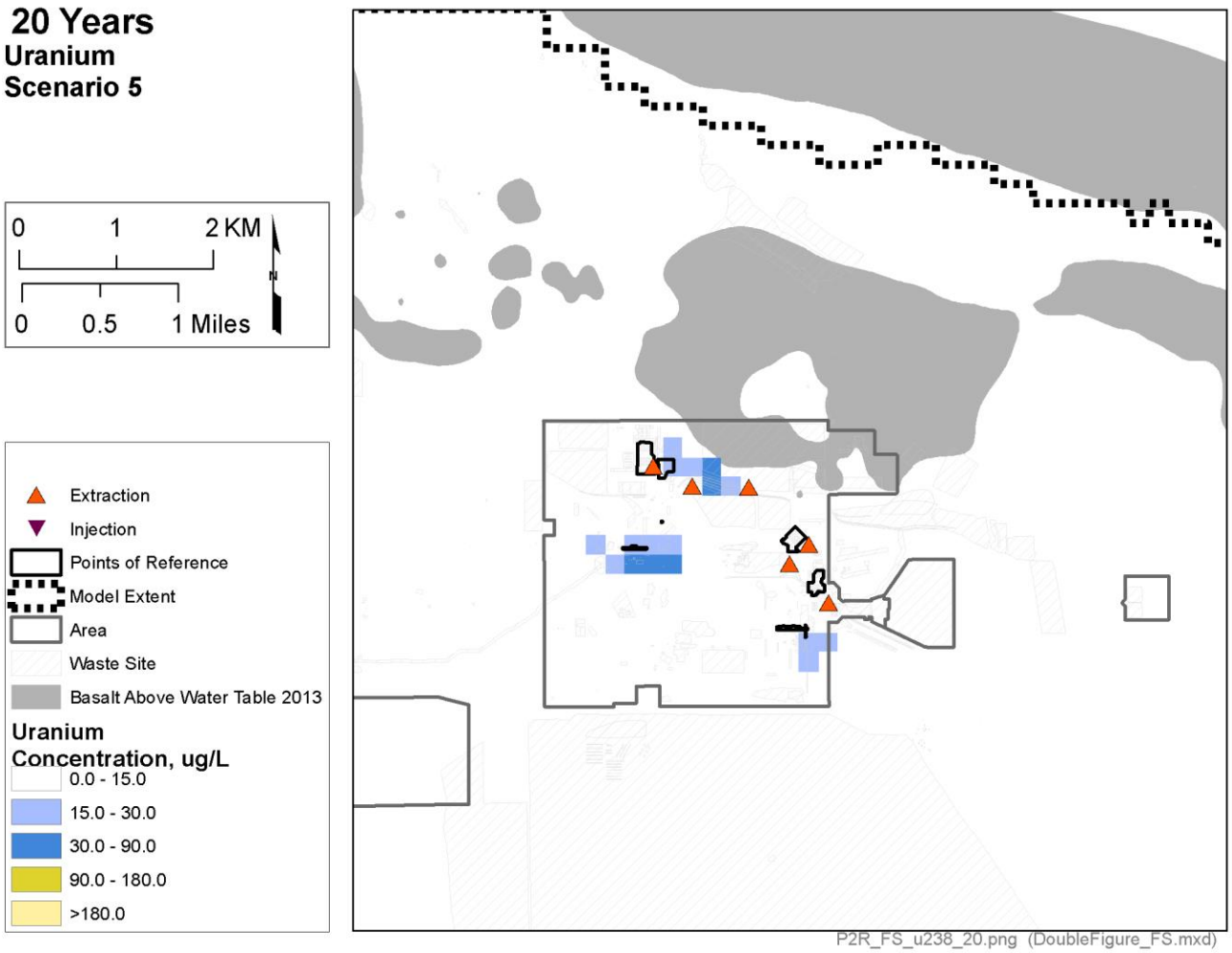

Figure B-245 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 5 simulation.

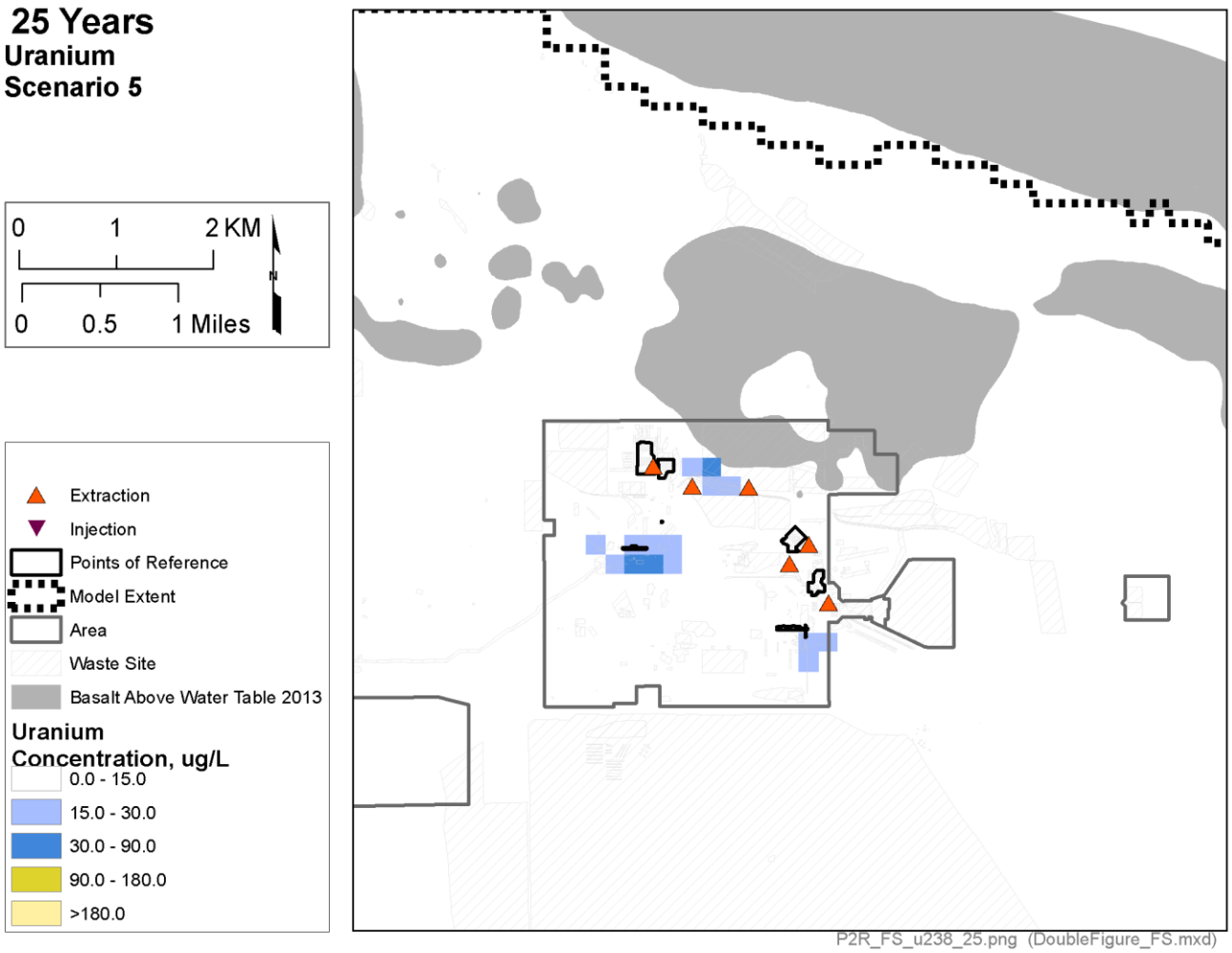

Figure B-246 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 5 simulation.

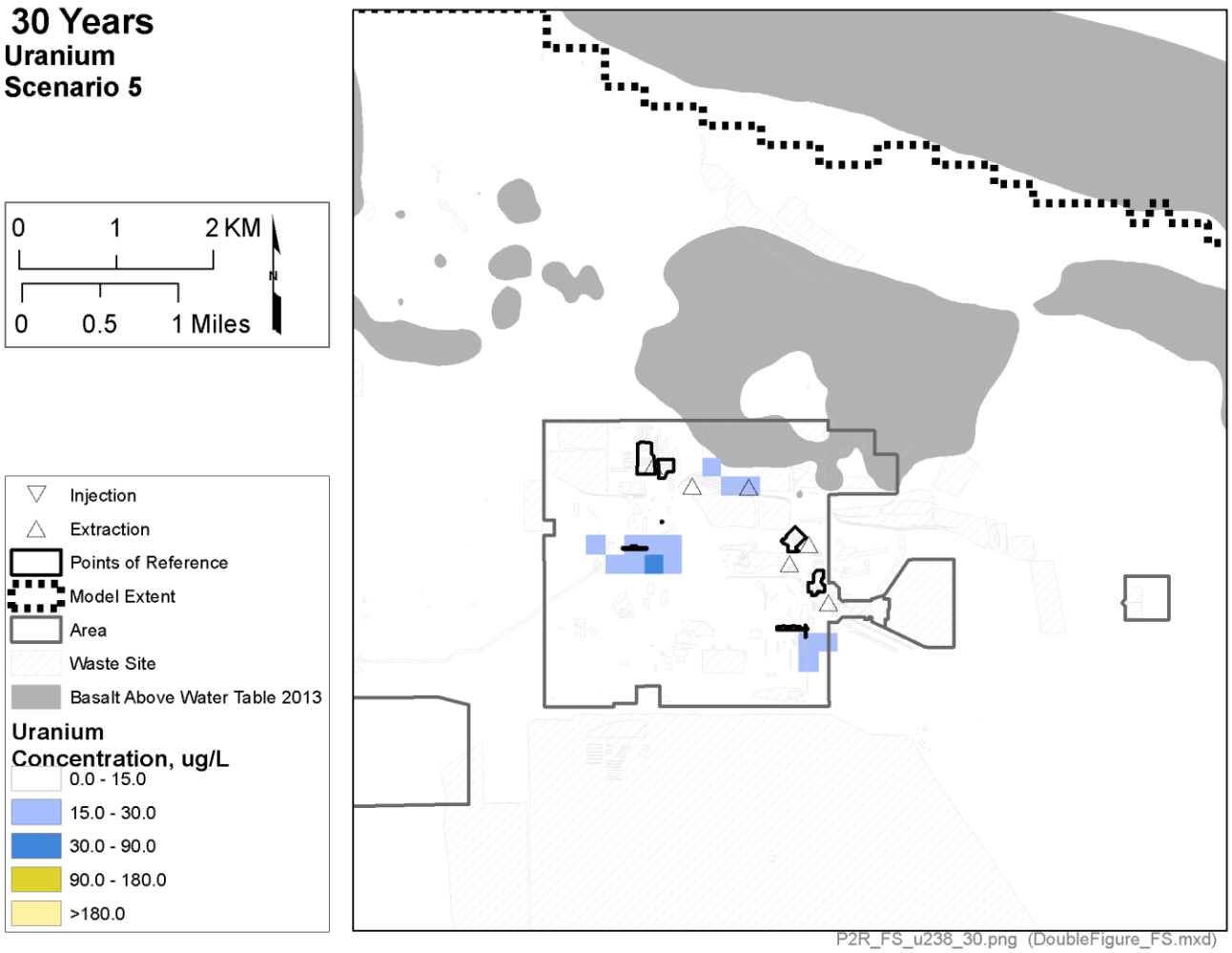

Figure B-247 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 5 simulation.

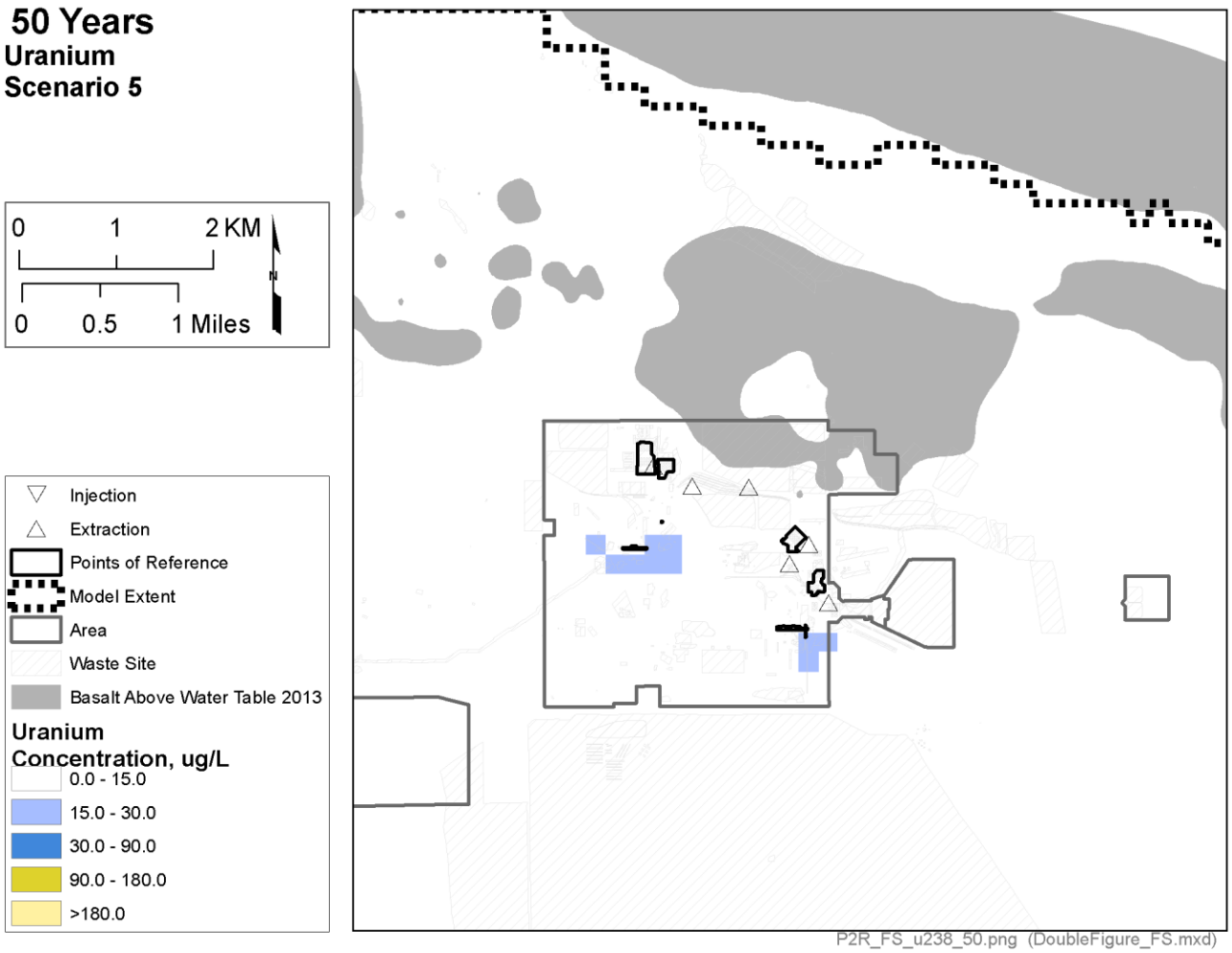

Figure B-248 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 5 simulation.

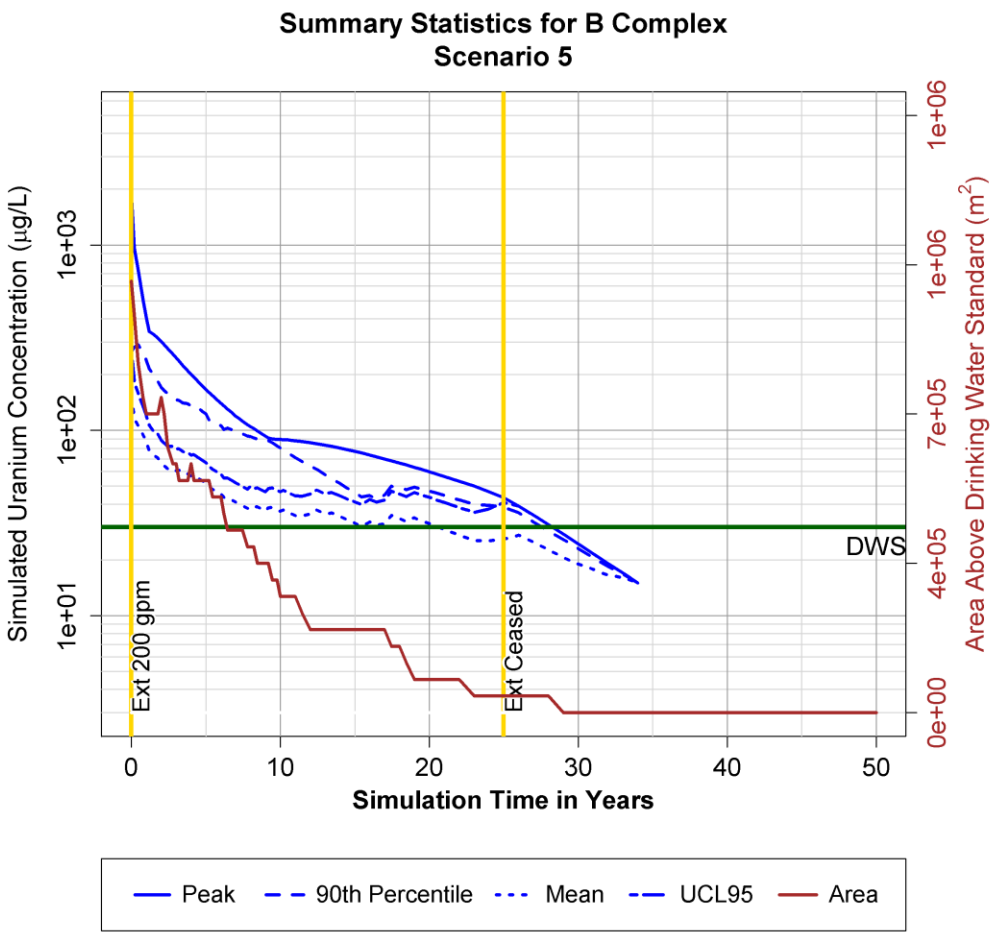

Figure B-249 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

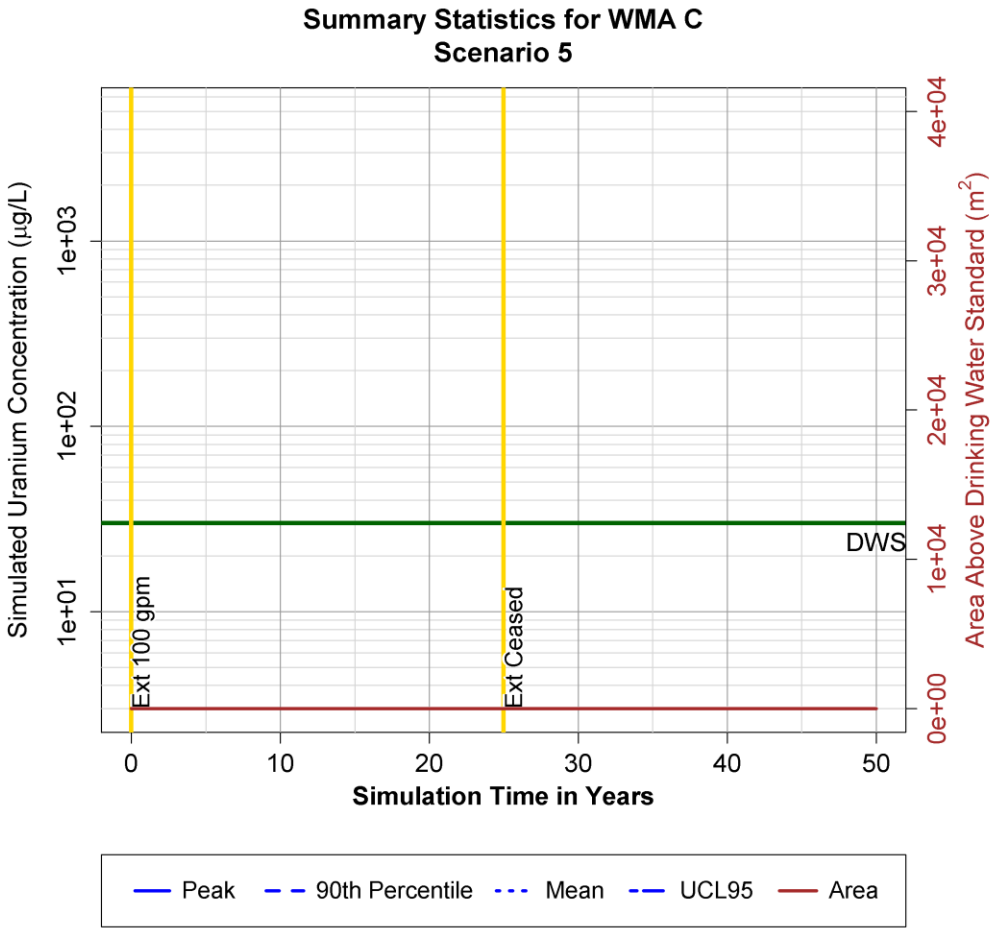

Figure B-250 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

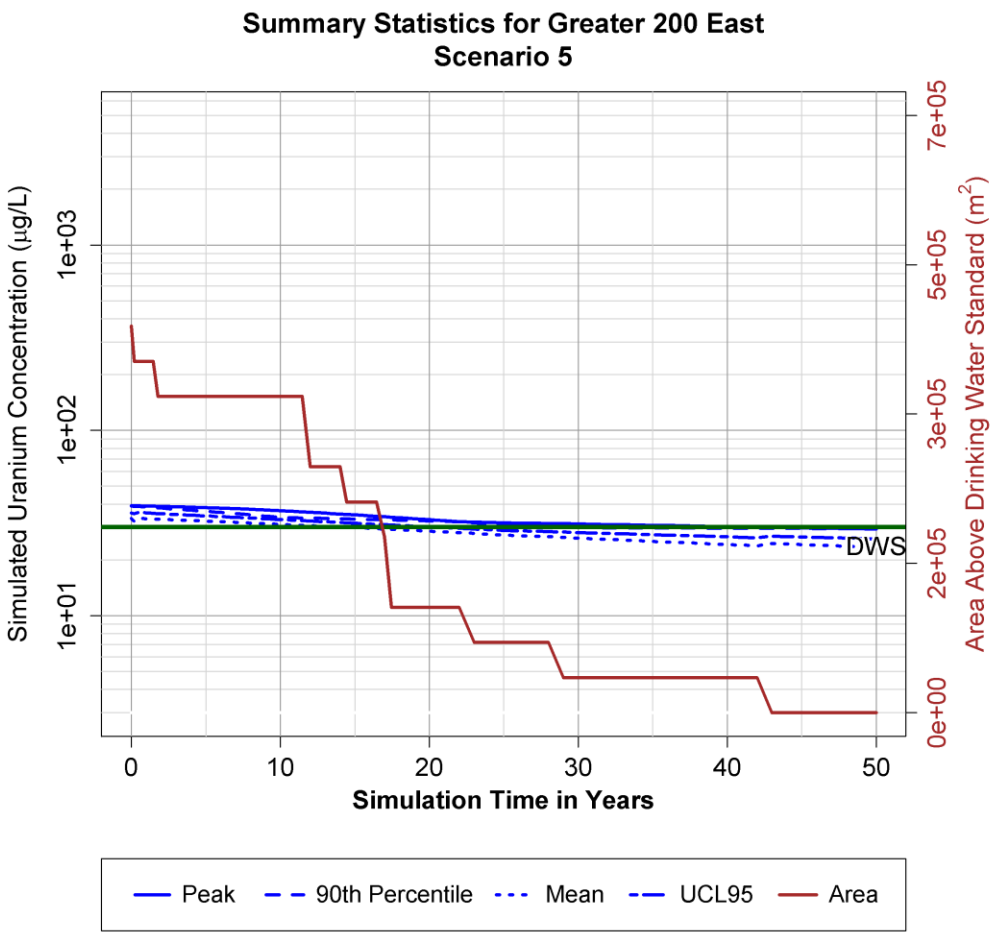

Figure B-251 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

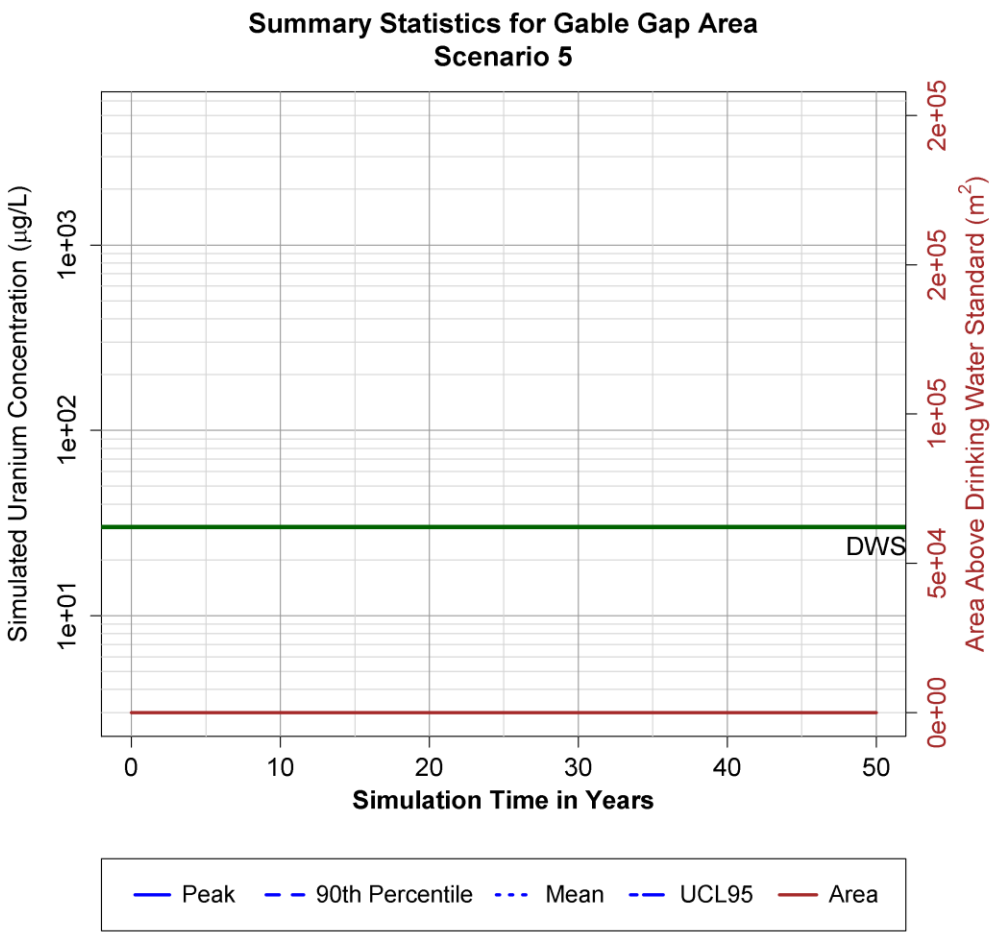

Figure B-252 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation.

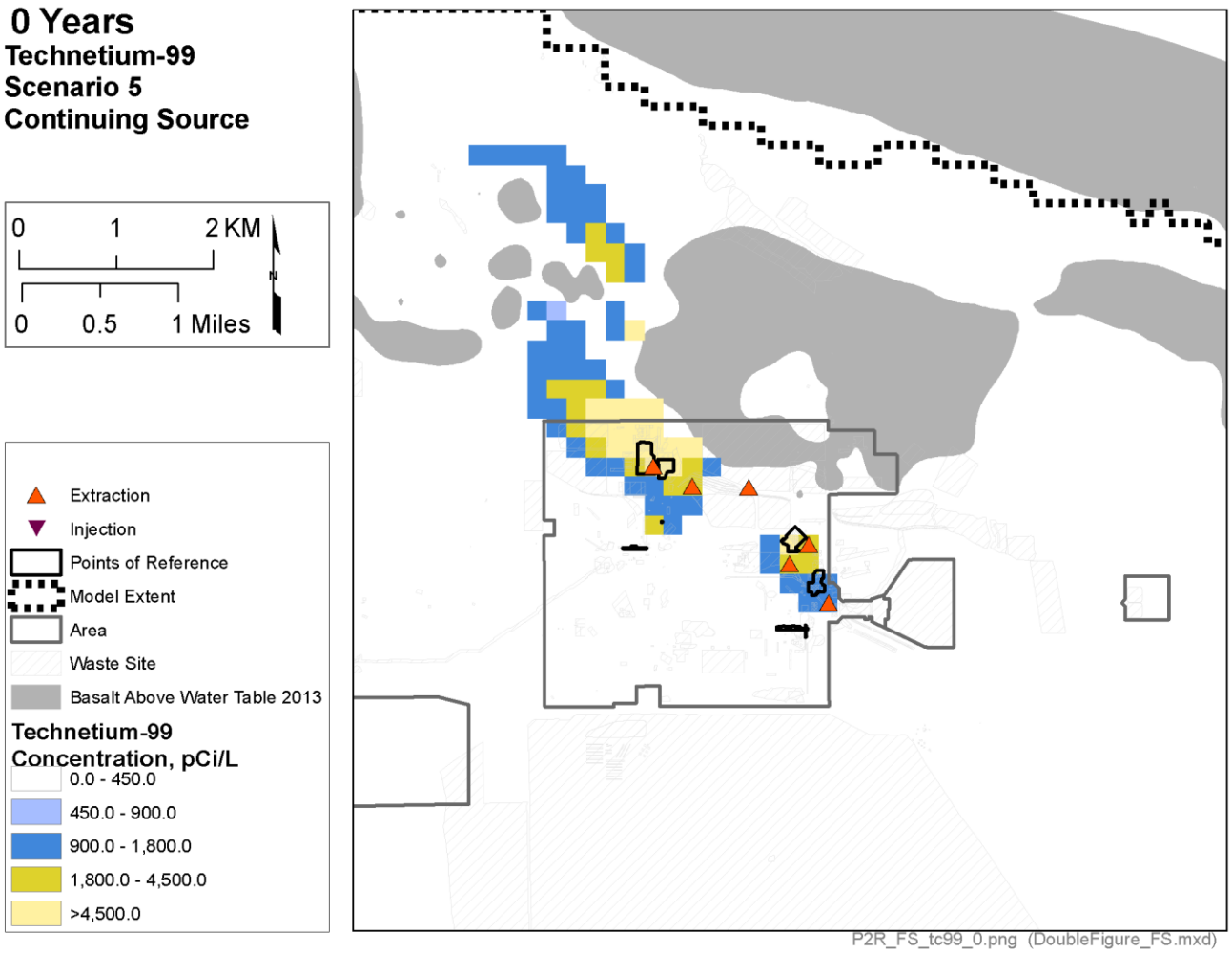

Figure B-253 - Plan view contours of the technetium-99 plume at simulation time 0 years based on the scenario 5 simulation with a continuing source term.

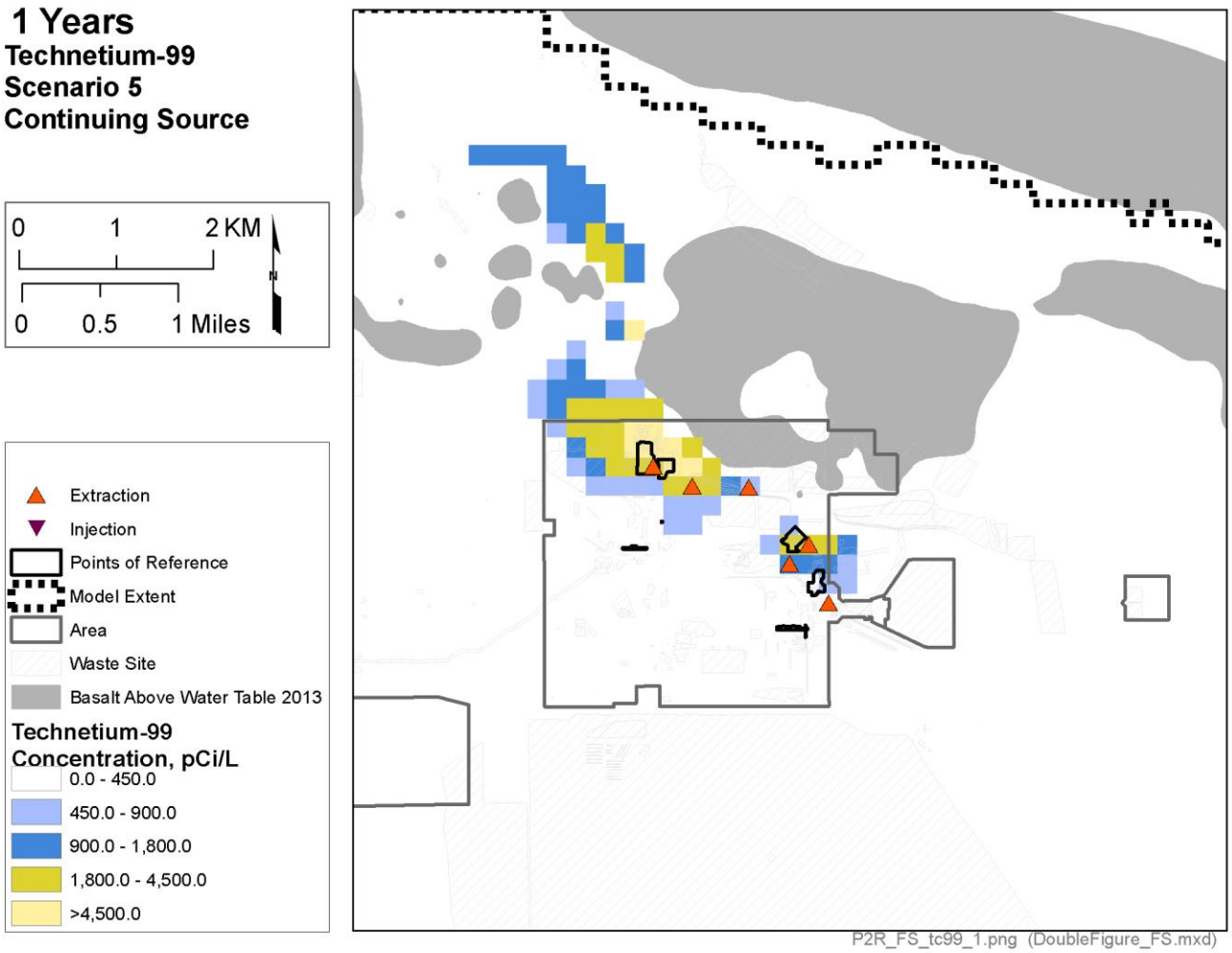

Figure B-254 - Plan view contours of the technetium-99 plume at simulation time 1 years based on the scenario 5 simulation with a continuing source term.

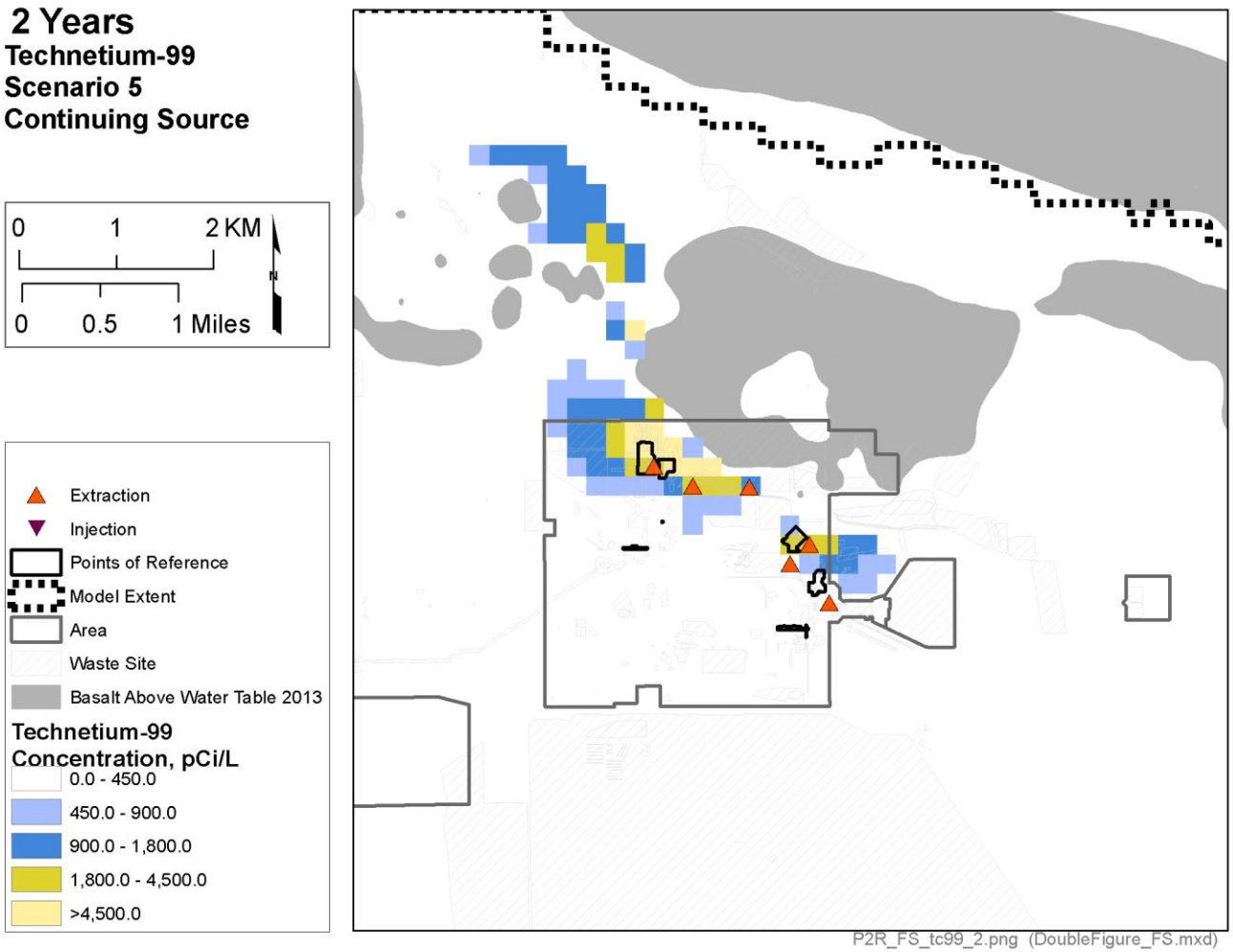

Figure B-255 - Plan view contours of the technetium-99 plume at simulation time 2 years based on the scenario 5 simulation with a continuing source term.

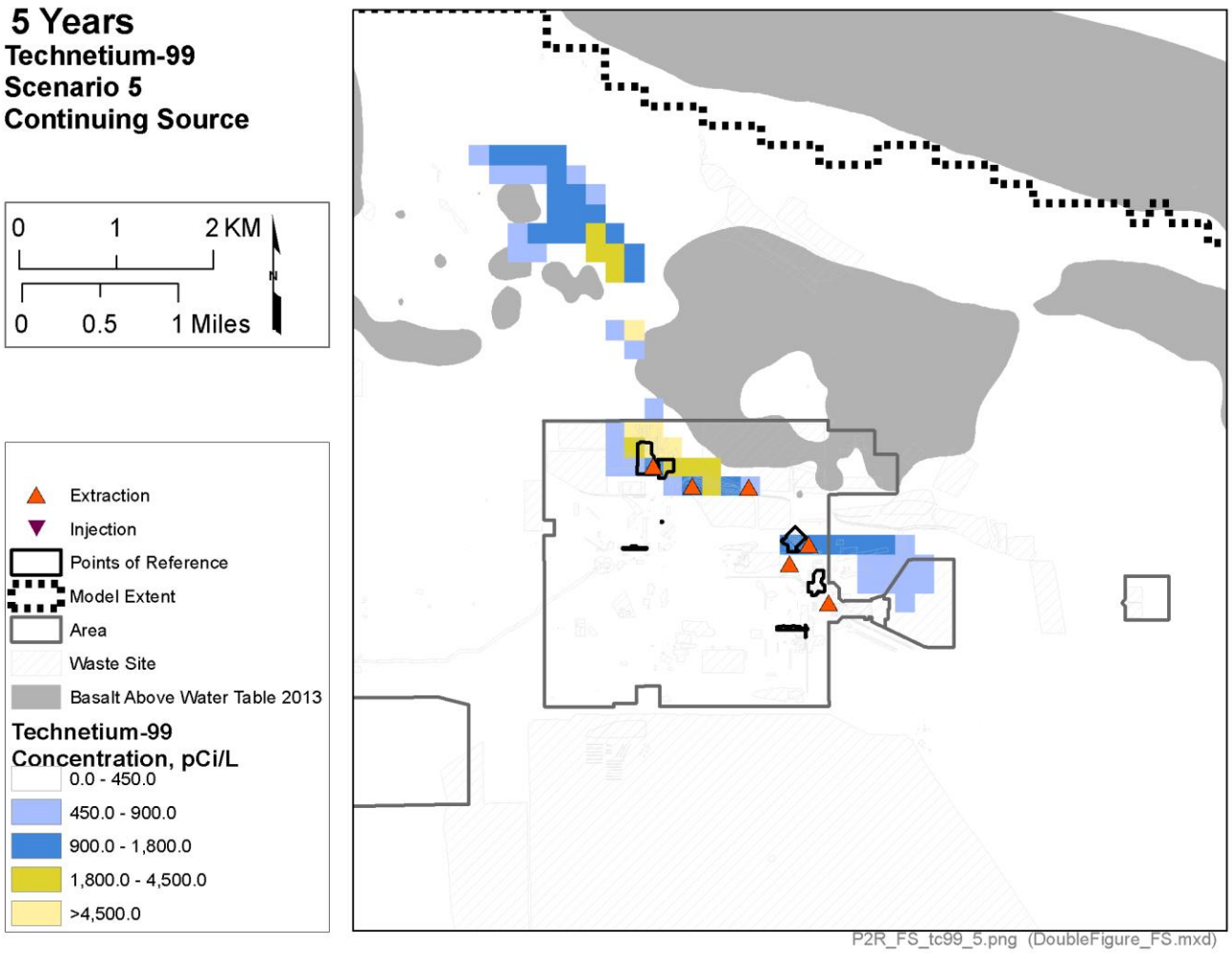

Figure B-256 - Plan view contours of the technetium-99 plume at simulation time 5 years based on the scenario 5 simulation with a continuing source term.

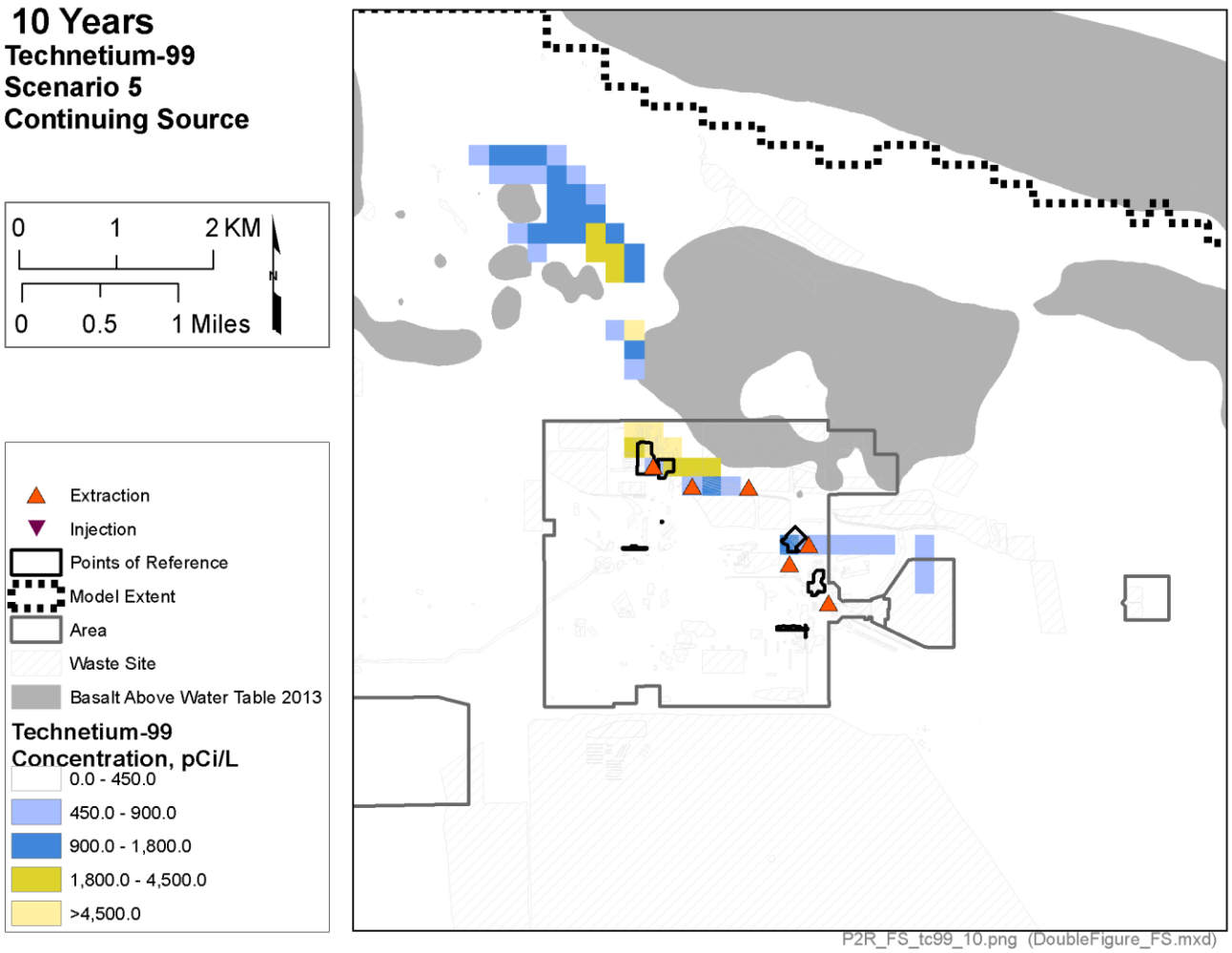

Figure B-257 - Plan view contours of the technetium-99 plume at simulation time 10 years based on the scenario 5 simulation with a continuing source term.

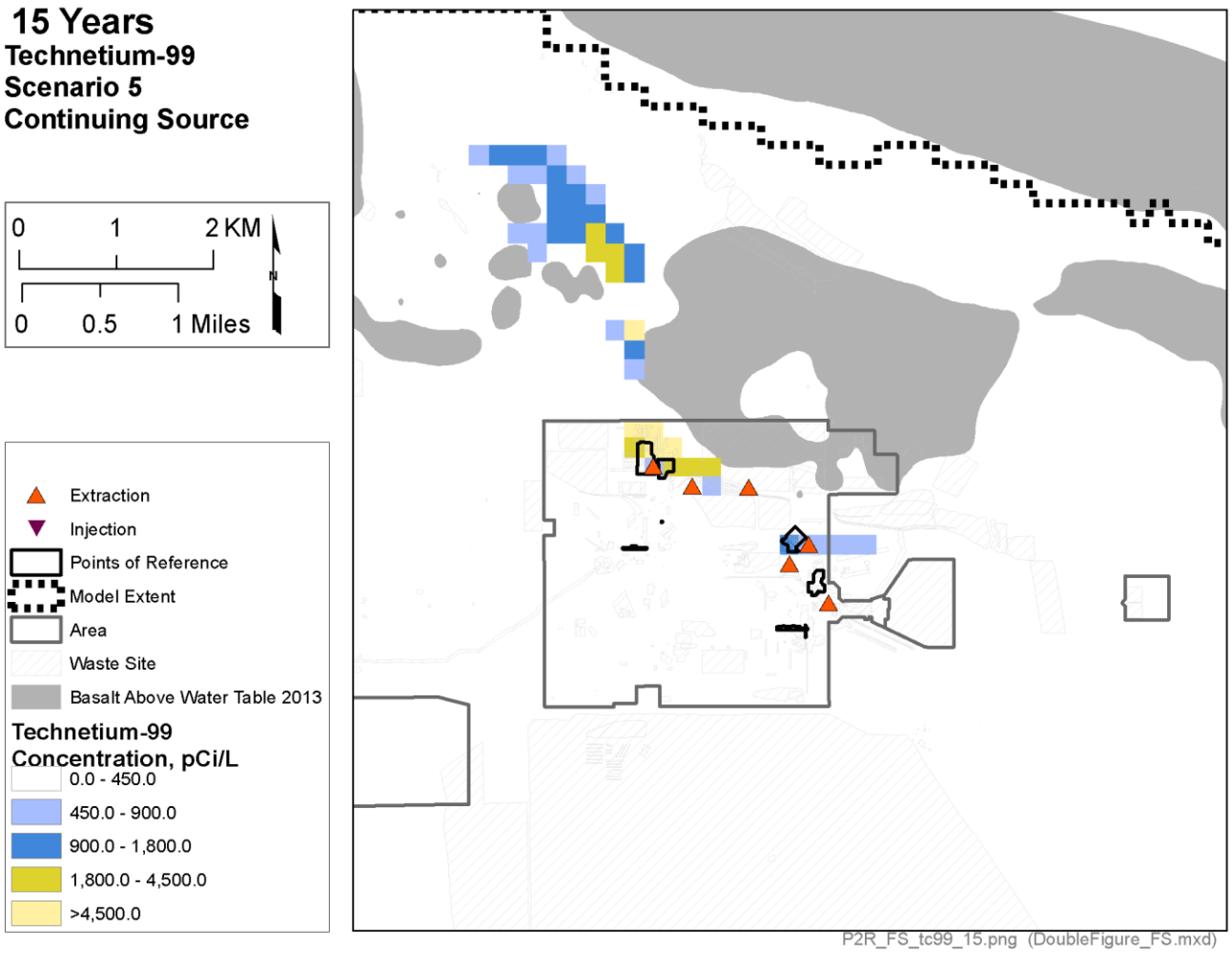

Figure B-258 - Plan view contours of the technetium-99 plume at simulation time 15 years based on the scenario 5 simulation with a continuing source term.

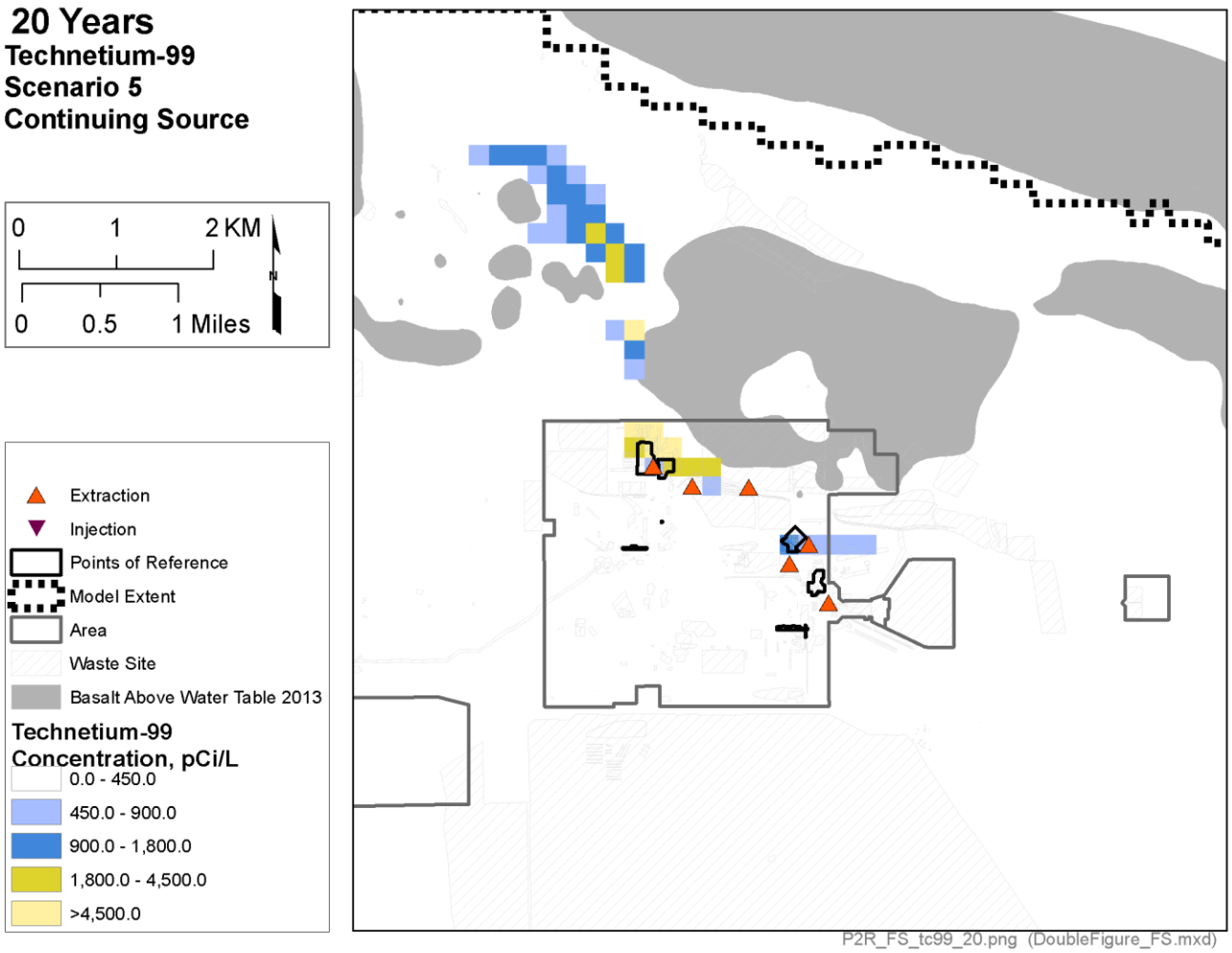

Figure B-259 - Plan view contours of the technetium-99 plume at simulation time 20 years based on the scenario 5 simulation with a continuing source term.

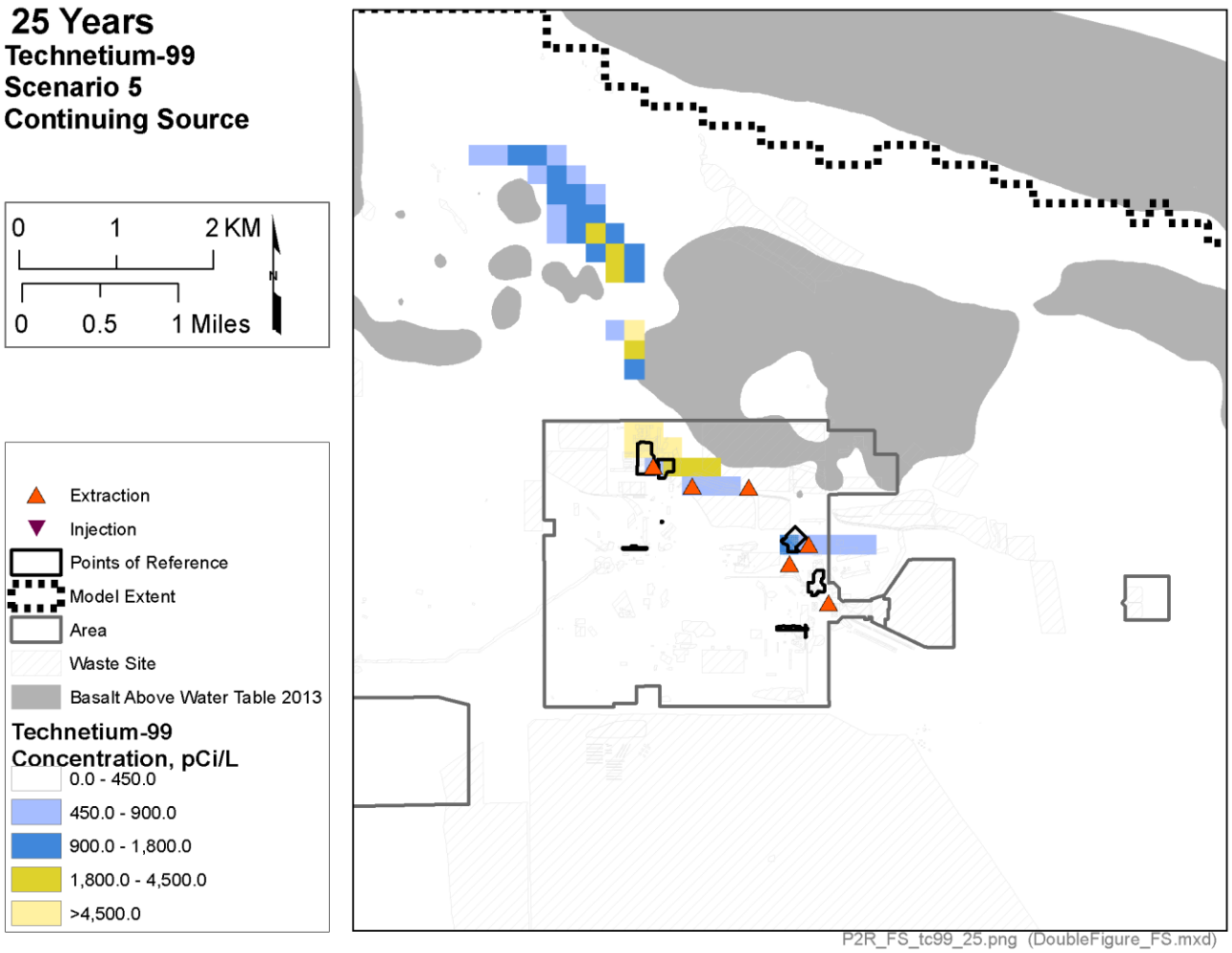

Figure B-260 - Plan view contours of the technetium-99 plume at simulation time 25 years based on the scenario 5 simulation with a continuing source term.

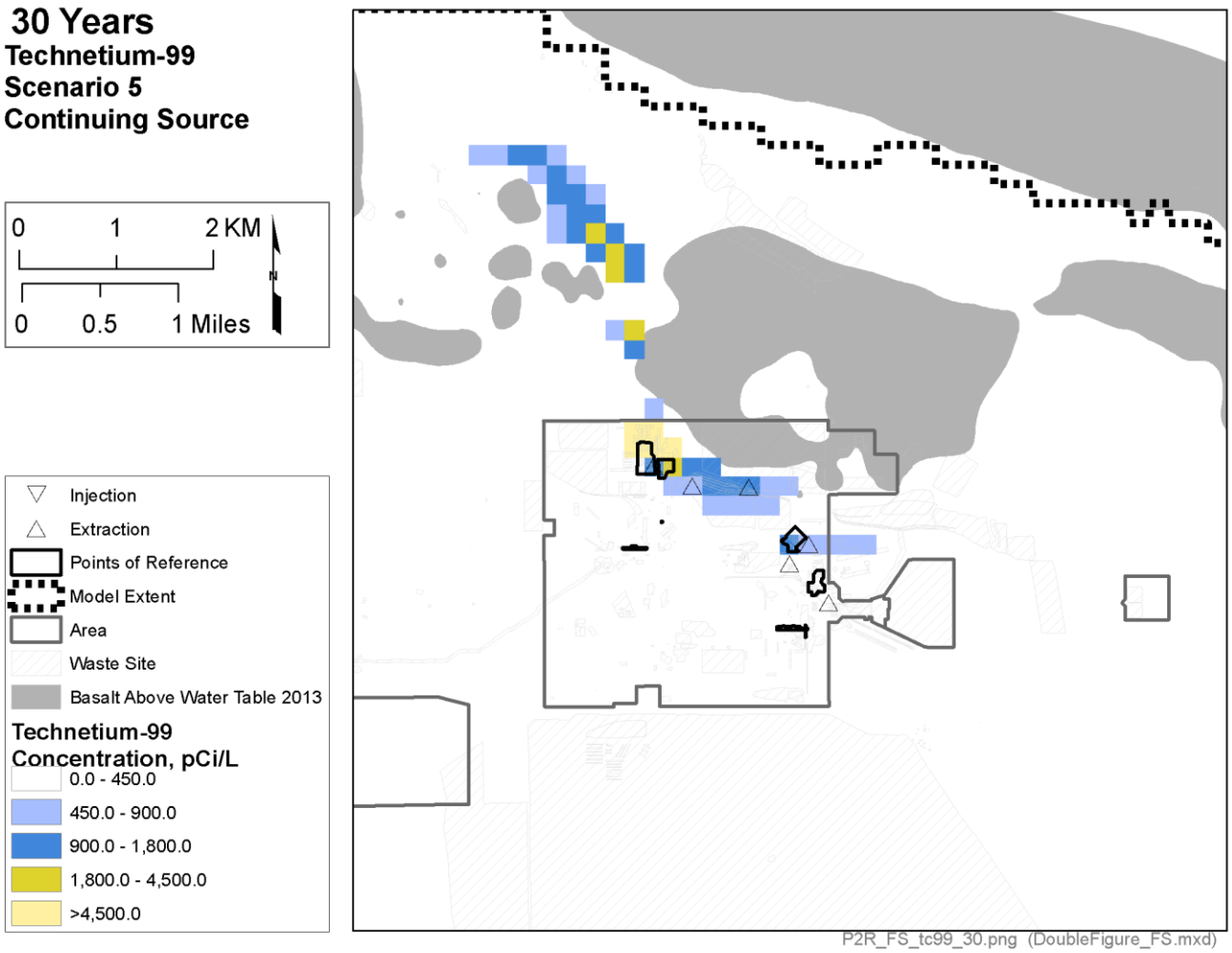

Figure B-261 - Plan view contours of the technetium-99 plume at simulation time 30 years based on the scenario 5 simulation with a continuing source term.

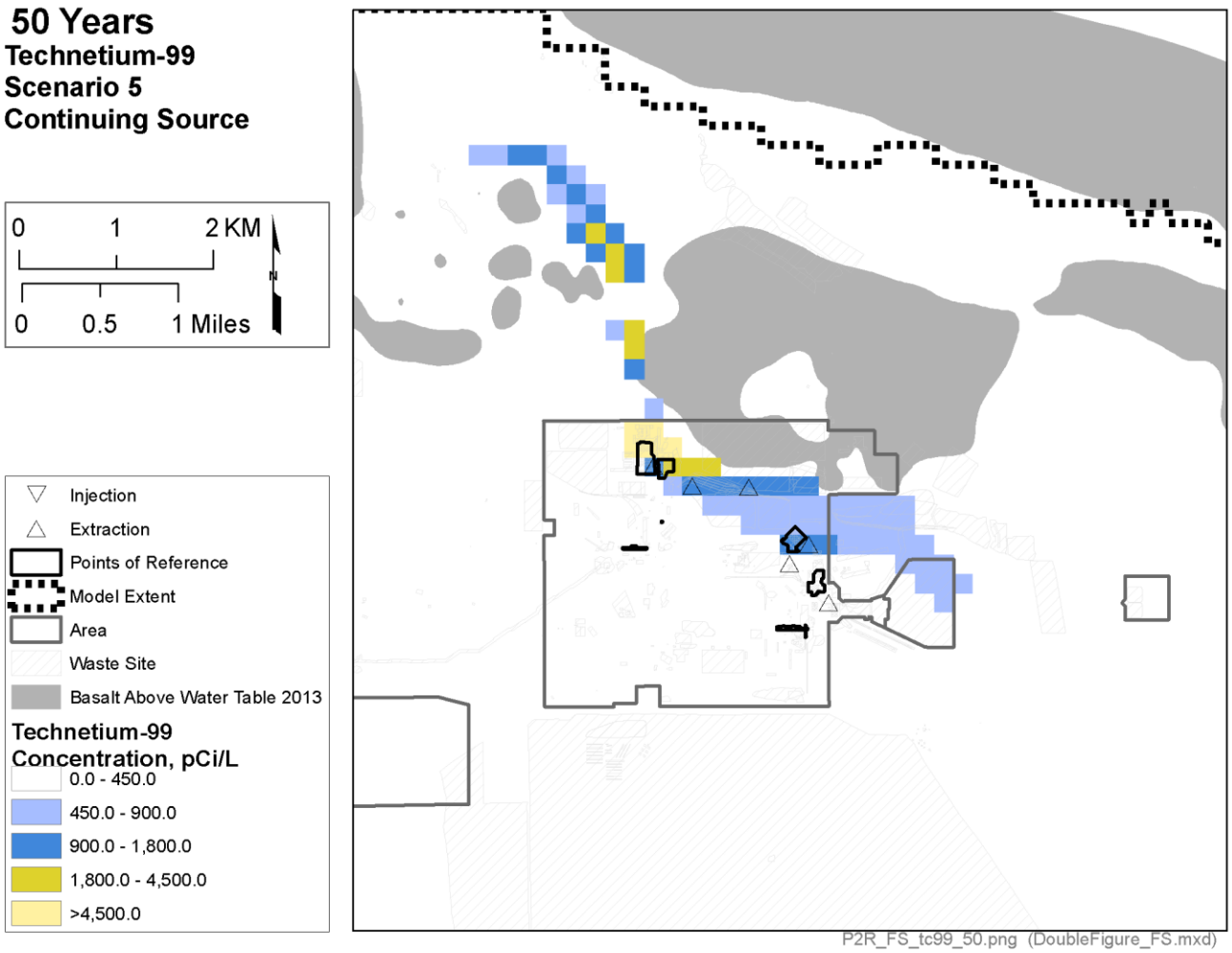

Figure B-262 - Plan view contours of the technetium-99 plume at simulation time 50 years based on the scenario 5 simulation with a continuing source term.

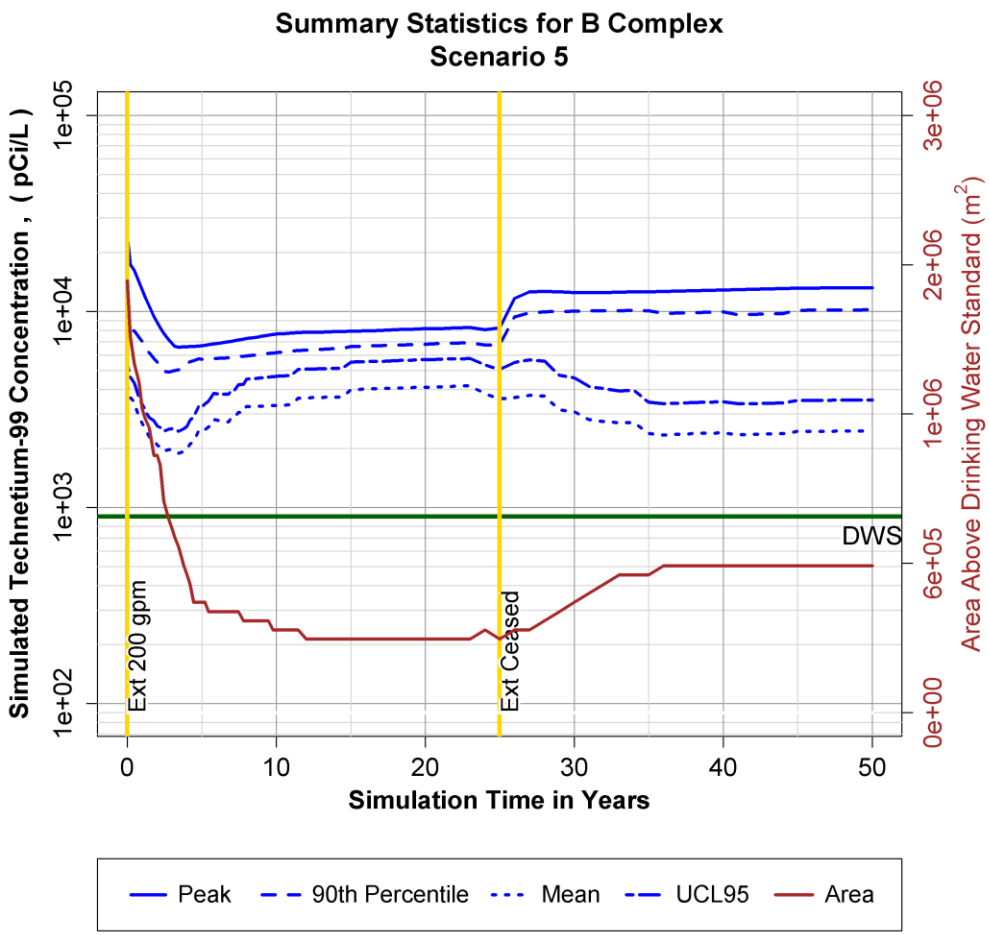

Figure B-263 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

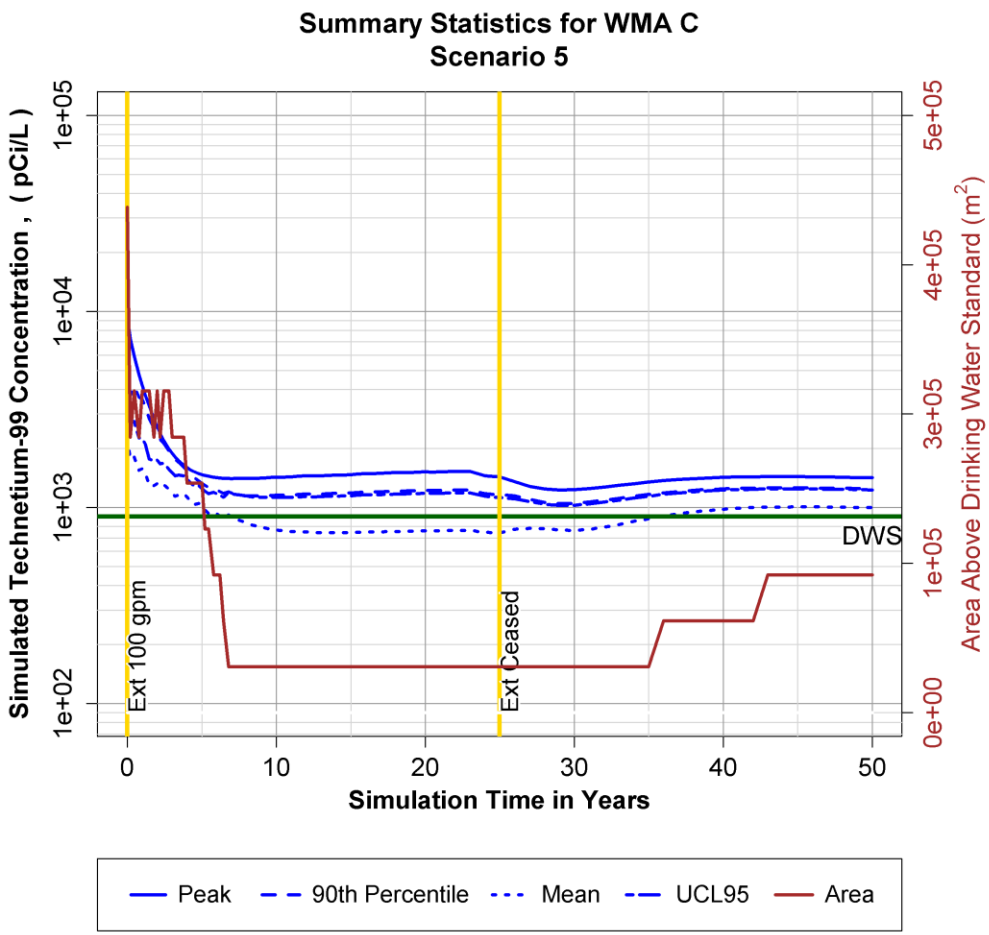

Figure B-264 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

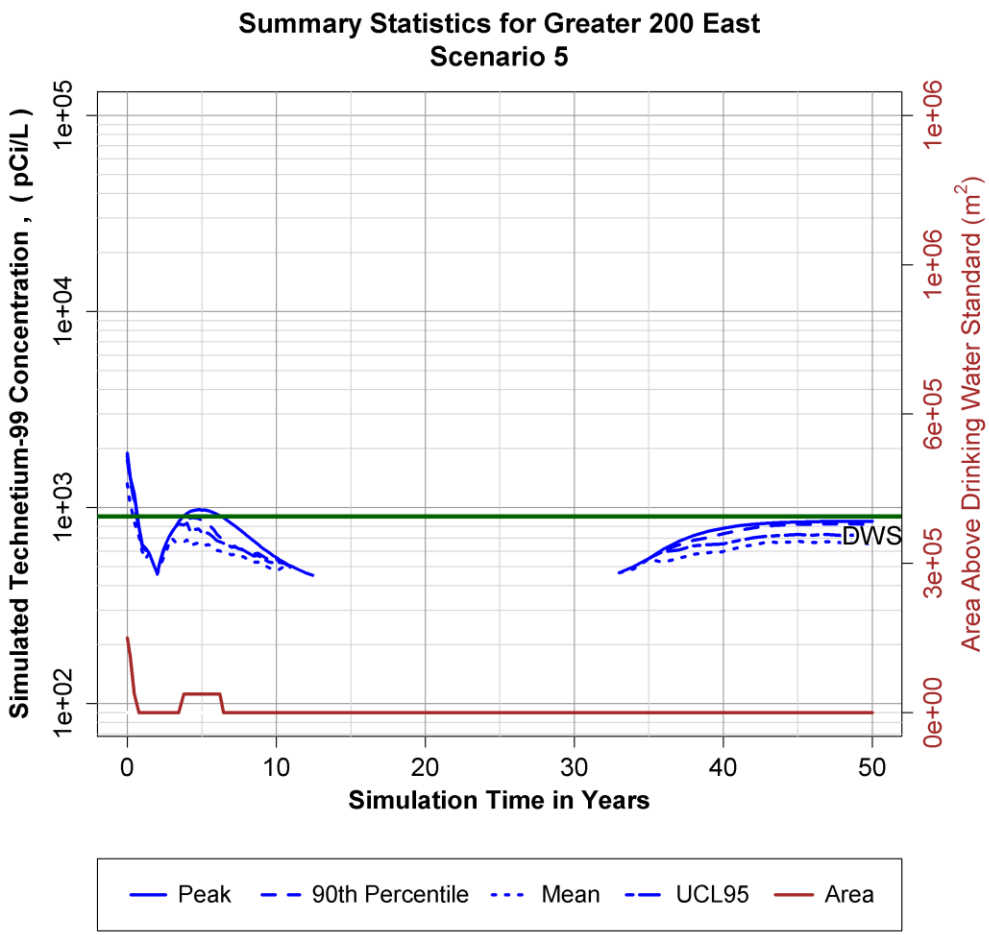

Figure B-265 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

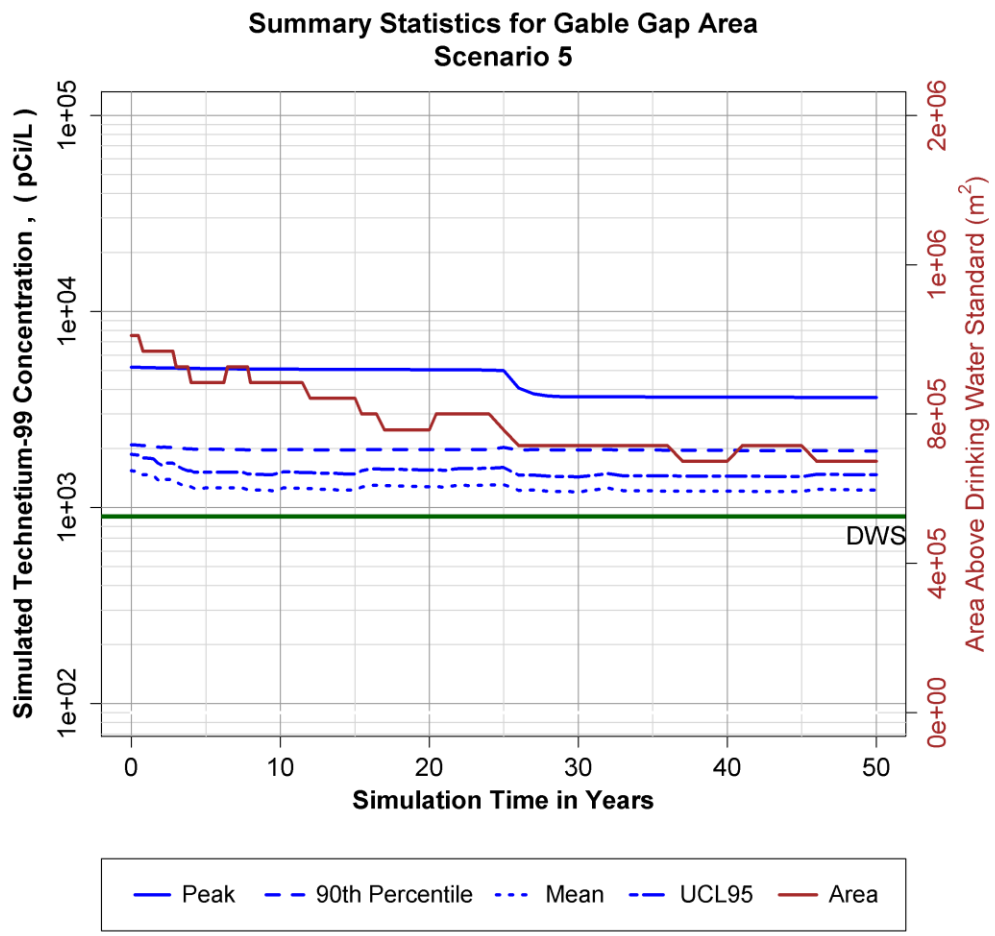

Figure B-266 - Statistical summary of simulated concentration within the model domain for the technetium-99 plume for the scenario 5 simulation with a continuing source term.

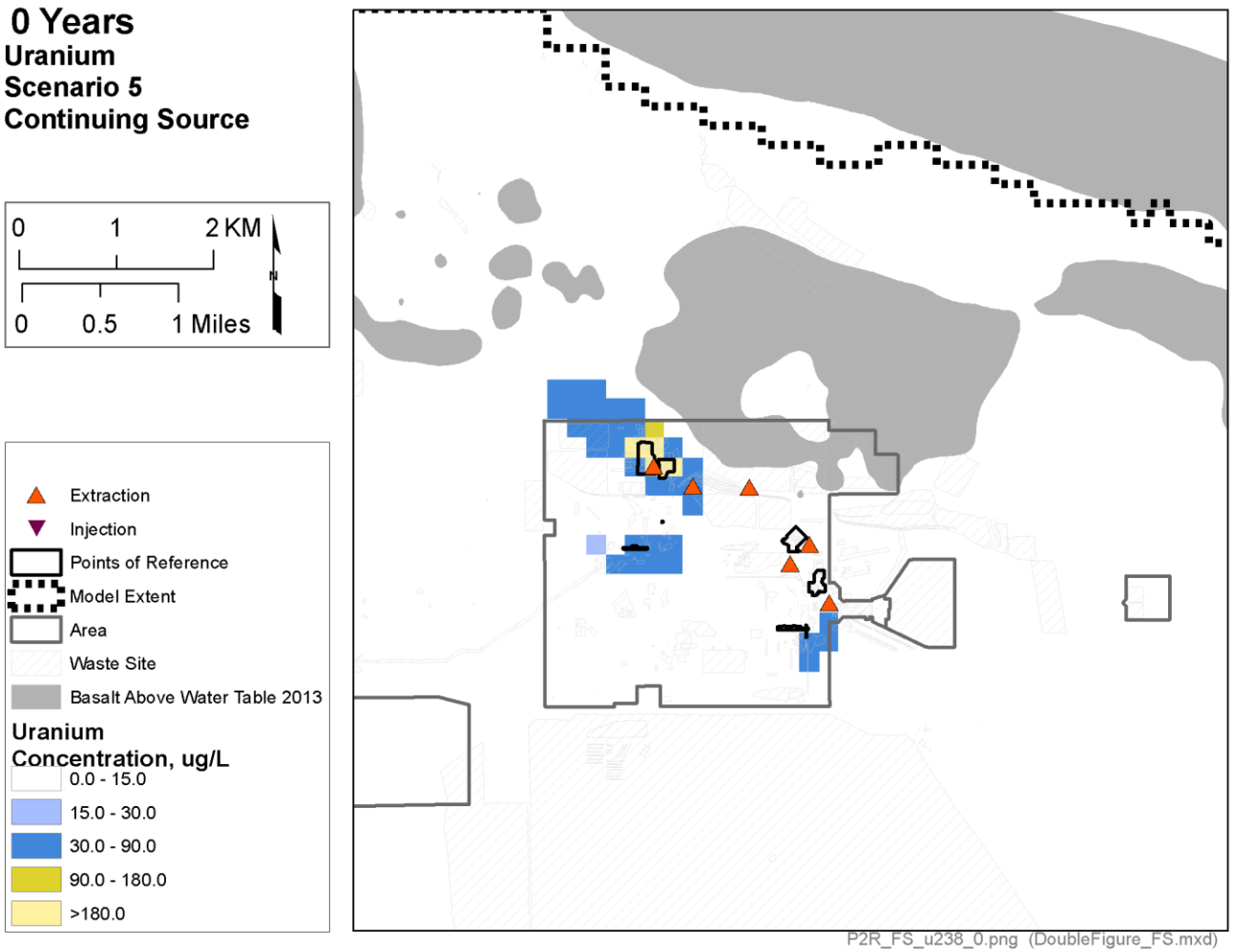

Figure B-267 - Plan view contours of the uranium plume at simulation time 0 years based on the scenario 5 simulation with a continuing source term.

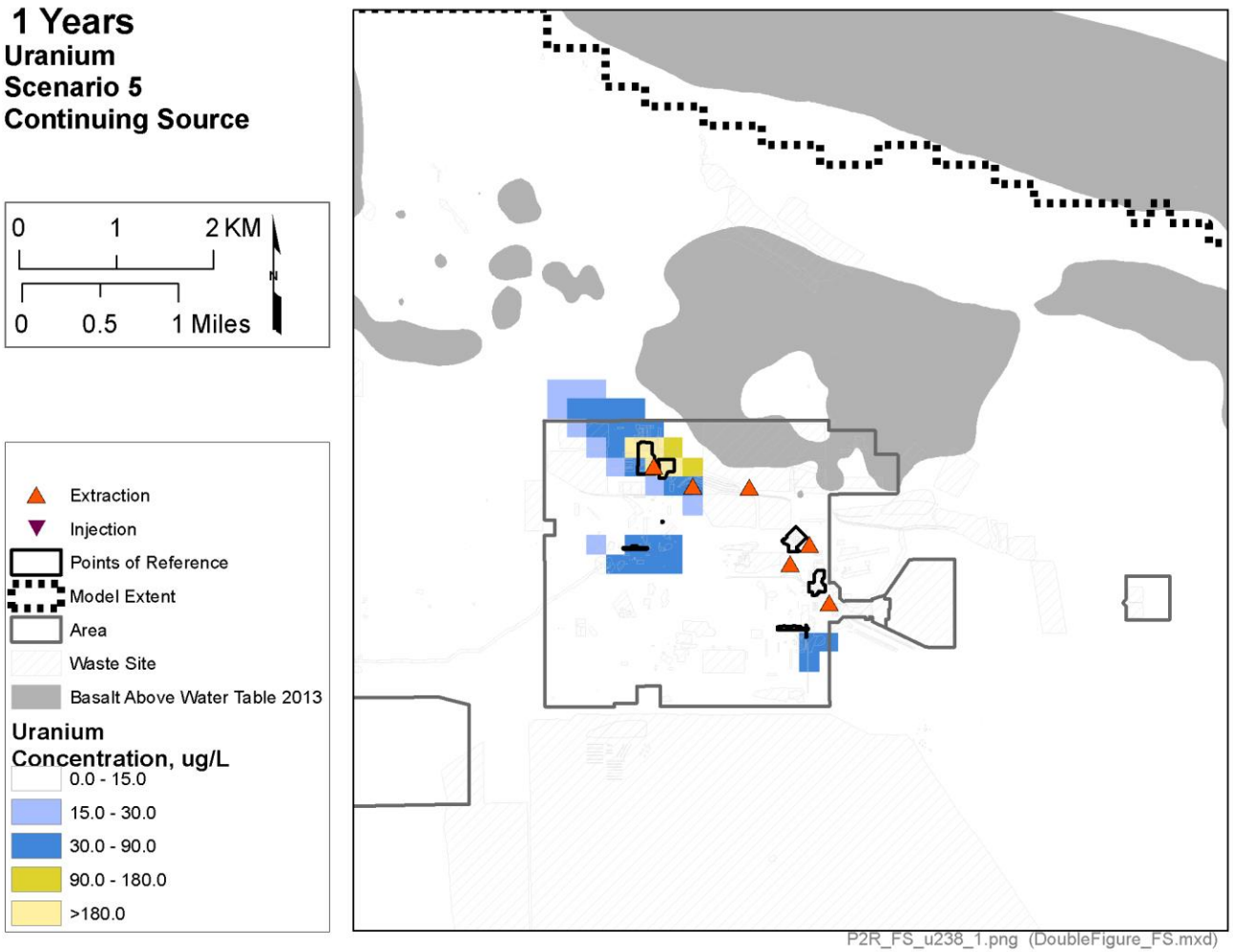

Figure B-268 - Plan view contours of the uranium plume at simulation time 1 years based on the scenario 5 simulation with a continuing source term.

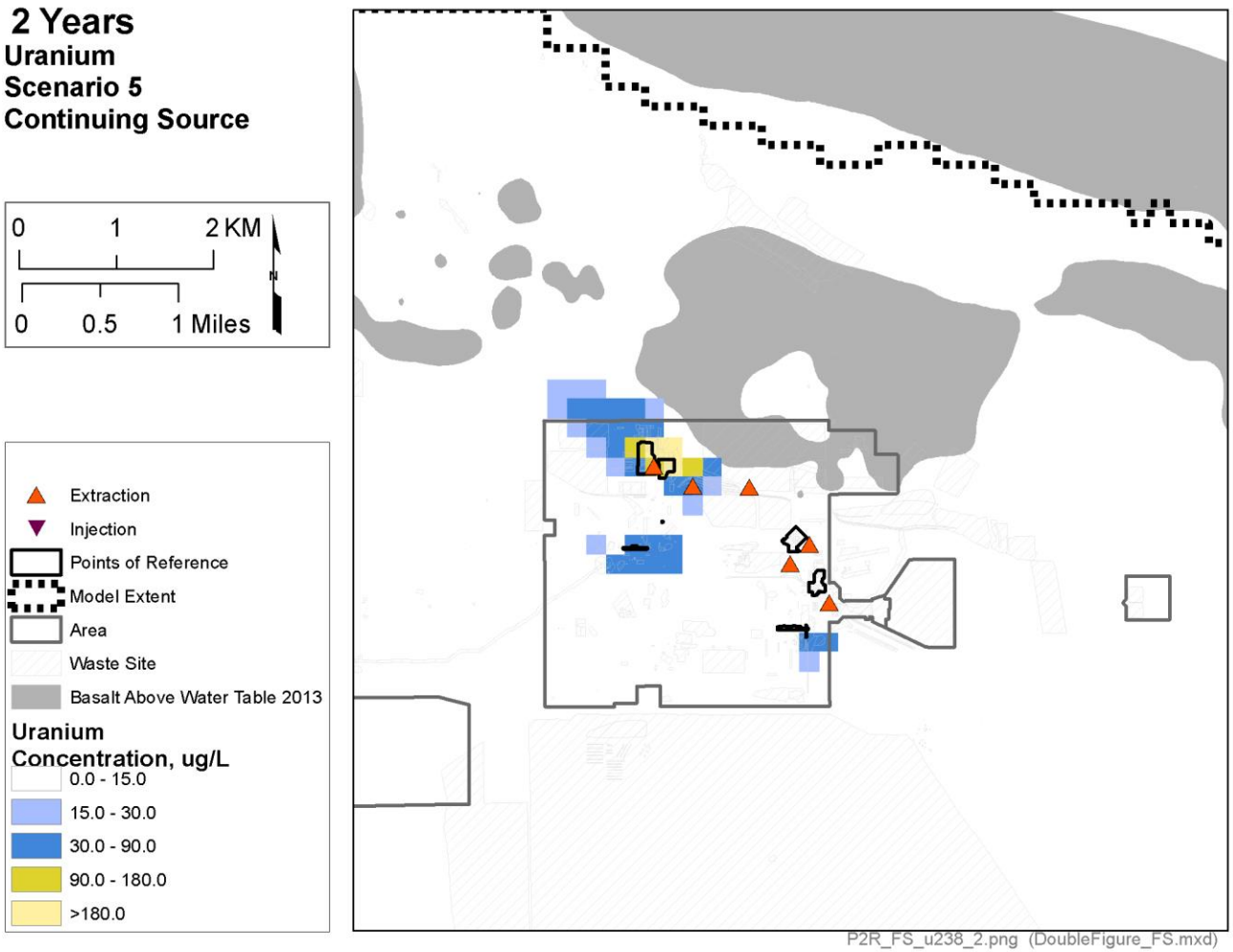

Figure B-269 - Plan view contours of the uranium plume at simulation time 2 years based on the scenario 5 simulation with a continuing source term.

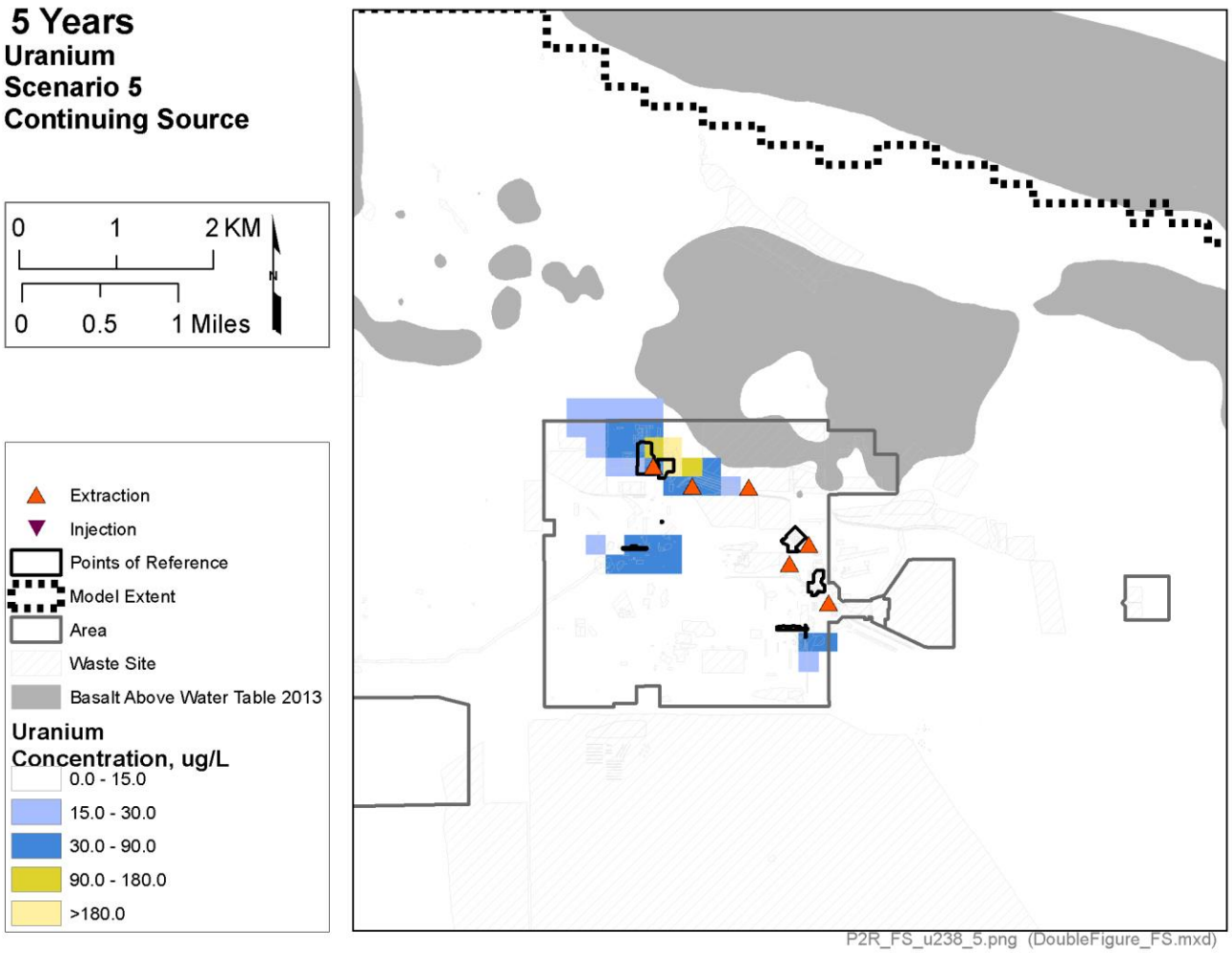

Figure B-270 - Plan view contours of the uranium plume at simulation time 5 years based on the scenario 5 simulation with a continuing source term.

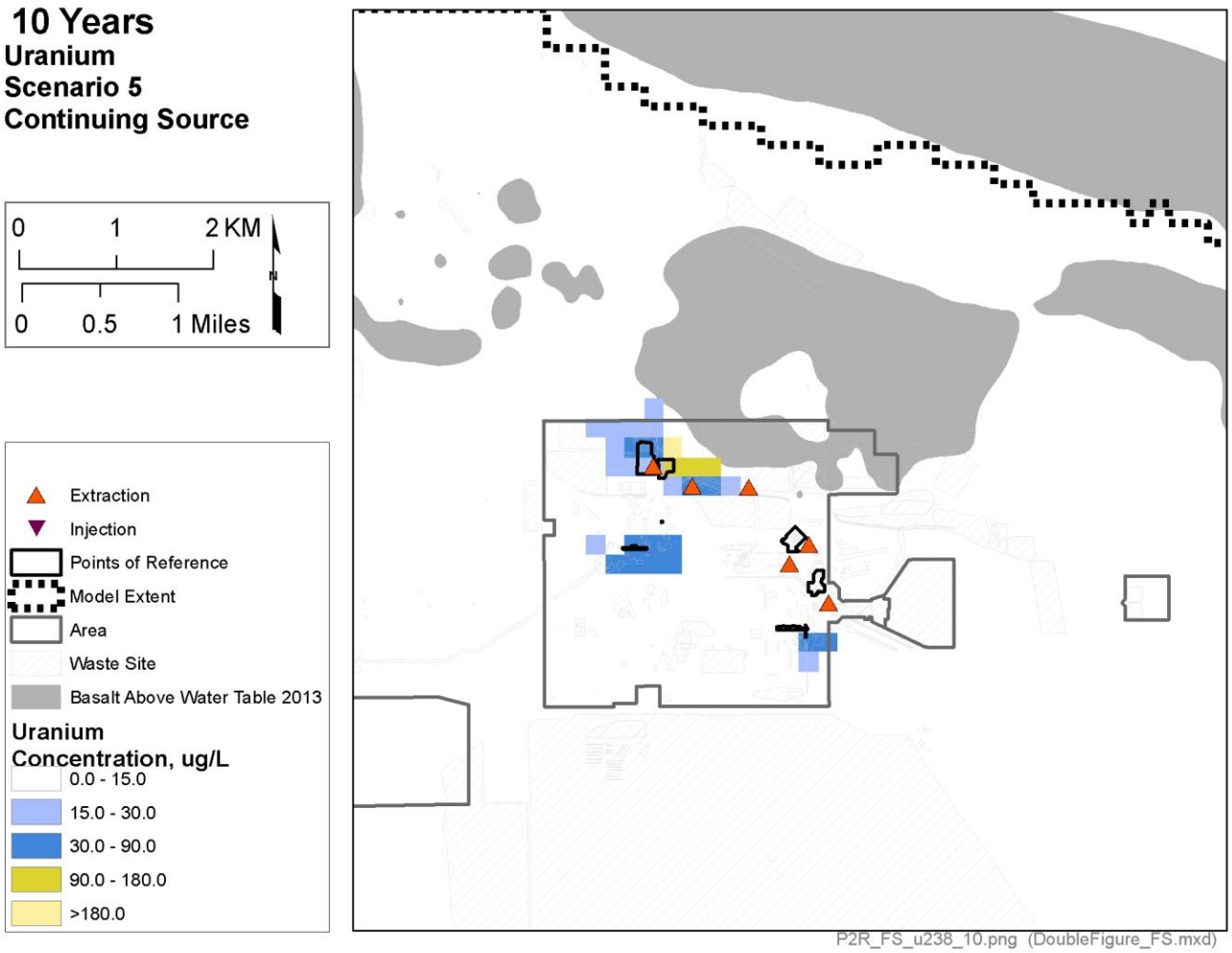

Figure B-271 - Plan view contours of the uranium plume at simulation time 10 years based on the scenario 5 simulation with a continuing source term.

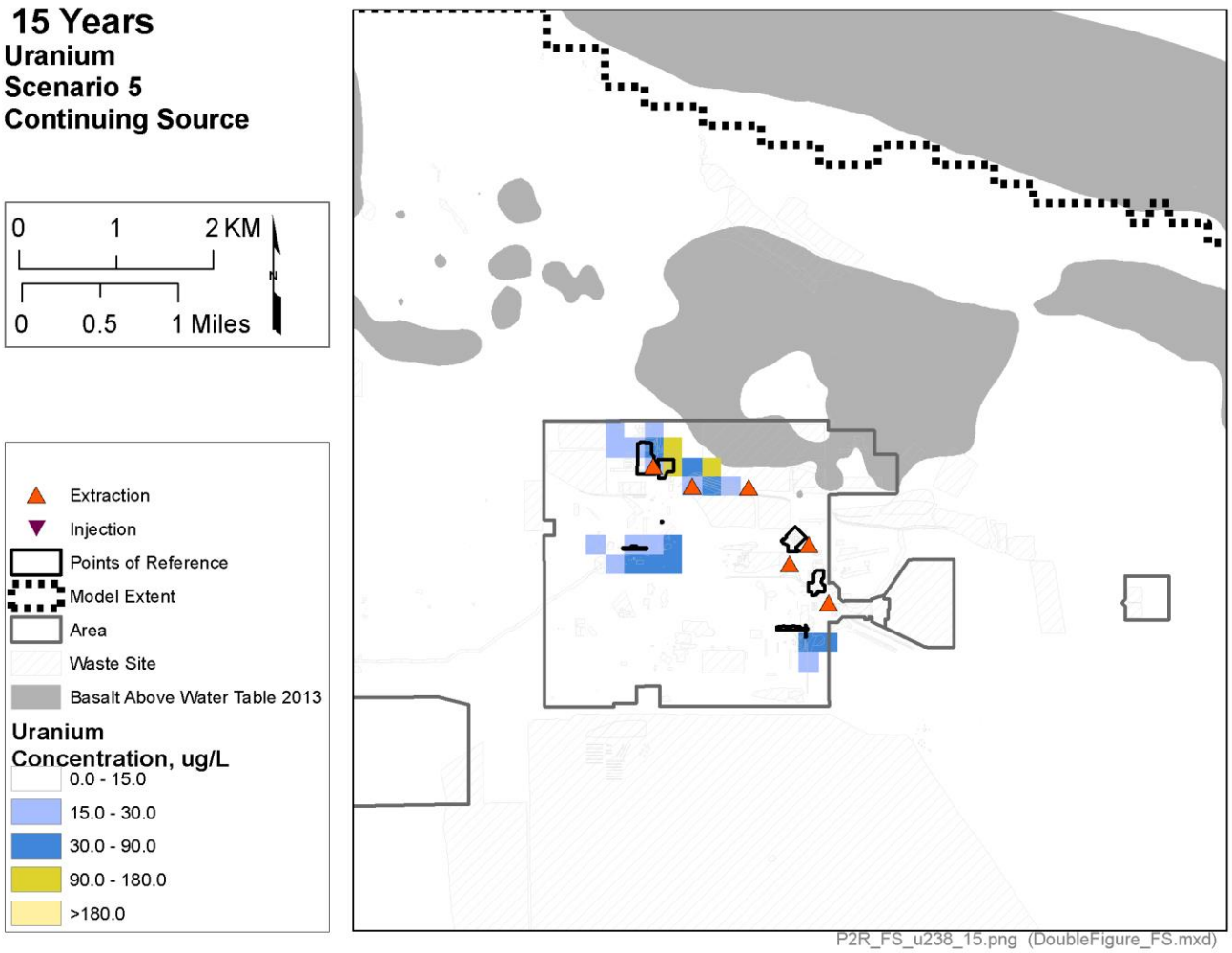

Figure B-272 - Plan view contours of the uranium plume at simulation time 15 years based on the scenario 5 simulation with a continuing source term.

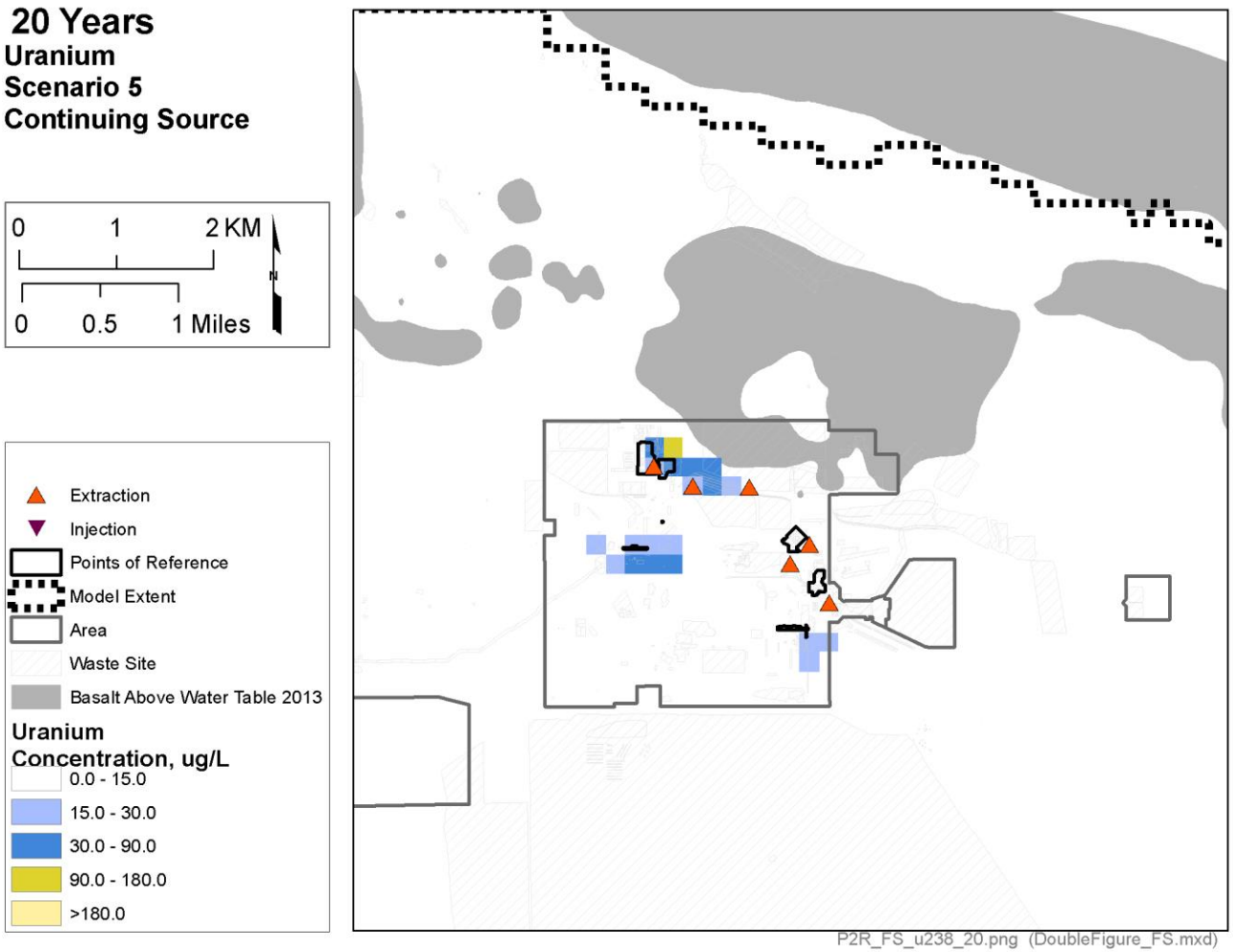

Figure B-273 - Plan view contours of the uranium plume at simulation time 20 years based on the scenario 5 simulation with a continuing source term.

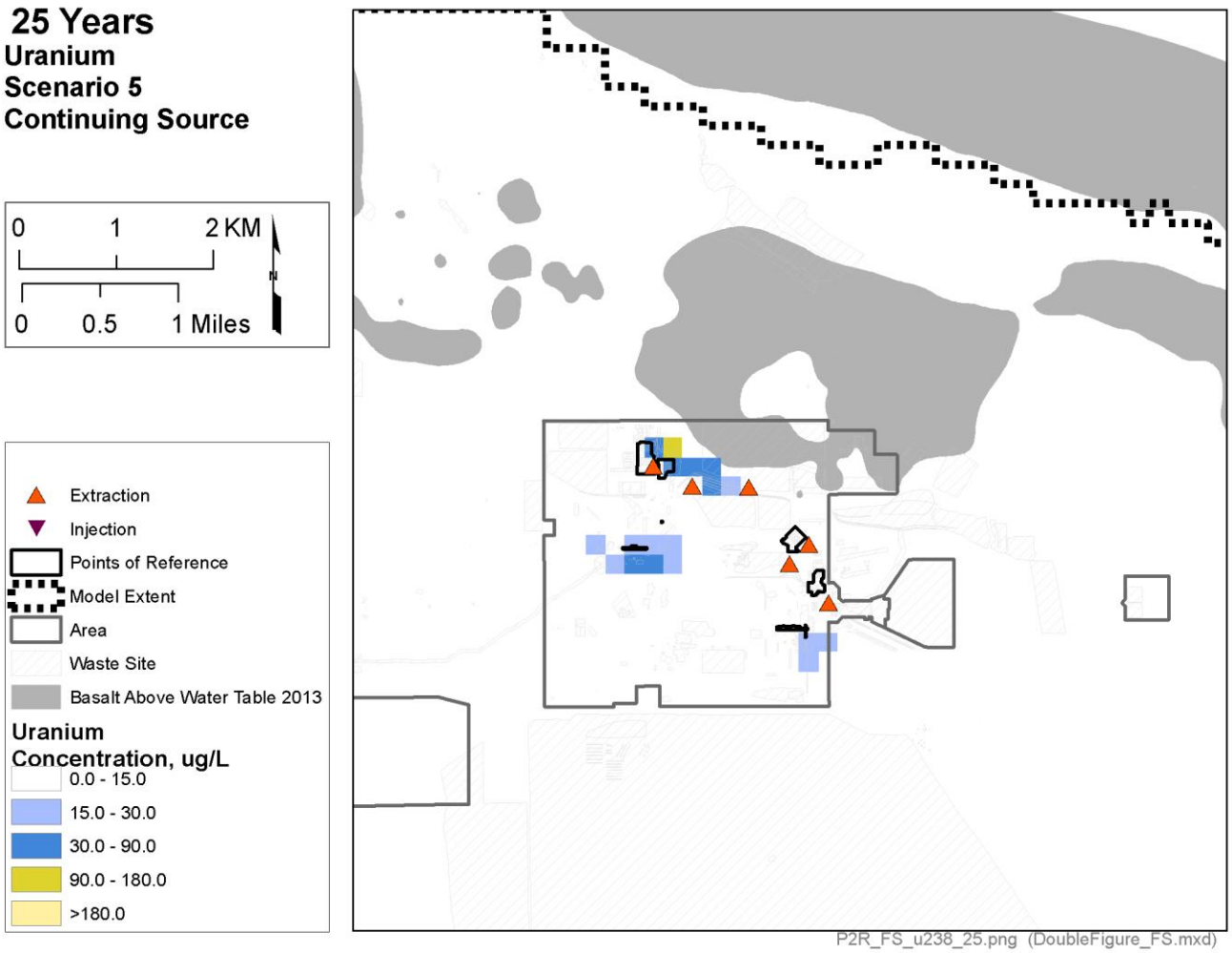

Figure B-274 - Plan view contours of the uranium plume at simulation time 25 years based on the scenario 5 simulation with a continuing source term.

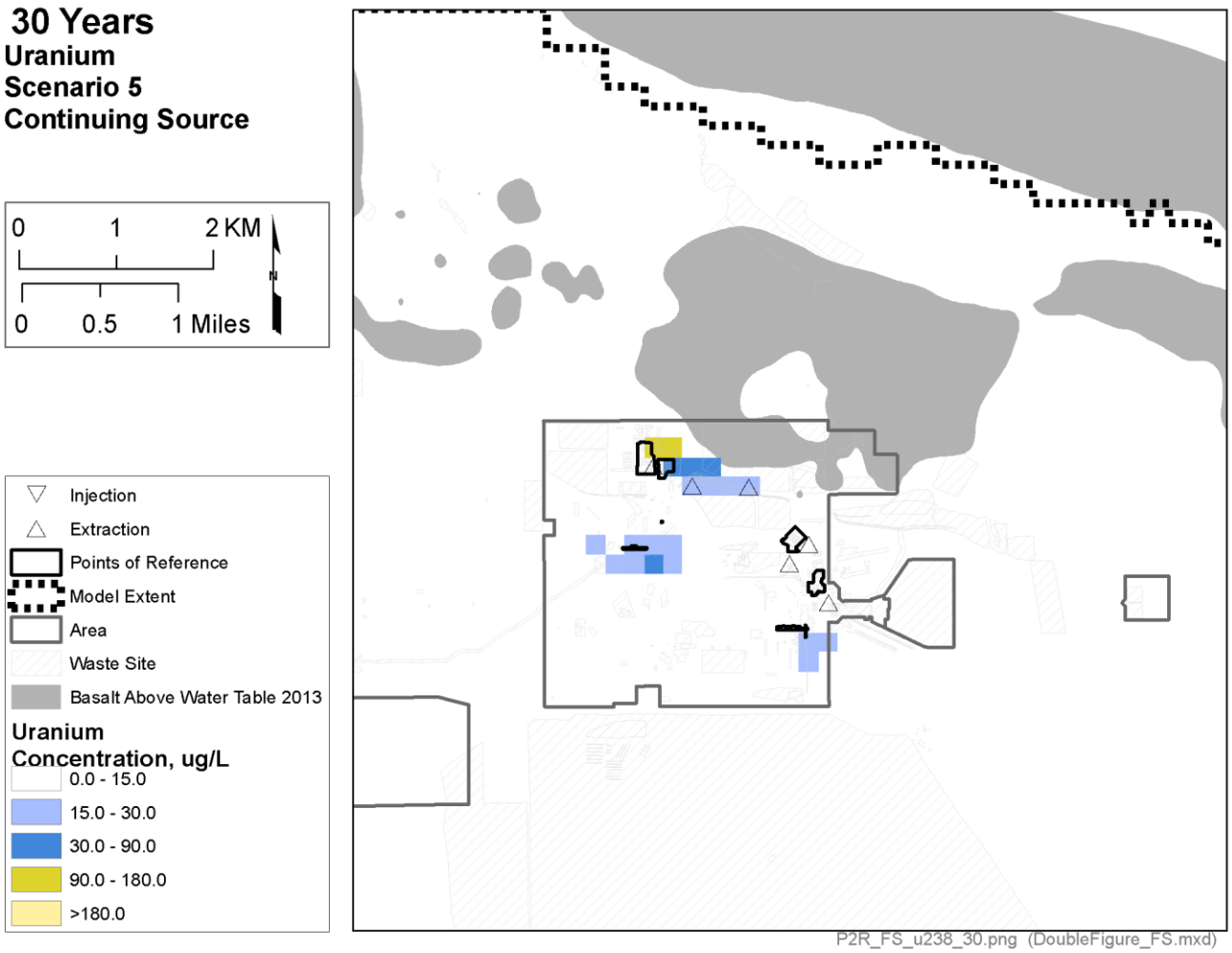

Figure B-275 - Plan view contours of the uranium plume at simulation time 30 years based on the scenario 5 simulation with a continuing source term.

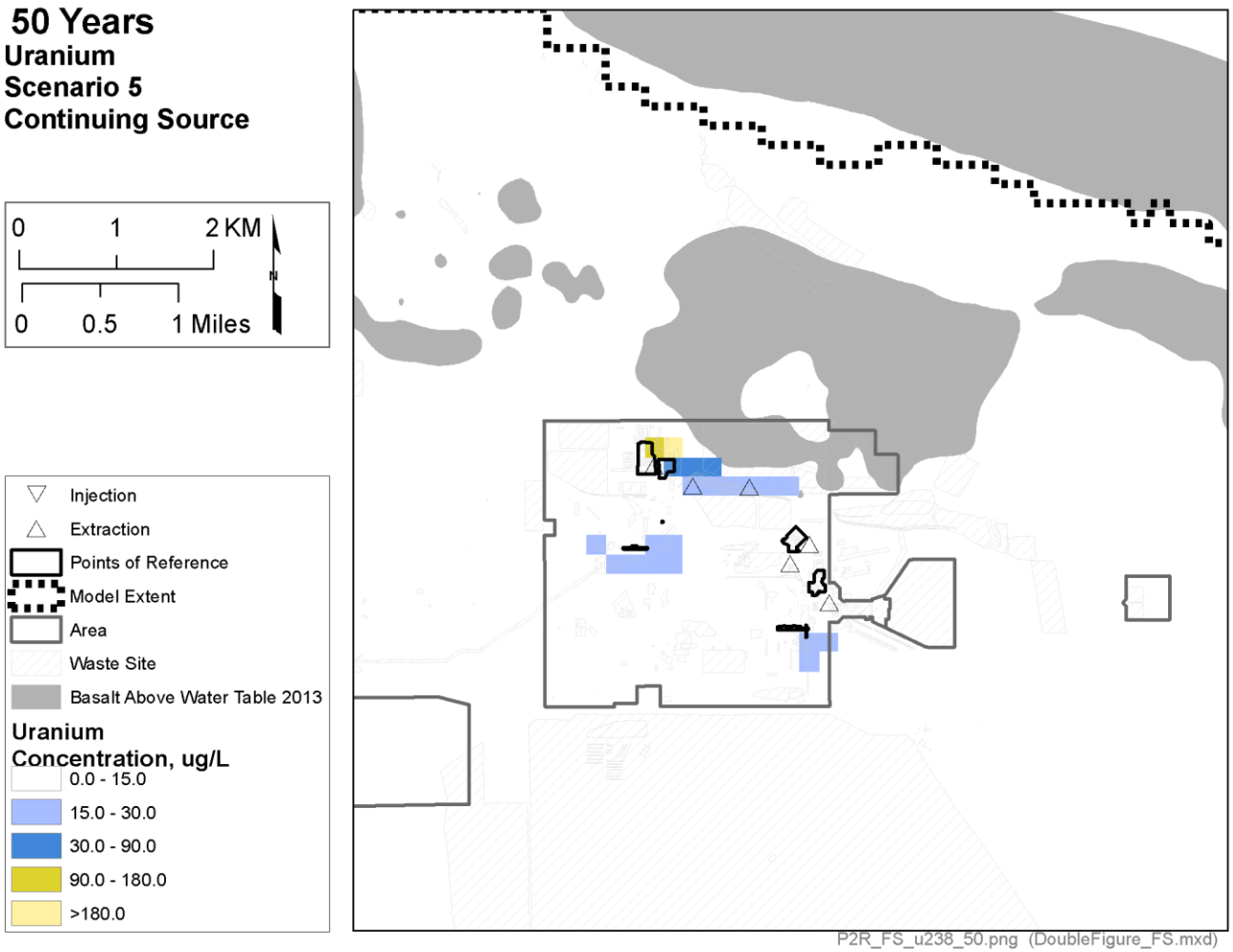

Figure B-276 - Plan view contours of the uranium plume at simulation time 50 years based on the scenario 5 simulation with a continuing source term.

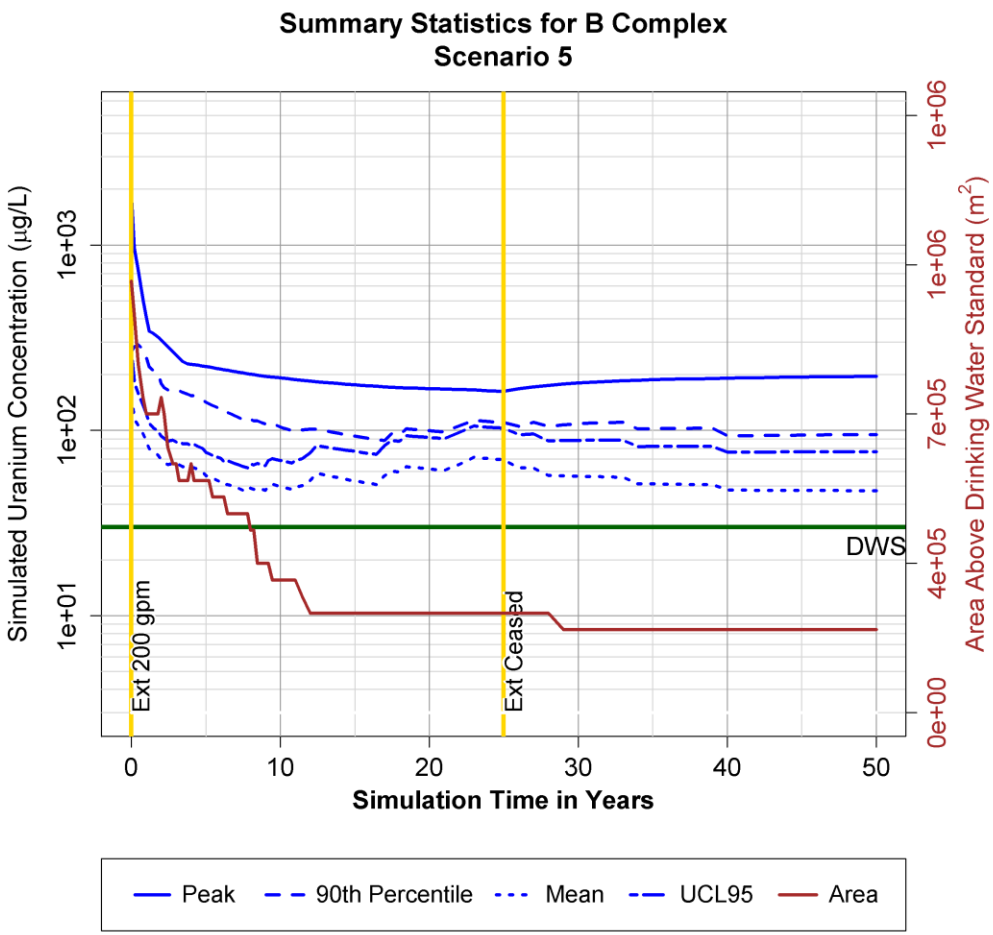

Figure B-277 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

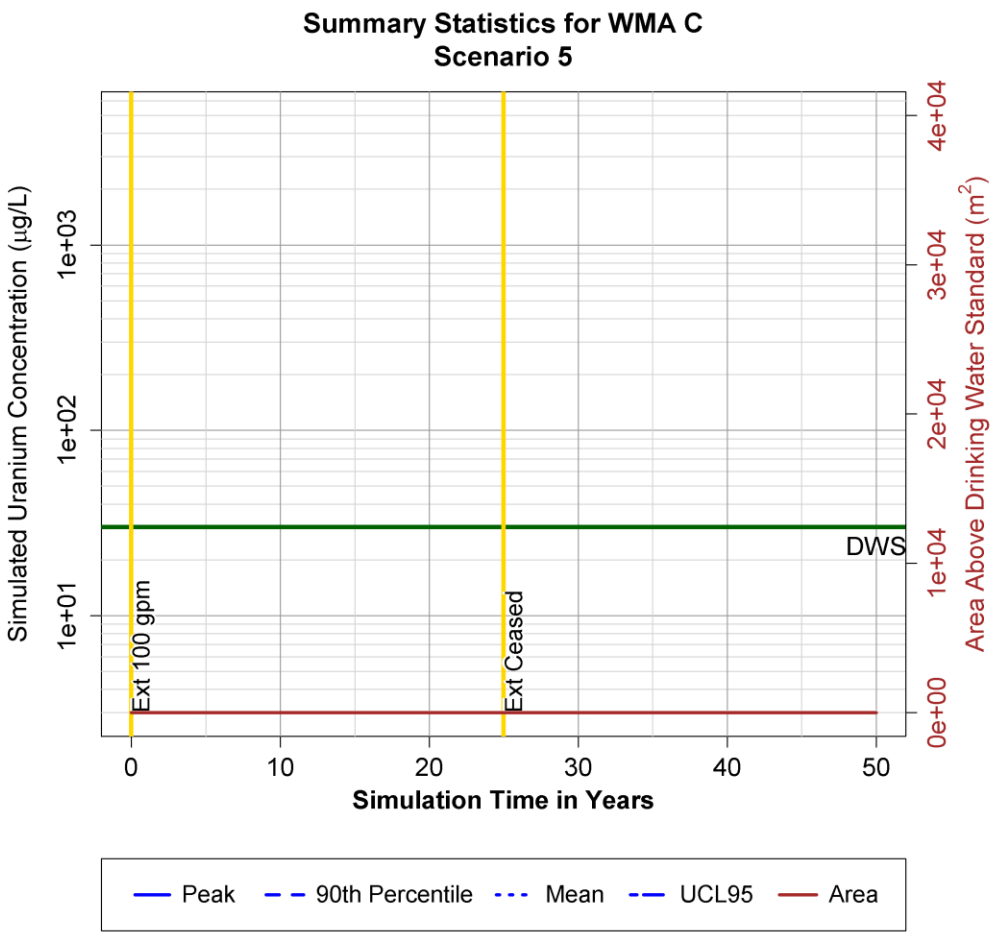

Figure B-278 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

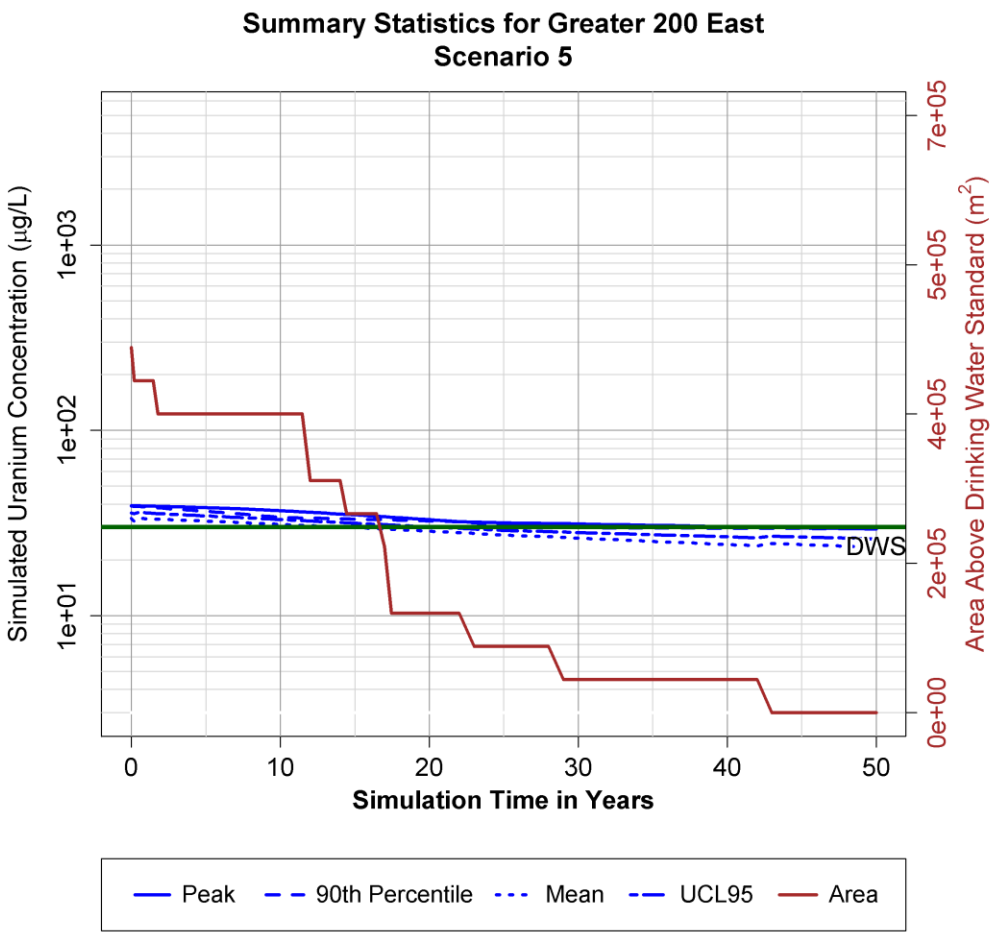

Figure B-279 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

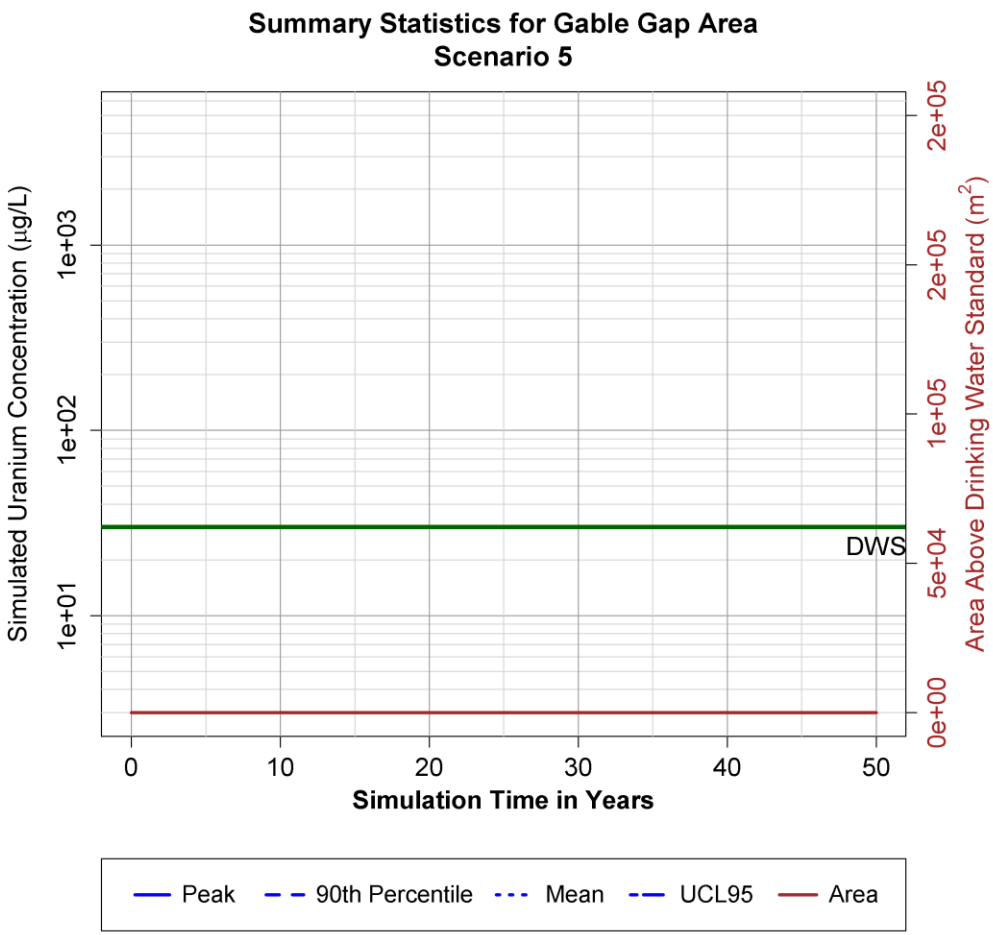

Figure B-280 - Statistical summary of simulated concentration within the model domain for the uranium plume for the scenario 5 simulation with a continuing source term.

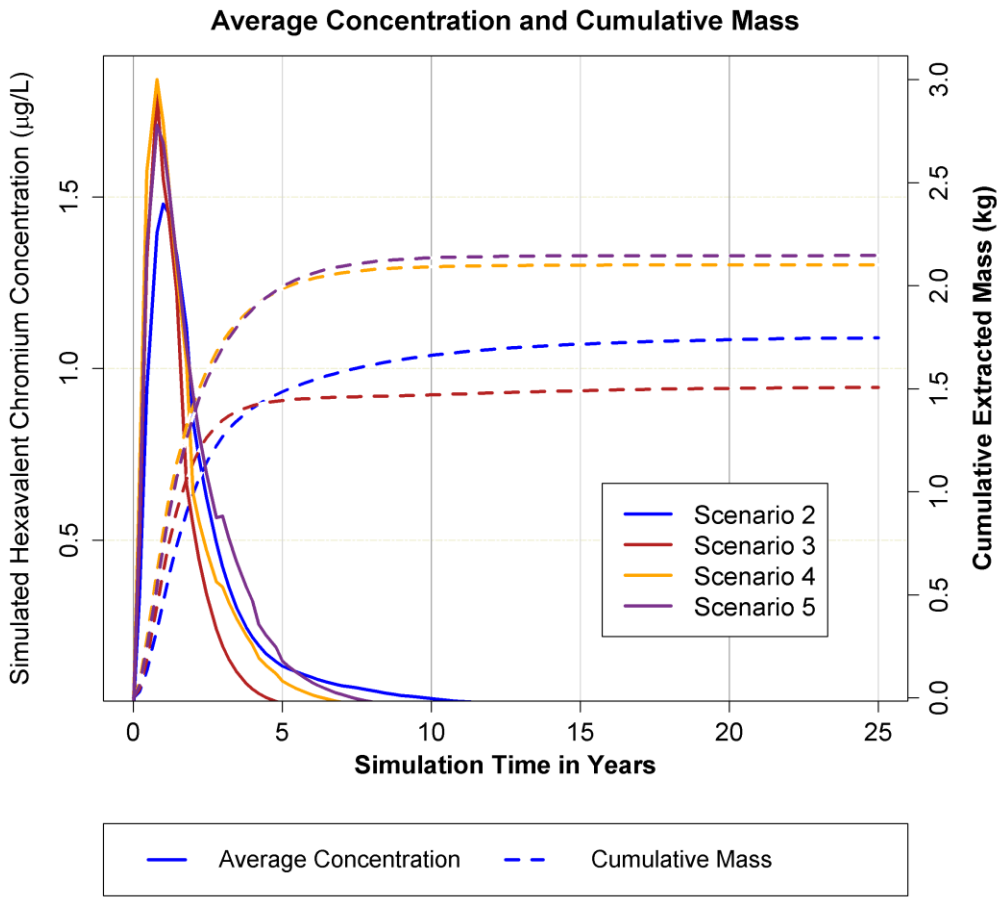

Figure B-281 - Summary of simulated extraction within the model domain for the hexavalent chromium plume for all scenarios.

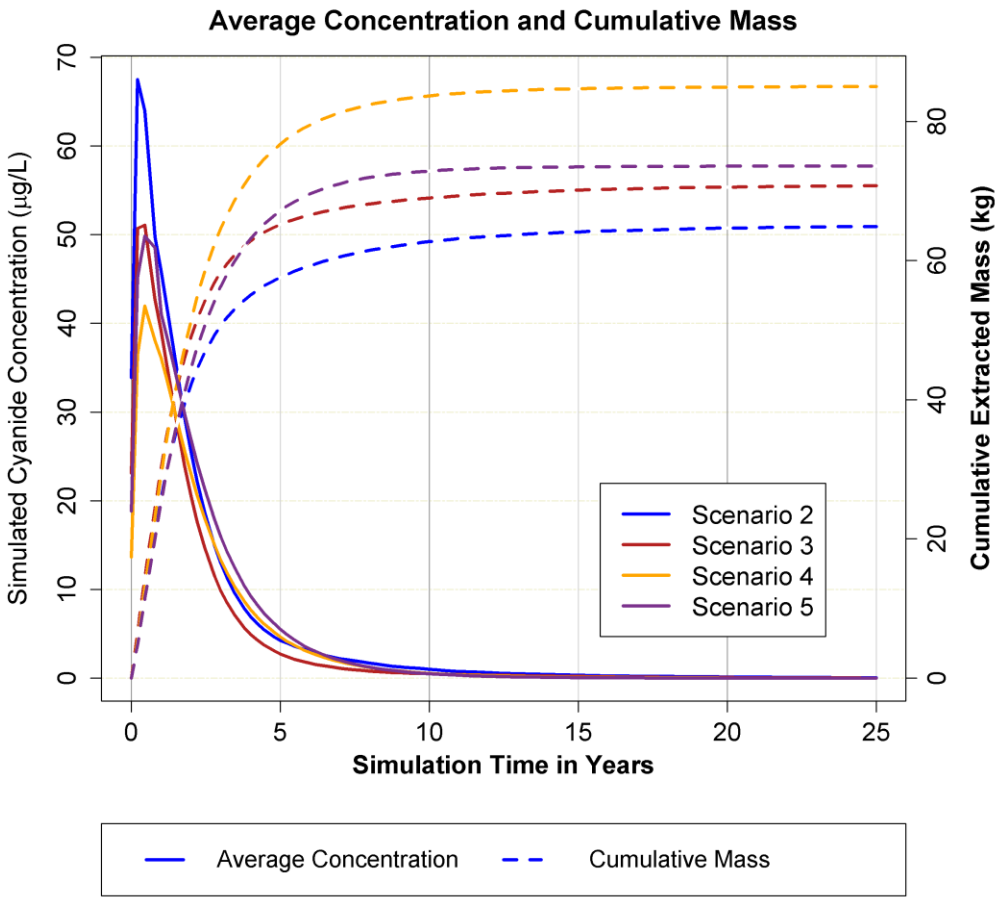

Figure B-282 - Summary of simulated extraction within the model domain for the cyanide plume for all scenarios.

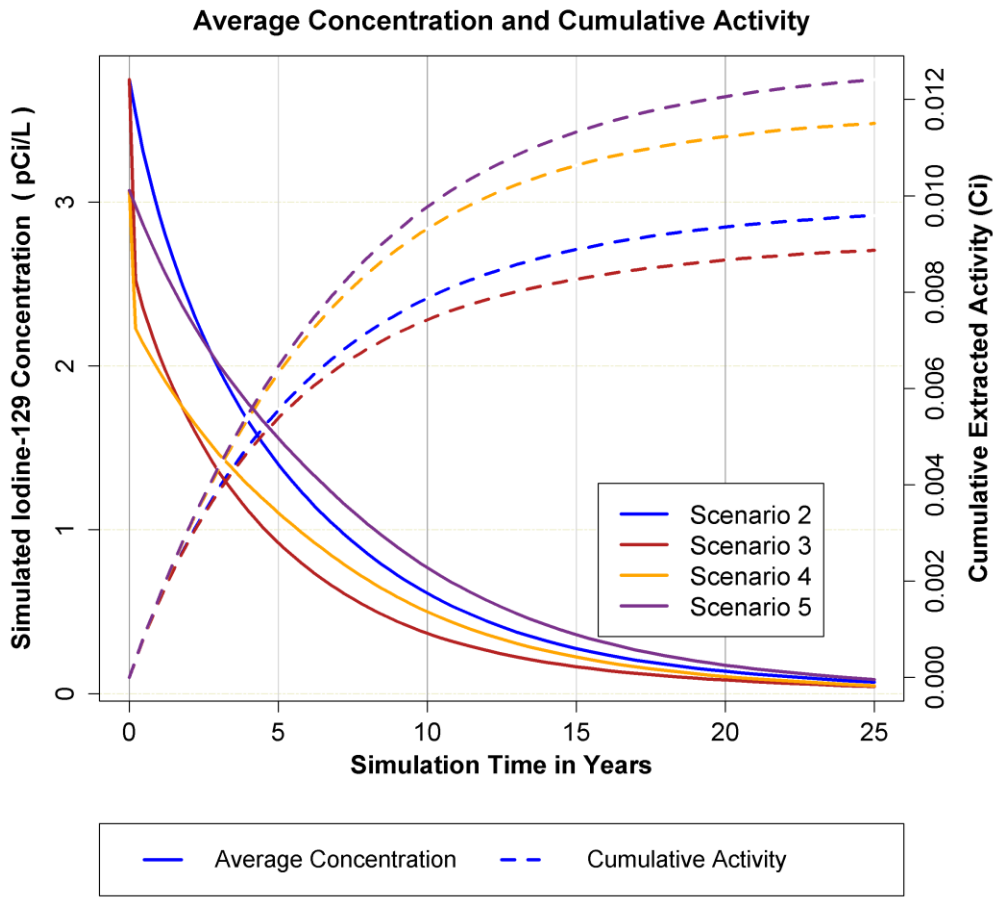

Figure B-283 - Summary of simulated extraction within the model domain for the iodine-129 plume for all scenarios.

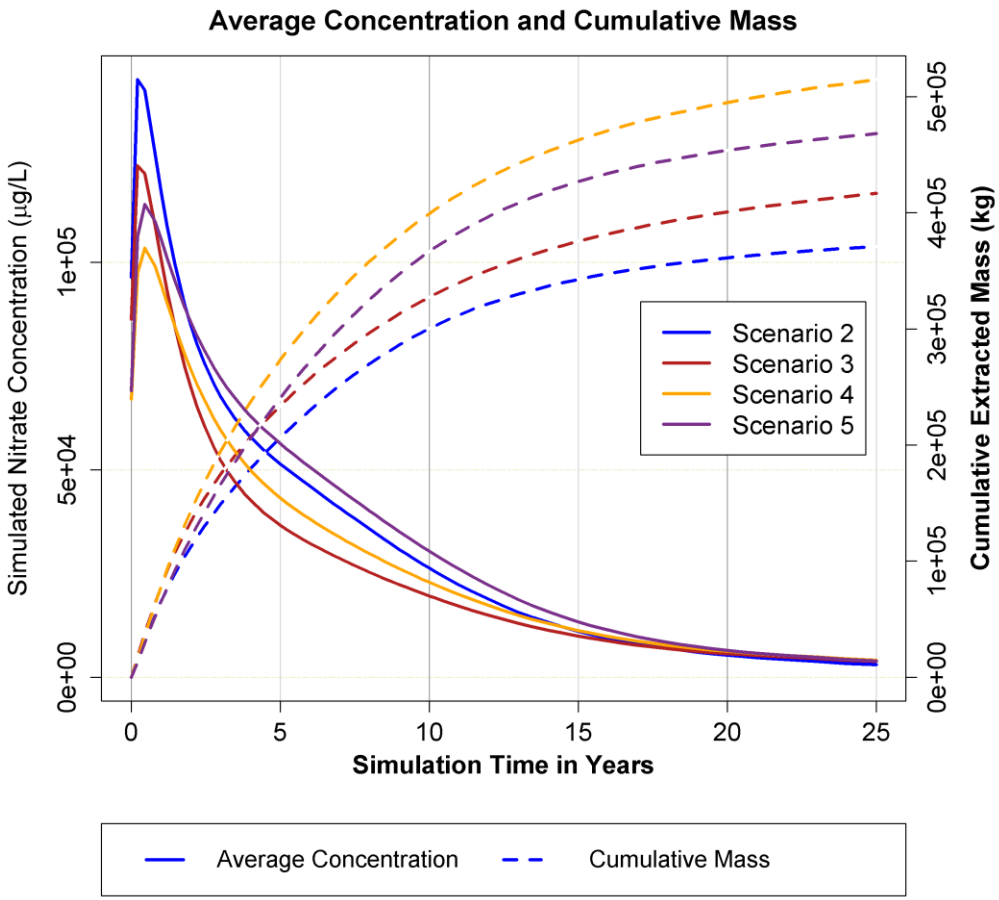

Figure B-284 - Summary of simulated extraction within the model domain for the nitrate plume for all scenarios.

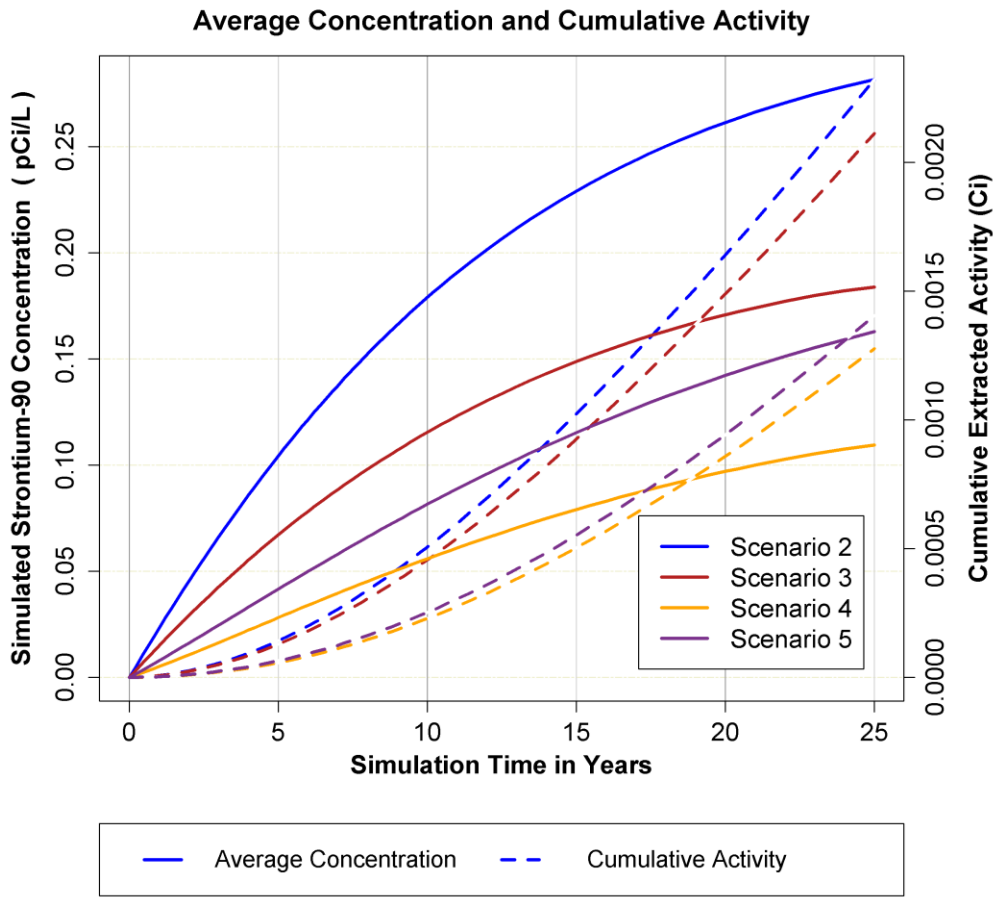

Figure B-285 - Summary of simulated extraction within the model domain for the strontium-90 plume for all scenarios.

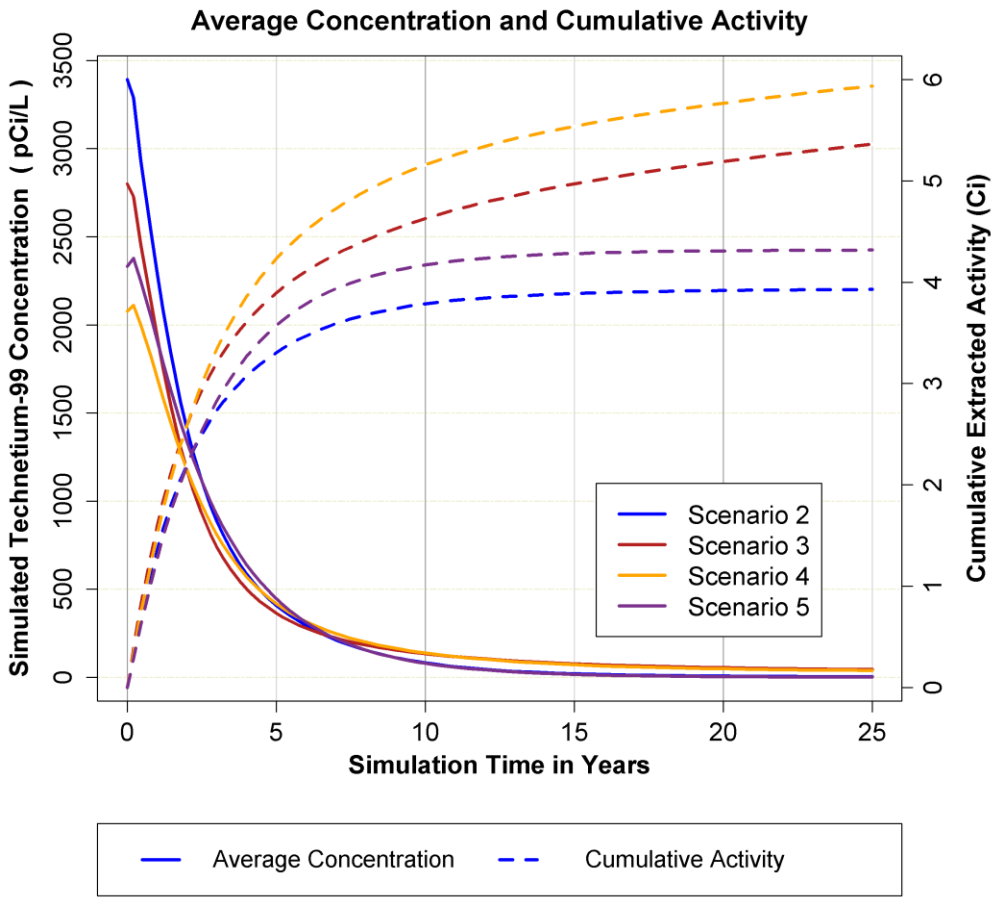

Figure B-286 - Summary of simulated extraction within the model domain for the technetium-99 plume for all scenarios.

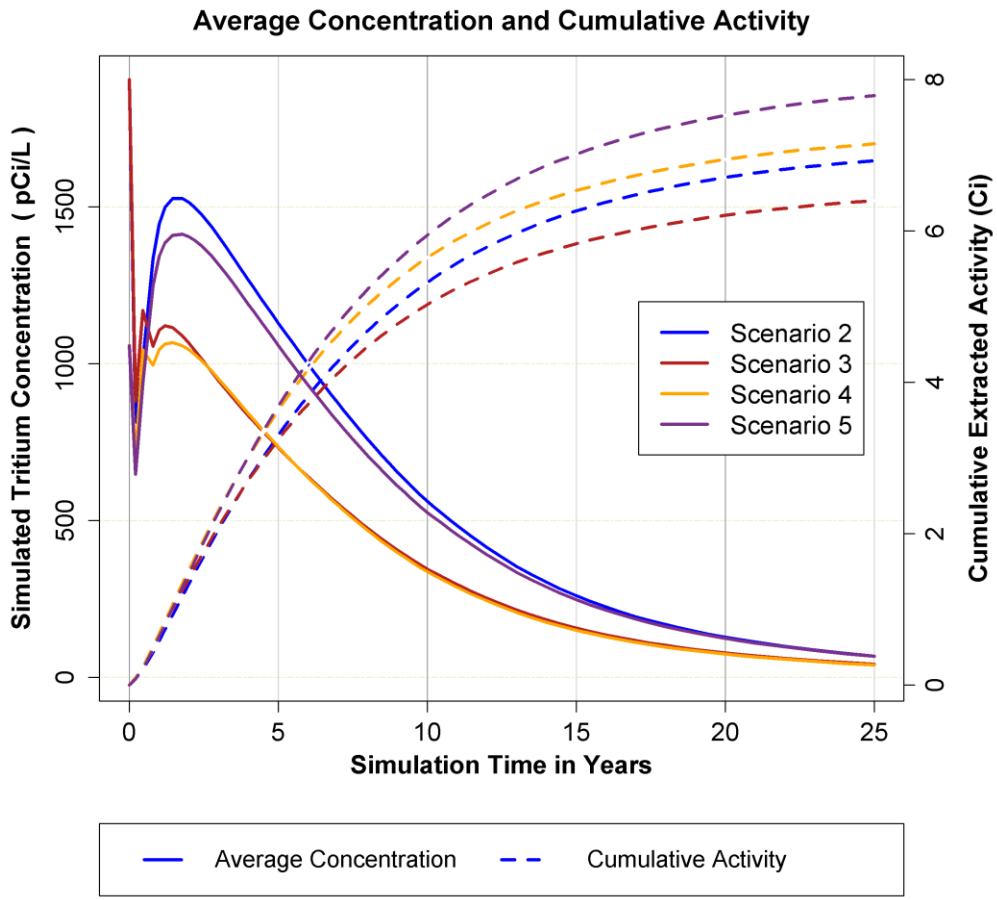

Figure B-287 - Summary of simulated extraction within the model domain for the tritium plume for all scenarios.

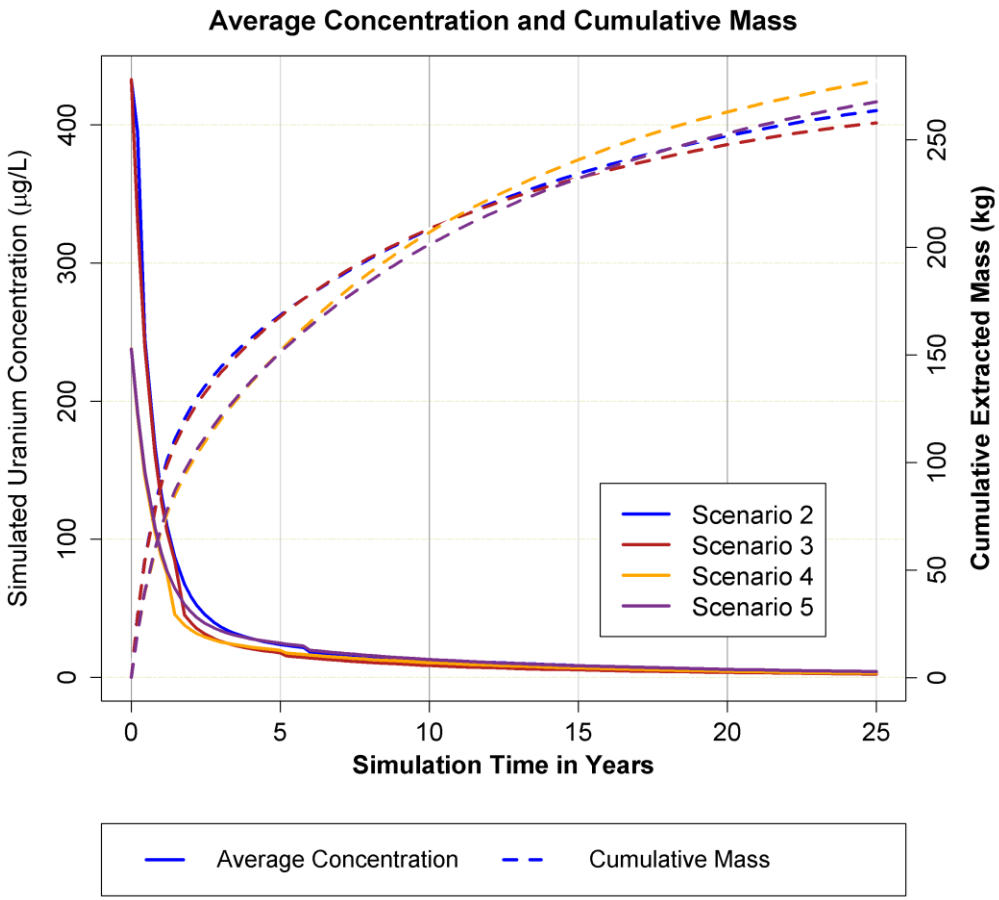

Figure B-288 - Summary of simulated extraction within the model domain for the uranium plume for all scenarios.

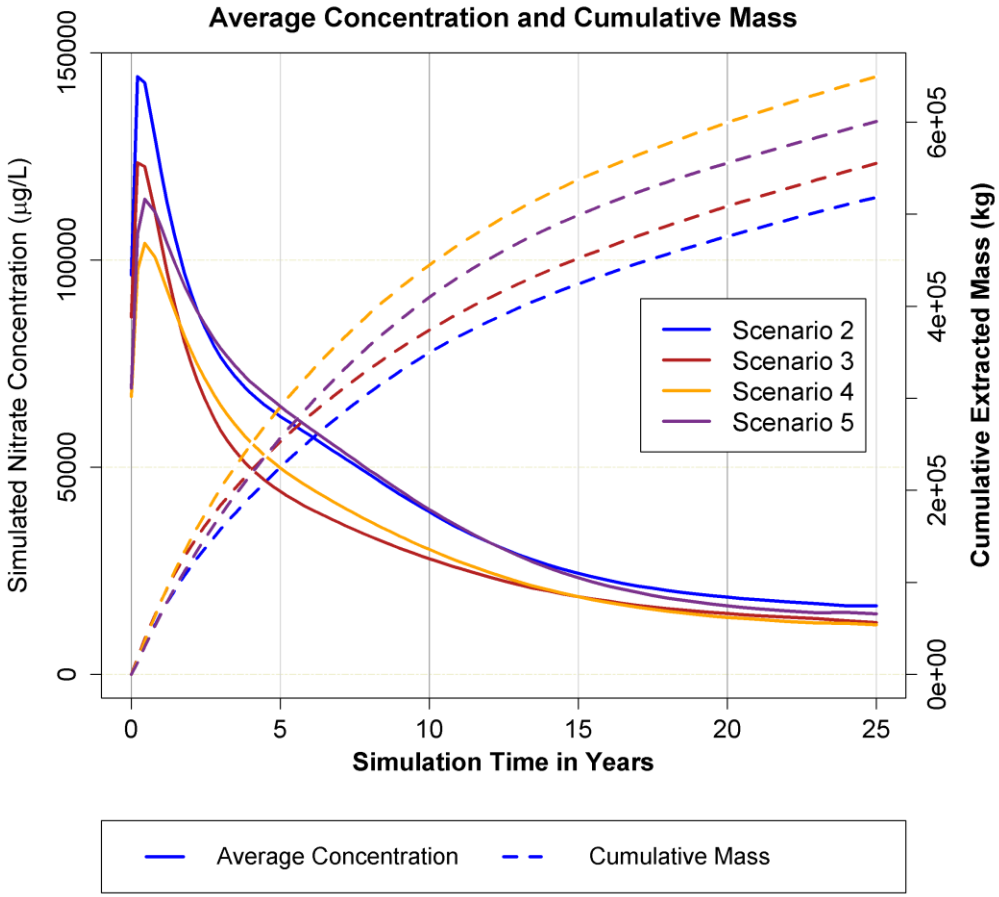

Figure B-289 - Summary of simulated extraction within the model domain for the nitrate plume for all scenarios with a continuing source term.

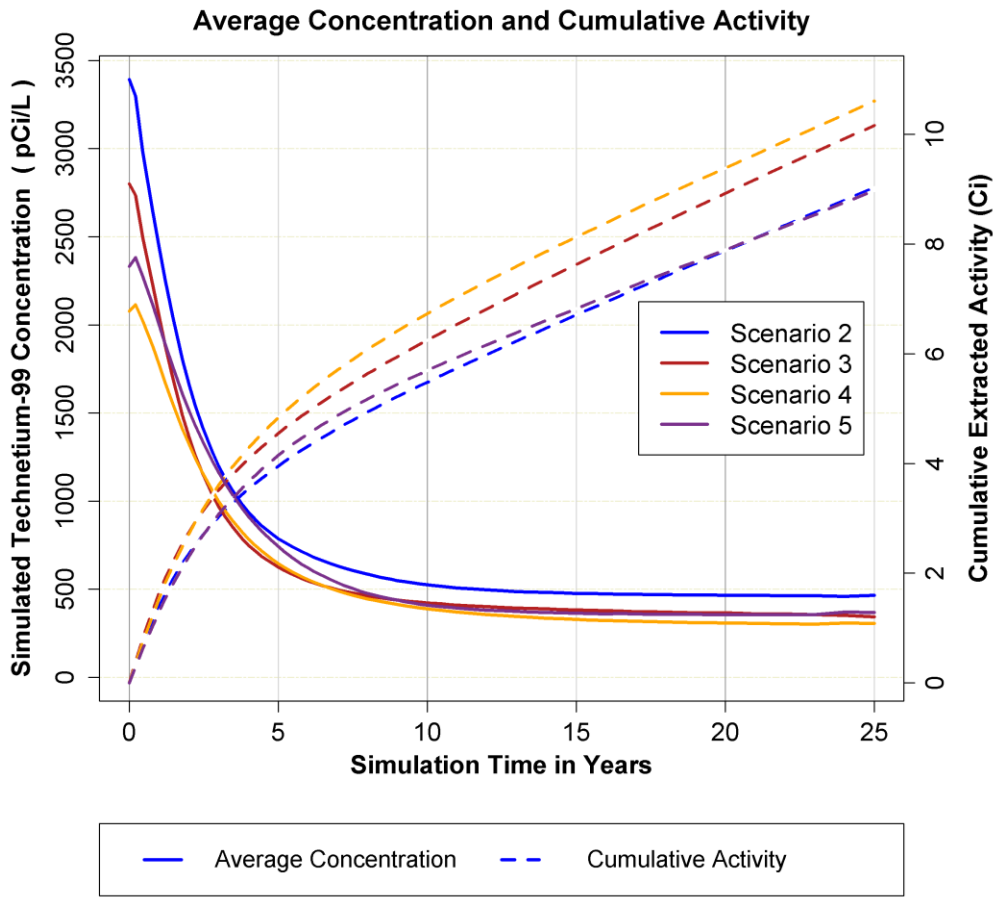

Figure B-290 - Summary of simulated extraction within the model domain for the technetium-99 plume for all scenarios with a continuing source term.

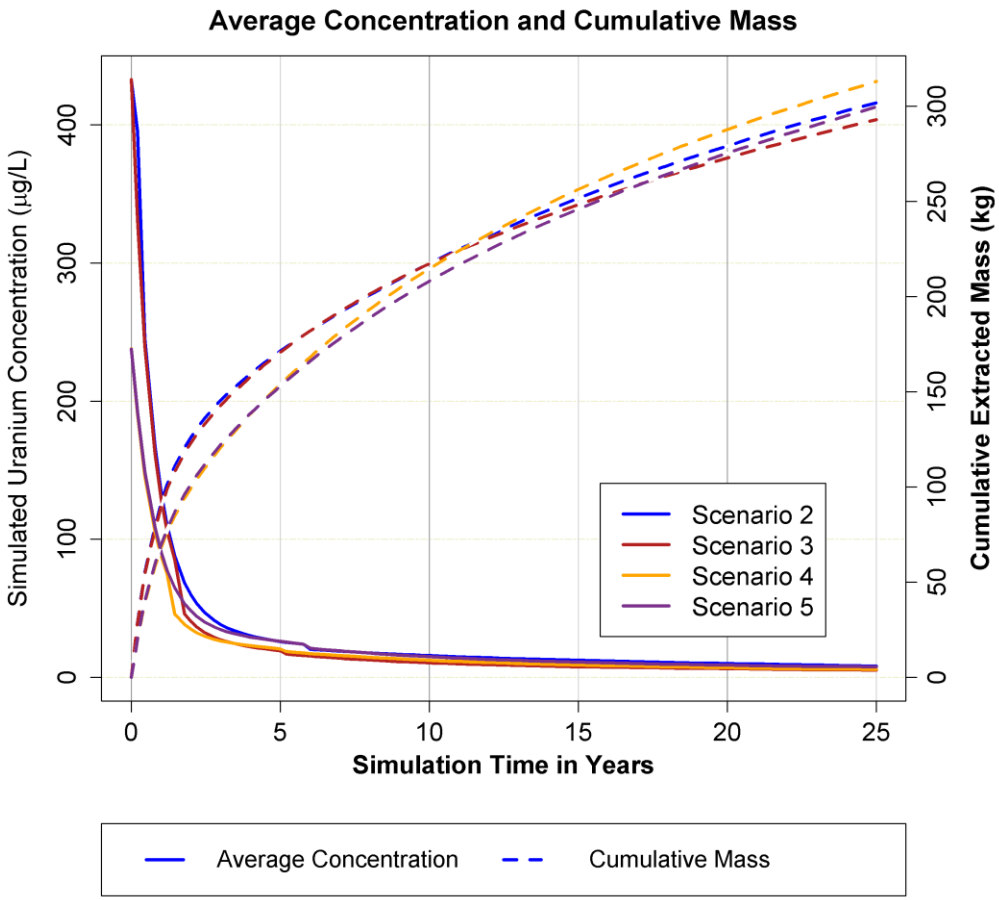

Figure B-291 - Summary of simulated extraction within the model domain for the uranium plume for all scenarios with a continuing source term.

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Appendix B

ECE-200BP518-00003, Environmental Cost Estimate for the 200-BP-5/200-PO-1 Interim Action Feasibility Study

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ECE-200BP518-00003, REV. 0

CHPRC Environmental Cost Estimate Cover Page

Project: Environmental Cost Estimate for 200-BP-5/200-PO-1 Interim Action Feasibility Study **Date:** 11/19/2018

Project Cost Estimator: C. Arola

Project Cost Checker: B. Ostapkowicz

ER & QA Lead Cost Estimator: G. Mah-Hing

Estimate Number: ECE-200BP518-00003 **Revision:** 0

Document Review & Approval *Signatures of approval*

Project Cost Estimator:	C. Arola, Sr. Cost Estimator	Date: 20 NOV 2018
Project Cost Checker:	B. Ostapkowicz, Engineer	Date: 11/20/2018
ER & QA Lead Cost Estimator:	G. Mah-Hing, Sr. Environmental Cost Estimator	Date: 11/26/18
Responsible Manager:	C. Wittreich, Control Account Manager	Date: 11/26/2018

Revision History:

Revision No.	Description	Date	Affected Pages
0	Initial Release	11/19/2018	All

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Executive Summary

This interim action feasibility study cost estimate is based on the development of remedial alternatives identified in Chapter 5, "Development and Screening of Alternatives," of DOE/RL-2018-30[1]. The alternatives were developed to identify a combination of remedial actions to clean up groundwater within the 200-BP-5 and 200-PO-1 Operable Units within the eastern portion of the Hanford Site Central Plateau.

Based on technology screening and evaluations, three alternatives were assembled and selected for evaluation, including the required No Action alternative:

- Alternative 1: No Action
- Alternative 2: 25 Years of Pump and Treat at B Complex and 10 Years Pump and Treat at Waste Management Area C
- Alternative 3: 25 Years of Pump and Treat at B Complex and 10 Years Pump and Treat at Waste Management Area C and Gable Gap

Cost estimates were developed for each of the alternatives using EPA 540-R-00-002[2];) and standard industry practices. The estimates created for this report are considered to be within an accuracy range of +50%/−30%. This environmental cost estimate describes this estimate, and summary reports and details are included in the appendices. Table ES-1 provides a summary of the costs for each alternative.

Table ES-1. Summary of Cost Estimates for Each Alternative

200-BP-5 and 200-PO-1 OUs Cost Estimate Summary by Alternative	Alternative 1: No Action	Alternative 2: 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3: 25 Years P&T at B Complex and 10 Years P&T
Total project duration (years)	0	27	27
Capital cost	$0	$24,300,000	$37,800,000
Annual O&M cost	$0	$183,000,000	$216,000,000
Periodic O&M cost	$0	$6,500,000	$8,100,000
Total nondiscounted cost	$0	$214,000,000	$261,000,000

[1] DOE/RL-2018-30, 2018, *200-BP-5 and 200-PO-1 Groundwater Operable Units Feasibility Study for Interim Action*, Draft A , U.S. Department of Energy, Richland Operations Office, Richland, Washington.
[2] EPA 540-R-00-002, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Available at: https://semspub.epa.gov/work/HQ/174890.pdf.

Table ES-1. Summary of Cost Estimates for Each Alternative

200-BP-5 and 200-PO-1 OUs Cost Estimate Summary by Alternative	Alternative 1: No Action	Alternative 2: 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3: 25 Years P&T at B Complex and 10 Years P&T
Total present value of alternative	$0	$199,000,000	$245,000,000
Expected Accuracy Range for Total Present Value: −30% to +50%			
−30%	$0	$139,000,000	$172,000,000
+50%	$0	$299,000,000	$368,000,000

Note: The accuracy is expected to be within +50% and −30%. The costs presented in this table include general and administration and contingencies.

O&M = operations and maintenance
OU = operable unit
P&T = pump and treat
WMA = waste management area

Contents

1 Introduction 1

2 Purpose of Estimate 1

3 General Project Description 1

4 Scope of Work 2

5 Estimate Methodology 7

5.1 Markups and Contingencies 7
5.2 Project Management, Remedial Design, and Construction Management 9
5.3 Escalation Rate 9
5.4 Estimate Classification 9
5.5 Present Value Analysis 10
5.6 Cost Resources 11
5.7 Labor Costs 11
5.8 Sales Tax 11
5.9 Allowance Costs 11
5.10 Construction 12
5.11 Operations and Maintenance 13
5.12 Institutional Controls 13

6 Exclusions 13

7 Cost Summary Table 13

8 Cost Development 14

9 References 14

Appendices

A Cost Estimate Quantity Inputs ..... A-i

B Summary Cost Tables ..... B-i

C Estimate Detail ..... C-i

D Line Item Detail ..... D-i

Figures

Figure 1. Uranium and Technetium-99 Groundwater Plumes in the 200 East Area 3
Figure 2. Existing and New Components for Alternative 2 5
Figure 3. Existing and New Components for Alternative 3 6
Figure 4. Scope Contingency Percentages Ranges 8

Figure 5. Cost Estimate Accuracy 10
Figure 6. Real Discount Rates 11
Figure 7. Example Percentages for Project Management and Technical Services Capital Costs 12

Table

Table 1. Summary of Cost Estimates for Each Alternative 13

Terms

CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COPC	contaminant of potential concern
Cr(VI)	hexavalent chromium
DOE	U.S. Department of Energy
ECE	environmental cost estimate
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FS	feasibility study
G&A	general and administrative
HDPE	high-density polyethylene
IC	institutional control
MDBI	Mob/Demob Bond & Insurance
O&M	operations and maintenance
OH&P	overhead and profit
OU	operable unit
P&T	pump and treat
RCRA	*Resource Conservation and Recovery of 1976*
RI	remedial investigation
ROD	Record of Decision
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WMA	Waste Management Area

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1 Introduction

CH2M HILL Plateau Remediation Company (CHPRC) has prepared this environmental cost estimate (ECE) in support of DOE/RL-2018-30, *200-BP-5 and 200-PO-1 Groundwater Operable Units Feasibility Study for Interim Action*. The following discussion provides the basis of this estimate. The cost estimate summaries have been prepared for comparative response action evaluations based on information available at the time that this ECE was prepared. The cost estimates reflect specific response action approaches, scope assumptions and exclusions, and cost-estimating methodologies. The response action cost estimates have expected ranges of accuracy, described in Section 5.4, "Estimate Classification." The final costs for the selected response action will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final project scope, final project schedule, and other factors.

2 Purpose of Estimate

This ECE and cost estimate backup supports the response action alternatives analysis provided in DOE/RL-2018-30. It provides an overview of response action-specific cost inputs, methodology, and results.

The purposes of this ECE are as follows:

- Describe the methodology applied in performing the cost estimates
- Describe the general and action-specific assumptions and cost inputs applied to the cost estimates
- Summarize the response action alternative cost estimates

This ECE also documents the references that provide more detailed information used to prepare the cost estimates.

3 General Project Description

In 1989, representatives from the Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and U.S. Department of Energy (DOE) signed Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). The Tri-Party Agreement created a cohesive regulatory framework, schedule, and adjudication process to administer environmental remediation activities at the Hanford Site for both *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) response action and *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action activities. As part of the Tri-Party Agreement, a number of geographic and/or functional areas were created from the various plant sites on the plateau or the river corridor area; they were termed "operable units (OUs)." The two groundwater OUs in the 200 East Area are 200-BP-5 and 200-PO-1.

The 200-BP-5 OU encompasses contaminated groundwater associated with historical operation of DOE nuclear fuel reprocessing and the waste storage and disposal facilities located primarily within the northern portion of the 200 East Area. The 200-BP-5 OU extends from the 200 East Area, northwest to the Columbia River, and east to the eastern flank of Gable Mountain. At its northernmost extent, the 200-BP-5 OU borders the Columbia River, adjacent to two other groundwater OUs, 100-BC-5 and 100-KR-4.

The 200-PO-1 OU is located beneath the southern portion of the 200 East Area and extends to the south/southeast of the 200 East Area across the Hanford Site. The OU extends east to the Columbia River, south to the 300-FF-5 Groundwater OU, and north to the 200-BP-5 Groundwater OU.

Contamination in the 200-BP-5 OU resulted largely from liquid waste discharges during the operational period of B Plant and associated facilities within the northern portion of the 200 East Area. Continuing sources to groundwater have been identified at the B Complex (including Waste Management Area [WMA] B-BX-BY) and WMA C. Liquids from the Plutonium-Uranium Extraction (PUREX) Plant, B Plant, and U Plant operations were disposed to the soil at locations overlying the 200-PO-1 OU and contributed to groundwater contamination.

The 200-BP-5 Remedial Investigation (RI) Report (DOE/RL-2009-127, *Remedial Investigation Report for the 200-BP-5 Groundwater Operable Unit*) identified 15 groundwater contaminants of potential concern (COPCs): arsenic, cesium-137, cobalt-60, cyanide, fluoride, hexavalent chromium (Cr(VI)), gross alpha, iodine-129, nitrate, plutonium-239/240, strontium-90, sulfate, technetium-99, tritium, and uranium. The most widely distributed of these COPCs are iodine-129, nitrate, technetium-99, and uranium. Groundwater contaminant concentrations in the 200-BP-5 far-field area (north of the Gable Gap) have naturally dispersed over time and are below groundwater standards. Concentrations of COPCs above applicable groundwater standards currently only occur in the near-field area south of Gable Gap.

The 200-PO-1 OU RI Addendum (DOE/RL-2009-85-ADD1, *Remedial Investigation Report for the 200-PO-1 Groundwater Operable Unit Addendum 1*) identified six groundwater COPCs: iodine-129, nitrate, strontium-90, technetium-99, tritium, and uranium. The most widely distributed COPCs are iodine-129, and tritium. Groundwater contaminant concentrations originating from 200-PO-1 OU sources have naturally dispersed over time in the 200-PO-1 far-field area; only iodine-129, nitrate, and tritium are currently detected above DWSs in the far-field area.

The focus of the interim action for the 200-BP-5 and 200-PO-1 OUs is uranium and technetium-99 in the B Complex area, and technetium-99 in the WMA C and Gable Gap areas (Figure 1).

4 Scope of Work

The cost estimate for the 200-BP-5/200-PO-1 project was developed in accordance with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, OSWER 9355.0-75, and standard industry practices.

Quantities used in the creation of this estimate were based on the information provided by the project team and are documented in Appendix A.

An overview of the remedial alternative concepts developed for detailed and comparative analysis and cost estimating is provided below. Three alternatives are evaluated to address the contaminated groundwater.

- Alternative 1: No Action
  - 40 CFR 300.430(e)(6), “National Oil and Hazardous Substances Pollution Contingency Plan,” “Remedial Investigation/Feasibility Study and Selection of Remedy,” requires consideration of a No Action alternative. The No Action alternative, which serves as a baseline for evaluating other remedial alternatives, is retained throughout the feasibility study (FS) process. No Action means that no further remediation would be implemented to alter the existing conditions.

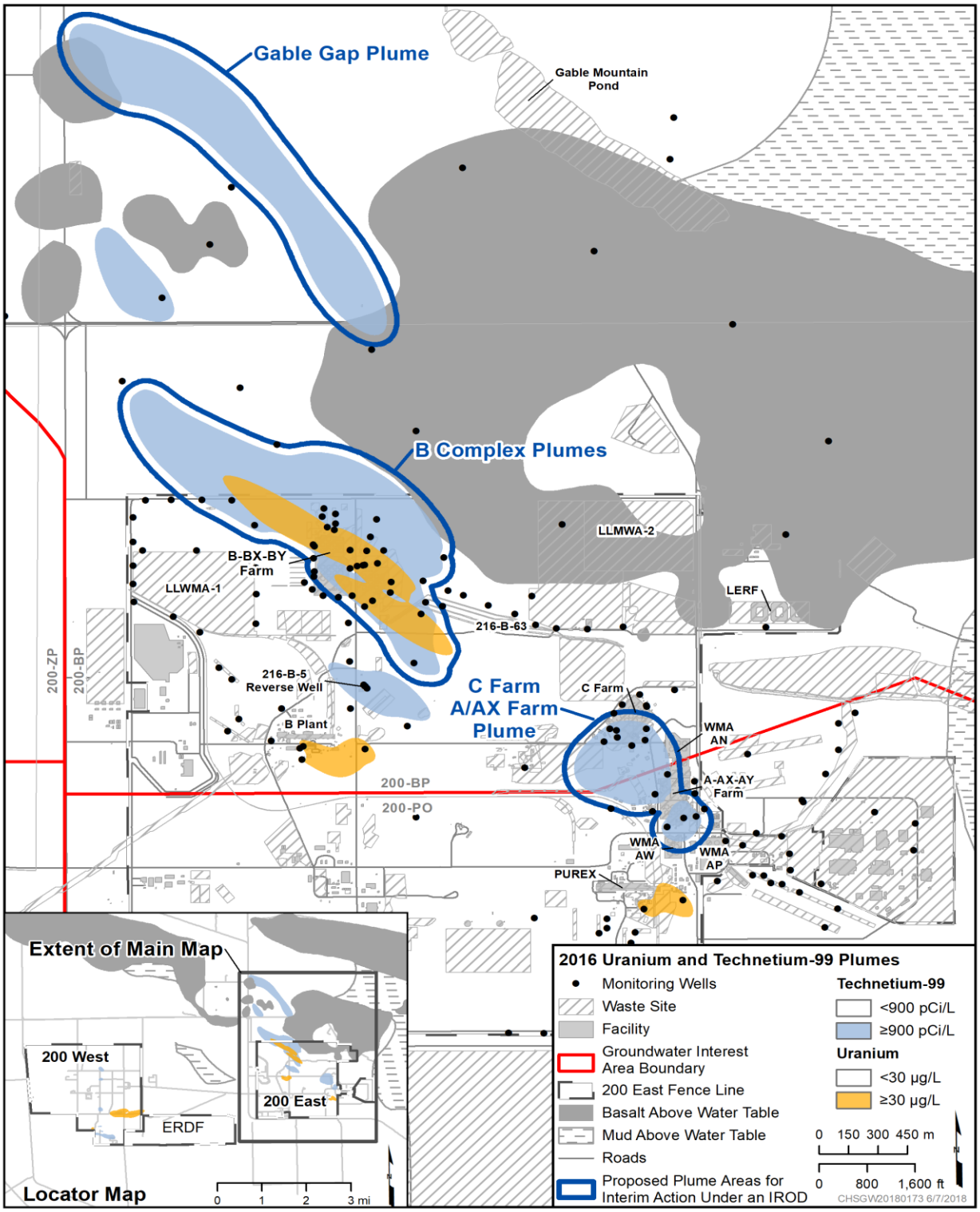


Figure 1. Uranium and Technetium-99 Groundwater Plumes in the 200 East Area

- Alternative 2: 25 Years of pump and treat (P&T) at B Complex and 10 Years of P&T at WMA C.

  The primary components of this alternative are summarized below and shown in Figure 2:

  – Total groundwater extraction is 1,134 L/min (300 gal/min) (756 L/min [200 gal/min] from B Complex and 378 L/min [100 gal/min] from WMA C). Total groundwater injection is 1,134 L/min (300 gal/min) in the 200 West Area.

  – 1,134 L/min (200 gal/min) groundwater extraction at the B Complex for 25 years. This alternative uses an existing 567 L/min (150 gal/min) from the 200-BP-5 removal action, and adds an additional 189 L/min (50 gal/min) from the B Complex.

  – 378 L/min (100 gal/min) groundwater extraction at WMA C for 10 years.

  – 1,134 L/min (300 gal/min) groundwater injection in the 200 West Area, and installation of three new injection wells and associated piping. Each new injection well is assumed to have a capacity of 189 L/min (50 gal/min). One of the injection wells is allocated to B Complex to accommodate the additional 189 L/min (50 gal/min) capacity above the existing 567 L/min (150 gal/min) removal action, and two injection wells (total capacity of 378 L/min [100 gal/min]) are allocated to WMA C.

  – One new extraction well and associated piping in B Complex and three new extraction wells and associated piping at WMA C.

  – Expand B Complex transfer station to accommodate WMA C flow.

  - Addition of a new technetium-99 treatment train for the 200 West P&T to accommodate additional flow from WMA C.

  - Modify flow from modutanks so existing cross-site transfer lines can accommodate additional flow from WMA C.

  - Addition of a new air stripper to the 200 West P&T to accommodate additional flow from WMA C.

- Alternative 3: 25 Years of P&T at B Complex and 10 Years of P&T at WMA C and Gable Gap.

  The primary components of this alternative are summarized below and shown in Figure 3:

  – 756 L/min (200 gal/min) groundwater extraction at the B Complex for 25 years. This alternative uses an existing 567 L/min (150 gal/min) from the 200-BP-5 Removal Action and adds an additional 189 L/min (50 gal/min) from the B Complex.

  – 378 L/min (100 gal/min) P&T at WMA C for 10 years.

  – 378 L/min (100 gal/min) P&T at Gable Gap for 10 years.

  – 1,134 L/min (300 gal/min) groundwater injection in the 200 West Area, and installation of three new injection wells and associated piping. Each new injection well is assumed to have a capacity of 189 L/min (50 gal/min). One of the injection wells is allocated to B Complex to accommodate the additional 189 L/min (50 gal/min) capacity above the existing 567 L/min (150 gal/min) removal action, and two injection wells (total capacity of 378 L/min [100 gal/min]) are allocated to WMA C.

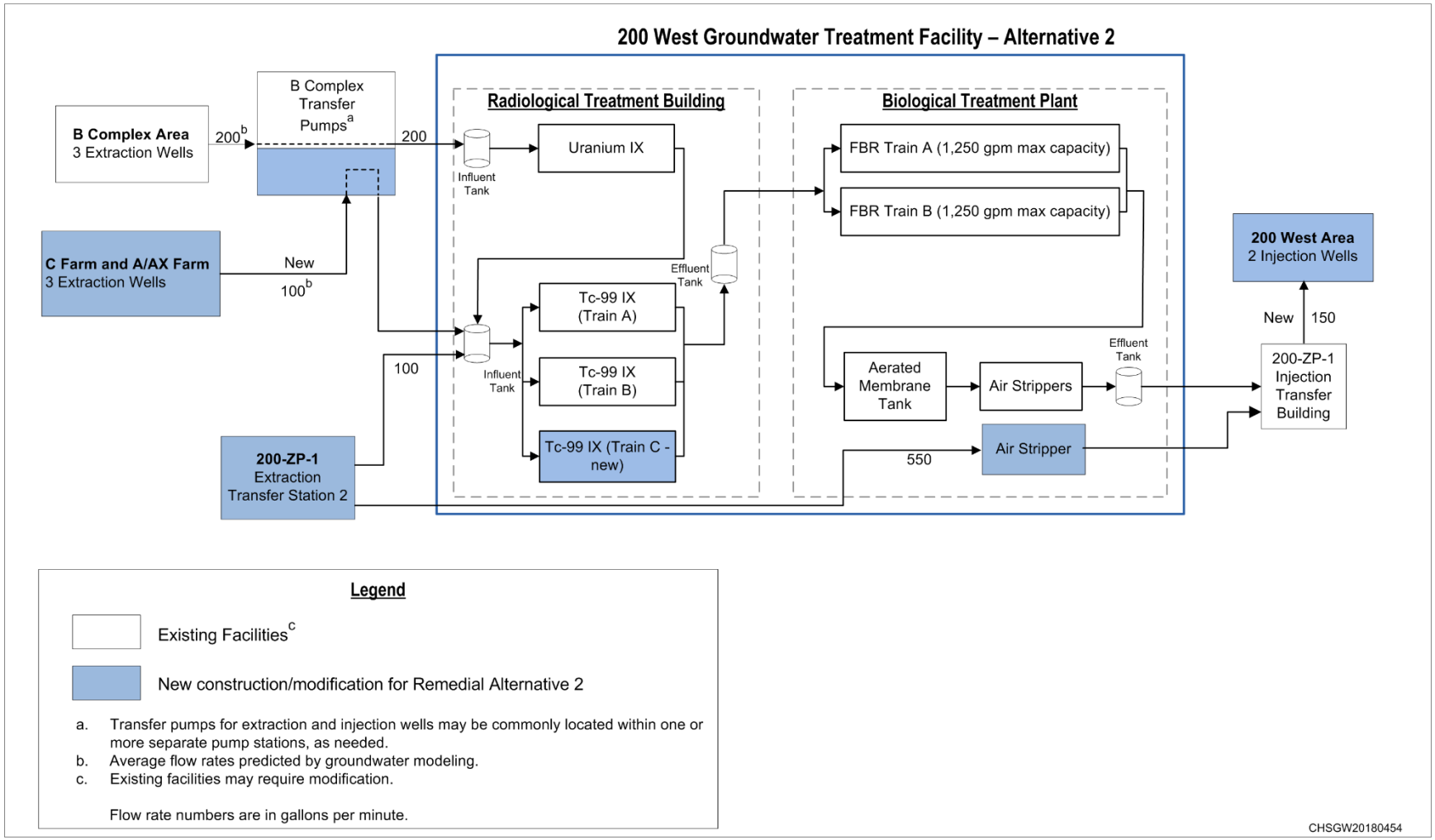


Figure 2. Existing and New Components for Alternative 2

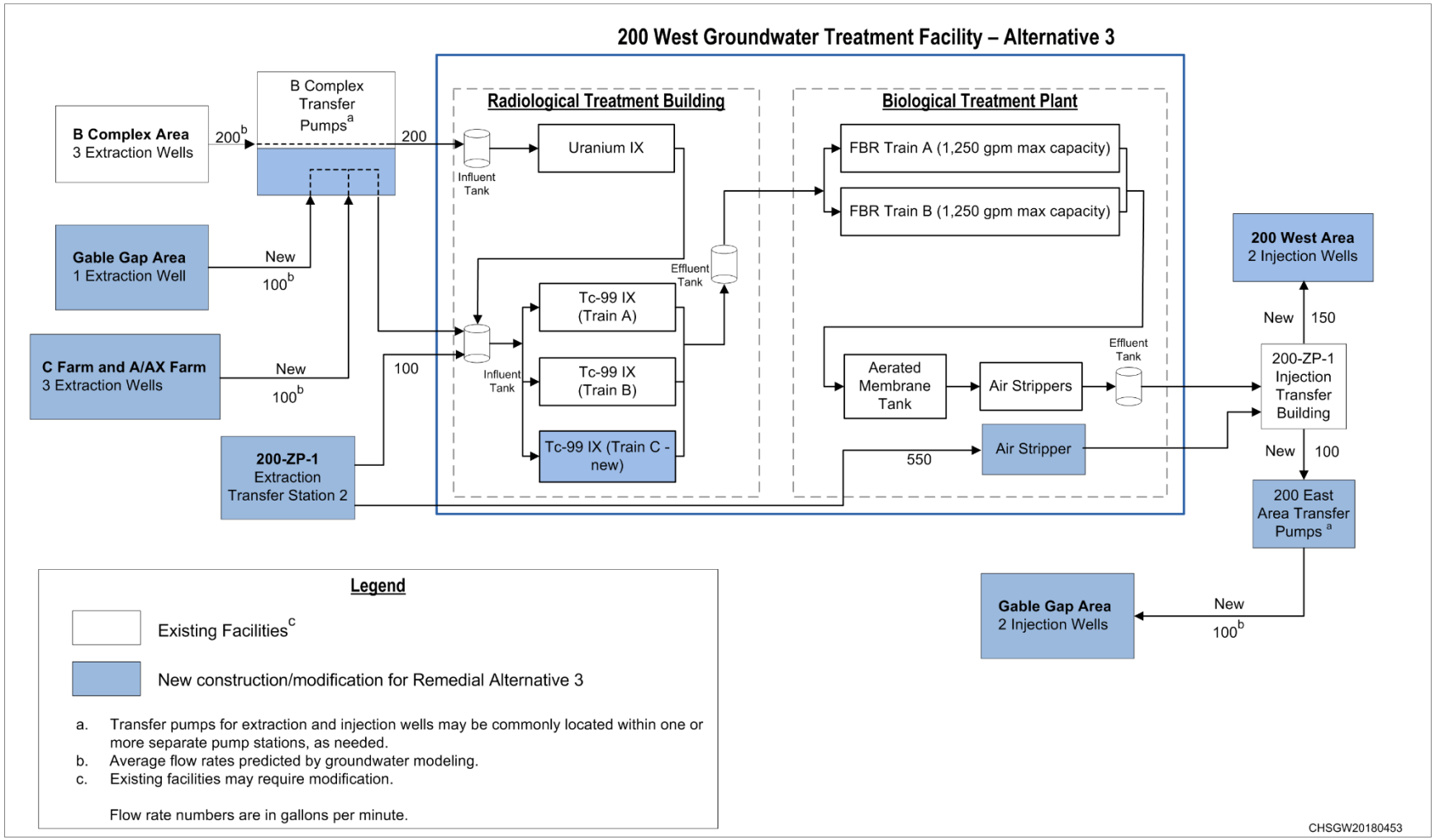


Figure 3. Existing and New Components for Alternative 3

- 378 L/min (100 gal/min) injection at Gable Gap, with installation of two new injection wells and associated piping.
- One new extraction well and associated piping in B Complex; three new extraction wells and associated piping at WMA C; and one new extraction well and associated piping at Gable Gap.
- One new transfer station at WMA C and one new transfer station at the B Complex.
- Addition of a new technetium-99 treatment train for the 200 West P&T to accommodate additional flow from WMA C and Gable Gap.
- Modify flow from the modutanks so existing cross-site transfer lines can accommodate additional flow from WMA C and Gable Gap.
- Addition of a new air stripper to the 200 West P&T to accommodate additional flow from WMA C and Gable Gap.

5 Estimate Methodology

This cost estimate was prepared based on engineering development that occurred at the FS level. Assumed project scope items were itemized at a major assembly level, and unit costs were applied for the major assemblies, with some breakout of more detailed support costs where deemed necessary for clarity. Where available, costs for major systems were based on existing system costs at the Hanford Site. Percentage allowances were applied for some of the capital and operations and maintenance (O&M) cost items based on Hanford Site and environmental project experience.

This cost estimate has been prepared to use in project evaluations and is based on the information available at the time that this estimate was prepared. The final cost of the project will depend on final design, selected scope of work, actual labor and material costs, competitive market conditions, implementation schedule, and other factors. As a result, the final project costs may vary from the estimate presented here; therefore, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions to help ensure proper project evaluation and adequate funding.

5.1 Markups and Contingencies

The following typical markups and contingencies were applied to the cost estimate:

- Mob/demob bond & insurance (MDBI) applied to capital costs: 10%.
- Contractor overhead and profit (OH&P): 25% (overhead of 15% and profit of 10%) or 0% (when CHPRC only).
- Washington State sales tax of 8.6% (6.5% state general sales tax plus 2.1% city tax rate).
- Scope contingency of 15% (Figure 4, and EPA Guidance [EPA 540-R-00-002, pp. 5-10]).

Exhibit 5-6
Example FS-Level Scope Contingency Percentages

Remedial Technology	Scope Contingency (%)
Soil Excavation	15-55
Groundwater Treatment (Multiple)	15-35
On-Site Incineration	15-35
Extraction Wells	10-30
Vertical Barriers	10-30
Synthetic Cap	10-20
Sludge Stabilization	10-20
Off-Site Disposal	5-15
Off-Site Incineration	5-15
Drum Processing	5-15
Bulk Liquid Processing	5-15
Groundwater Treatment (Single)	5-10
Clay Cap	5-10
Surface Grading/Diking	5-10
Revegetation	5-10

Source: Exhibit 5-6, "Example FS-Level Scope Contingency Percentages," in EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*.

Figure 4. Scope Contingency Percentages Ranges

- Bid contingency of 10% (per EPA guidance for FS costs, "Bid contingency typically ranges from 10 to 20 percent," pp. 5-11).
- The Project Management, Remedial Design, and Construction Management percentages are based on the total cost of the capital for each alternative; therefore, the percentages change per alternative. The percentages applied to this are as follows: Project Management of 5%, Remedial Design of 6%, and Construction Management of 6% for Capital Costs.
- CHPRC general and administrative (G&A): 19.26%.

The markups were added in the following order:

1. MDBI.
2. The contractor OH&P markup was applied to any non-CHPRC labor, equipment, and materials. Where there was no contractor under CHPRC, this markup is 0%.
3. Washington State sales tax.

4. Scope and bid contingencies.
5. Project Management, Remedial Design, and Construction Management.
6. CHPRC G&A.

5.2 Project Management, Remedial Design, and Construction Management

Project management, remedial design, and construction management capital costs are estimated using factors based on EPA 540-R-00-002, Exhibit 5-8:

- For projects with subtotal construction costs less than $100,000—remedial design is planned at 20%, project management is planned at 10%, and construction management is planned at 15% of the construction cost.
- For projects with subtotal construction costs from $100,000 to $500,000—remedial design is planned at 15%, project management is planned at 8%, and construction management is planned at 10% of the construction cost.
- For projects with subtotal construction costs from $500,000 to $2 million—remedial design is planned at 12%, project management is planned at 6%, and construction management is planned at 8% of the construction cost.
- For projects with subtotal construction costs from $2 million to $10 million—remedial design is planned at 8%, project management is planned at 5%, and construction management is planned at 6% of the construction cost.
- For projects with subtotal construction costs greater than $10 million—remedial design is planned at 6%, project management is planned at 5%, and construction management is planned at 6% of the construction cost.

For all of the alternatives, the subtotal construction costs are all greater than $10 million, so remedial design is estimated at 6%, project management is estimated at 5%, and construction management is estimated at 6% of the construction cost.

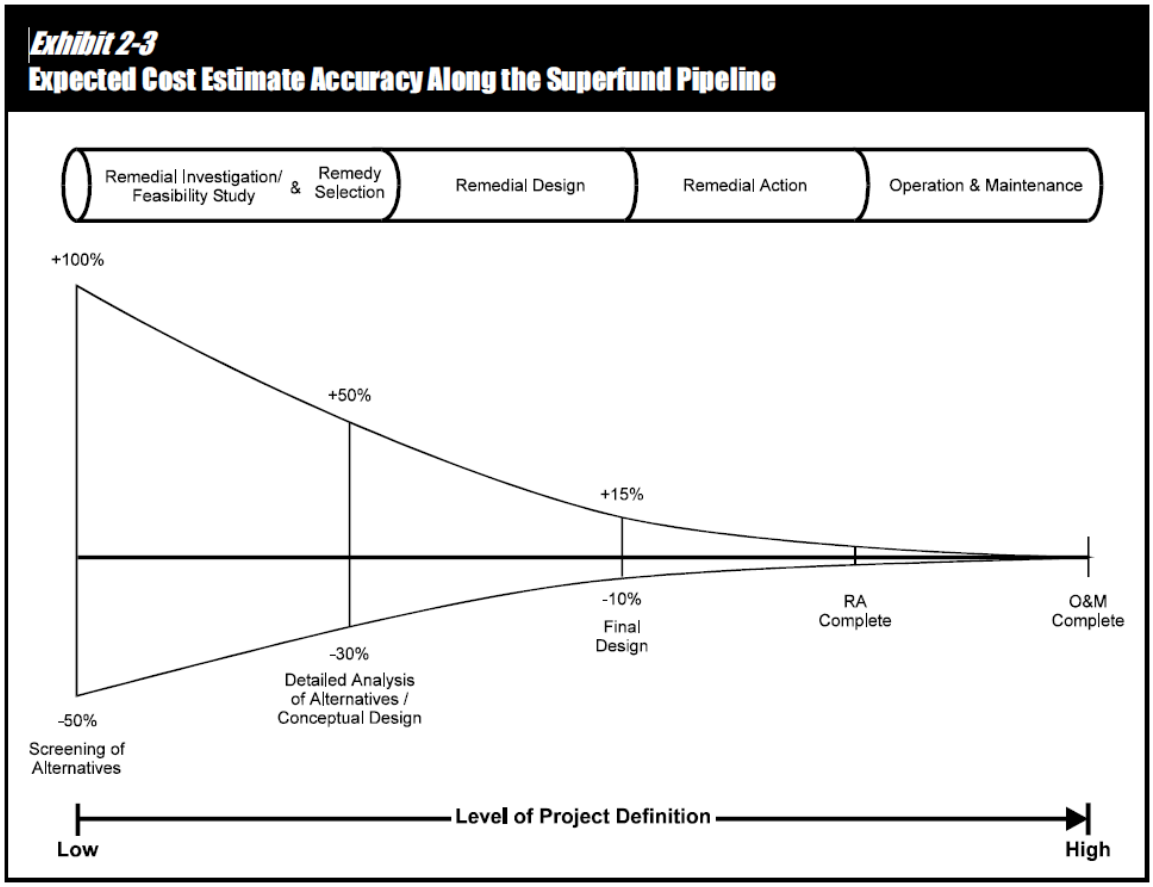
5.3 Escalation Rate

Escalation is not calculated in this estimate. The estimates are presented as 2018 costs.

5.4 Estimate Classification

The expected accuracy range of the cost estimate at this stage is approximately +50%, −30%. This accuracy range is consistent with EPA guidance (EPA 540-R-00-002) (Figure 5) for the level of project definition available at this point in the Superfund process.

The expected accuracy range is an indication of the degree to which the final cost outcome for a given project could vary from the estimated cost. Accuracy is traditionally expressed as a "±" percentage range around the point estimate after application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range ("±" measures are a useful simplification, given that actual cost outcomes have different frequency distributions for different types of projects). Typically, this results in a 90% confidence that the actual cost will fall within the bounds of the low and high ranges.



Source: Exhibit 2-3, "Expected Cost Estimate Accuracy Along the Superfund Pipeline," in EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*.

Figure 5. Cost Estimate Accuracy

The accuracy range of an estimate is dependent upon a number of characteristics of the estimate input information and the estimating process. The extent and the maturity of the input information as measured by percentage completion (and related to level of project definition) is an important determinant of accuracy. However, there are additional factors, other than the available input information, that also greatly affect the estimate accuracy measures. Primary among these factors are the state of technology in the project and the quality of reference cost-estimating data.

The accuracy of any given estimate is not fixed or determined by its classification category. Significant variations in accuracy from estimate to estimate are possible if any of the determinants of accuracy (e.g., technology, quality of reference cost data, quality of the estimating process, and skill and knowledge of the estimator) may vary. Accuracy is also not necessarily determined by the methodology used or the effort expended. Estimate accuracy must be evaluated on an estimate-by-estimate basis, usually in conjunction with some form of risk analysis process.

5.5 Present Value Analysis

As per EPA guidance (EPA 540-R-00-002), the cost estimate includes present value calculations for work performed throughout multiple years. The present value method establishes a common baseline for evaluating costs that occur during different time periods, thus allowing for direct cost comparisons between different alternatives. The present value represents the dollars that would need to be set aside

today, at the defined real discount rate, to ensure that funds would be available in the future as they are needed to perform the response action alternative. The purpose of the present value spreadsheets is to calculate the total present value for each alternative.

For Federal facility sites being cleaned up using Superfund authority, it is generally appropriate to apply the real discount rates found in Appendix C of OMB Circular No. A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," and shown in Figure 6.

Real Interest Rates on Treasury Notes and Bonds of Specified Maturities (in percent)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
-0.8	-0.6	-0.3	-0.1	0.2	0.6

Reference: OMB Circular No. A-94, *Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses*, Appendix C, "Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses," Revised November 2017.

Note: Analyses of programs with terms different from those presented above may use a linear interpolation. For example, a four-year project can be evaluated with a rate equal to the average of the three-year and five-year rates. Programs with durations longer than 30 years may use the 30-year interest rate.

Figure 6. Real Discount Rates

5.6 Cost Resources

The following cost resources were used in the development of the cost estimates:

- CHPRC historical data
- Vendor quotes and subcontracts (well drilling, completion costs, and pipeline fabrication)
- CHPRC finance (labor and overhead rates)
- Mission Support Alliance published service rates (heavy equipment and operators)
- Estimator judgment
- Subject matter expert information

5.7 Labor Costs

The estimate has been adjusted for local area labor rates through use of finance department resource rates as agreed upon in current contracts. Labor unit prices reflect a burden rate, including workers' compensation, unemployment taxes, fringe benefits, and medical insurance at 2018 rates.

5.8 Sales Tax

Sales tax is included in non-labor costs based on previous Hanford Site P&T systems and components used in this estimate. Washington State sales tax is 8.6%.

5.9 Allowance Costs

The cost estimate includes the following allowances within the cost estimate:

- Electrical hookups
- Power poles
- Aboveground cross-site transfer line from the 200 East Area to the 200 West P&T
- Well sampling during drilling

- Treatment of extracted groundwater

The assumptions used in the estimate include Project Management, Remedial Design, and Construction Management used in capital costs and Technical Support services costs based on percentage in accordance with EPA guidance (EPA 540-R-00-002, Exhibit 5-8; Figure 7).

Exhibit 5-8
Example Percentages for Professional/Technical Services Capital Costs

Capital Cost Element	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	> $10M (%)
Project Management	10	8	6	5	5
Remedial Design	20	15	12	8	6
Construction Management	15	10	8	6	6

Source: From Exhibit 5-8, "Example Percentages for Professional/Technical Services Capital Costs," in EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*.

Figure 7. Example Percentages for Project Management and Technical Services Capital Costs

5.10 Construction

The following assumptions were made in regard to construction for this cost estimate:

- Extraction, injection, and monitoring wells are 91 m (300 ft) in depth
- Injection wells have a total capacity of 189 L/min (50 gal/min) each
- Extraction well line items include the following:
  - Drilling mobilization (completion, cleanup, and demob included)
  - Extraction transfer station
  - Pump assembly, pump setting crew
  - Landing plate, riser pipe, disconnect boxes, allowance for electrical hookups, tray cable, extraction well rack, water level sensor, fiber optic splice box, fiber optic cable and interfaces
  - 37,800 L (10,000 gal) plastic water storage tank
  - High-density polyethylene (HDPE) pipe, pipe fusion crew (including testing), pipe fusion machine, freight for pipe
  - Geologist/geophysicist/hydrogeologist
- Injection wells
  - Drilling mobilization, completion, cleanup, and demobilization
  - HDPE pipe, pipe fusion crew (includes testing), pipe fusion machine, freight for pipe

- Injection rack, riser pipe, landing plate, tray cable
- Transfer station
- Geologist/geophysicists/hydrogeologist

5.11 Operations and Maintenance

The following assumptions were made in regard to O&M for this cost estimate:

- Operating costs of P&T system based on per gallon costs for operation of the 200 West P&T as published in DOE/RL-2016-69, *Calendar Year 2016 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations*.
- Pump replacement for extraction and monitoring wells will occur every 5 and 10 years, respectively.
- Extraction, injection, and monitoring wells are replaced every 25, 15, and 25 years, respectively.
- Extraction, injection, and monitoring wells are rehabilitated every 5, 2, and 10 years, respectively.

5.12 Institutional Controls

While remediation is underway, institutional controls (ICs) will be implemented to control access and prevent exposure to contamination. For the cost estimate for interim action costs, remedy specific, or OU, specific ICs were not included.

The programmatic IC costs for the Hanford Site have been projected for the next 1,000 years. The total nondiscounted cost for the ICs for 1,000 years is estimated to be $542,527,000 for the Hanford Site (about $22,700,000 per Record of Decision [ROD]). The total discounted cost for the ICs at the Hanford Site is estimated at $83,220,000 (about $3,500,000 per ROD).

6 Exclusions

The following items have been excluded from the estimate:

- Capital/construction costs for existing wells
- Pipeline replacement during the active portion of the project
- Sampling during drilling for injection wells drilled and constructed in the 200 West Area

7 Cost Summary Table

Alternatives were evaluated and estimates of duration, capital, and O&M costs were developed for each alternative based on information provided by the 200-BP-5/200-PO-1, and as summarized in Appendix A. Table 1 presents the costs for each alternative.

Table 1. Summary of Cost Estimates for Each Alternative

200-BP-5 and 200-PO-1 OUs Cost Estimate Summary by Alternative	Alternative 1: No Action	Alternative 2: 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3: 25 Years P&T at B Complex and 10 Years P&T
Total project duration (years)	0	27	27
Capital cost	$0	$24,300,000	$37,800,000

Table 1. Summary of Cost Estimates for Each Alternative

200-BP-5 and 200-PO-1 OUs Cost Estimate Summary by Alternative	Alternative 1: No Action	Alternative 2: 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3: 25 Years P&T at B Complex and 10 Years P&T
Annual O&M cost	$0	$183,000,000	$216,000,000
Periodic O&M cost	$0	$6,500,000	$8,100,000
Total nondiscounted cost	$0	$214,000,000	$261,000,000
Total present value of alternative	$0	$199,000,000	$245,000,000
Expected Accuracy Range for Total Present Value: −30% to +50%			
−30%	$0	$139,000,000	$172,000,000
50%	$0	$299,000,000	$368,000,000

Note: The accuracy is expected to be within +50% and −30%. The costs presented in this table include general & administration and contingencies.

OU = operable unit
P&T = pump and treat
WMA = waste management area

8 Cost Development

Appendix A documents key quantity inputs that support the alternative cost estimates. Appendix B presents cost summary tables for Alternatives 2 and 3. Appendix C provides the detailed cost development reports, and Appendix D provides the line item costs used in the estimate.

9 References

40 CFR 300.430, "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy," *Code of Federal Regulations*. Available at: http://www.gpo.gov/fdsys/pkg/CFR-2010-title40-vol27/xml/CFR-2010-title40-vol27-sec300-430.xml.

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Appendix A

Cost Estimate Quantity Inputs

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A1 Introduction

This appendix documents the key quantity inputs that support development of 200-BP-5 and 200-PO-1 remedial action alternative cost estimates.

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Table A-1. Cost Estimate Inputs

	Alternative 2 (Scenario 5)		Total	Alternative 3 (Scenario 4)		Total	Alt 2 Notes	Alt 3 Notes
	Existing	New	or Info	Existing	New	or Info		
Groundwater Extraction								
Number of Wells (8-inch diameter)	2	4		2	5		2 exst EWs in B Complex (50 & 75 gpm); 1 new EW in B Complex (75 gpm); 3 new EWs in C/A/AX Farm (33.3 gpm each)	2 exst EWs in B Complex (50 & 75 gpm); 1 new EW in B Complex (75 gpm); 3 new EWs in C/A/AX Farm (33.3 gpm each); 1 new EW in GG (100 gpm)
Flow rate per well (average) ,gpm	62.5	43.725		62.5	54.98			
Total extraction flow, gpm			300			400		
Assumed deep well depth (m) for new wells		91.5			91.5		assume 50 ft screen, 250 ft riser	assume 50 ft screen, 250 ft riser
Assumed shallow well depth, (m)								
Drilling footage, m		366			457			
Type of Submersible Pump (5 hp, 208-230 V)	4" dia, w/ controls			4" dia, w/ controls			assume 400 ft of static and friction head	assume 400 ft of static and friction head
Well Casing and Screen Diameter, in		8			8			
3"(?) HDPE Transfer Piping, m		3,270			8,010		From new B Complex EW to exst B Complex PS; from 3 new C/A/Ax Farm EWs to new C/A/AX Farm PS. First line lentgh per C. Cearlock email (6/18/18); 2nd lengths scaled off well map by G. Hickman. ***Pipe diameter uncertain.***	Piping as in Alt 2 plus piping from new GG EW to new B Complex PS (distances per C. Cearlock email (6/18/18)). ***Pipe diameter uncertain.***
6"(?) HDPE Transfer Piping, m		0			15,852		Use exst cross-site pipeline for B Complex water. New cross-site pipeline to convey extracted C/A/AX water from new C/A/AX Farm PS to 200 West GWTF. Distances per C. Cearlock email (6/18/18). ***Pipe diameter uncertain.***	Use exst cross-site pipeline for B Complex water (***assume exst pipeline can accommodate water from new [third] EW in B Complex***). New cross-site pipeline to convey extracted C/A/AX Farm water to new B Complex PS, and to convey combined C/A/AX Farm and GG waters from new B Complex PS to 200 West GWTF. Distances per C. Cearlock email (6/18/18). ***Pipe diameter uncertain.***
Transfer Stations - Extracted GW to 200 West GWTF								
Extracted Water Pump Stations	1	1	2	1	3	4	Use exst B Complex PS to convey extracted B Complex water to 200W GWTF. New C/A/AX Farm PS to convey extracted water from C/A/AX Farm to 200W GWTF.	Use exst B Complex PS to convey extracted B Complex water to 200W GWTF (***assume exst PS has capacity to accommodate water from new [third] EW in B Complex***). New Pump Stations: (1) New C/A/AX Farm PS to convy extracted C/A/AX Farm water to new B Complex PS; (2) New GG PS to convey extracted water from new GG EW to new B Complex PS; (3) New B Complex PS to convey extracted combined C/A/AX Farm and GG waters to 200W GWTF.
Extracted Water PS 1 Flow, gpm	150	100	250	150	100		New C/A/AX Farm PS. Note: B Complex water is kept segregated from other extracted waters in exst pipelinefor separate treatment of U	
PS 1 Collection Tank Capacity, gal		2,000			2,000		Sized to provide 20 min HRT	
Extracted Water PS 2 Flow,					100			New GG PS.
PS 2 Collection Tank Capacity, gal					2,000		Sized to provide 20 min HRT	
Extracted Water PS 3 Flow,					200			New B Complex PS
PS 3 Collection Tank Capacity, gal					4,000		Sized to provide 20 min HRT	
Groundwater Injection (Treated Effluent)- 200 East								
Number of Injection Wells	0	0	0	0	2	2		2 new IWs in GG
Injection Rate per Well, gpm	0	0		0	50			
Total injection flow, gpm						100		
Assumed well depth, m					91.5			
Drilling footage, m					183			

	Alternative 2 (Scenario 5)		Total	Alternative 3 (Scenario 4)		Total	Alt 2 Notes	Alt 3 Notes
	Existing	New	or Info	Existing	New	or Info		
Well Casing Diameter, in					8			
3"(?) HDPE Transfer Piping, m					350			Piping from GG_I_2 to GG_I_1, scaled off well map by G. Hickman. ***Pipe diameter uncertain.***
4"(?) HDPE Transfer Piping, m					13,830			Cross-site pipeline to convey treated water from 200W GWTF to GG_I_2 for reinjection, via B Complex area. Distances per C. Cearlock email (6/18/18)). ***Pipe diameter uncertain.***
Transfer Stations - Return of Treated Effluent to 200 East								
Effluent Pumping Stations, ea		1			2			New PS near 200W GWTF to convey treated water to new GG IWs for reinjection (via B Complex area).
Groundwater Injection (Treateed Effluent) - 200 West								
Number of Injection Wells		2		0	2			
Injection Rate per Well, gpm	150	50	250	150	75	300		
Assumed well depth, m		91.5			91.5			
Drilling footage, m		183			183			
Well Casing Diameter, in		8			8			
3"(?) HDPE Transfer Piping, m		4000			4,000		Allowance; piping to convey treated water from new 200W injection PS to 2 new 200W IWs.	
6"(?) HDPE Transfer Piping, m		500			500		Allowance; piping to convey treated water fropm 200W GWTF to new 200W injection PS.	
Monitoring Wells (new)								
Number of New Monitoring Wells		4			8		Assume 2 new MWs each in B Complex and C/A/AX Farm (and 4 in GG for Alt 3), per conference call on 6/18/18.	
Assumed Well Depth, m		91.5			91.5			
Drilling footage, m		366			366			
Well Casing Diameter, in		4			4			
Well and Pump O&M Schedule								
Extraction Well Pump Replacement, yrs		5			5			
Extraction Well Rehab, yrs		5			5			
Extraction Well Replacement, yrs		25			25			
Injection Well Rehab, yrs		2			2			
Injection Well Replacement, yrs		15			15			
Monitoring Well Pump Replacement, yrs		10			10			
Monitoring Well Rehab, yrs		10			10			
Monitoring Well Replacement, yrs		25			25			
P&T Performance Monitoring								
Active P&T Monitoring - years		25			25			
Number of MWs monitored		4			8		Assume cost of monitoring of existing MWs would be born by existing groundwater monitoring programs, and that those results could also be used to help evaluate P&T performance	
During 1st yr P&T Monitoring - samples/yr per well		4			4			
After 1st yr P&T Monitoring - samples/yr per well		2			2			
Post P&T Monitoring Verification - yrs		2			2			
Post P&T Monitoring Verification - samples/yr per well		2			2			
200 West GWTF								
GWTF modifications		Yes			Yes		Assume a new (third) air stripper and Tc-99 IX treatment train required, plus associated piping	Assume a new (third) air stripper and Tc-99 IX treatment train required, plus associated piping
GWTF O&M and monitoring, yrs		25			25			

Appendix B

Summary Cost Tables

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B1 Introduction

This appendix provides cost summary tables comparing the overall costs of the 200-BP-5 and 200-PO-1 Operable Unit alternatives.

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Table B-1. Comparison of Total Cost of Remedial Action Alternatives

Location: 200 BP-5/200-PO-1 Groundwater OU
Phase: Interim Action

Base Year: 2018
Date: 8/30/2018

	1	2	3
	Alternative 01	**Alternative 02**	**Alternative 03**
	Alternative 1 - No Action	Alternative 2 - 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3 - 25 Years P&T at B Complex, and 10 Years P&T at WMA C and Gable Gap
Total Project Duration (Years)	0	27	27
Capital Cost	$0	$24,300,000	$37,800,000
Annual O&M Cost	$0	$183,000,000	$216,000,000
Periodic O&M Cost	$0	$6,500,000	$8,100,000
Total Non-Discounted Cost	$0	$214,000,000	$261,000,000
Total Present Value of Alternative	$0	$199,000,000	$245,000,000
Expected Accuracy Range for Total Present Value is -30% to +50%			
-30%	$0	$139,000,000	$172,000,000
50%	$0	$299,000,000	$368,000,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial action objectives. Changes in the cost elements may occur as a result of new information and data collected during the engineering design of the remedial alternatives. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Note: Present value of costs in future years discounted using OMB Circular A-94 standard rates

Note: Accuracy range selected to it within AACEI "Class 5" Feasibility Estimate accuracy range (AACEI recommended practice 17R-97)

Table B-2. Comparison of Total Cost of Remedial Action Alternatives By Site

Location: 200 BP-5/200-PO-1 Groundwater OU
Phase: Interim Action
Base Year: 2018
Date: 8/30/2018

Site	Site Name		Alternative 01	Alternative 02	Alternative 03
			Alternative 1 - No Action	Alternative 2 - 25 Years P&T at B Complex and 10 Years P&T at WMA C	Alternative 3 - 25 Years P&T at B Complex, and 10 Years P&T at WMA C and Gable Gap
		Total Project Duration (Years)	0	27	27
1	**GAP**				
		Capital Cost	$0	$0	$13,600,000
		Annual O&M Cost	$0	$0	$32,400,000
		Periodic O&M Cost	$0	$0	$1,500,000
		Total Non-Discounted Cost	$0	$0	$47,500,000
		Total Present Value of Alternative	$0	$0	$46,000,000
2	**B-Complex**				
		Capital Cost	$0	$4,400,000	$4,400,000
		Annual O&M Cost	$0	$151,000,000	$151,000,000
		Periodic O&M Cost	$0	$5,200,000	$5,200,000
		Total Non-Discounted Cost	$0	$161,000,000	$161,000,000
		Total Present Value of Alternative	$0	$147,000,000	$147,000,000
3	**WMA-C**				
		Capital Cost	$0	$19,800,000	$19,800,000
		Annual O&M Cost	$0	$32,200,000	$32,200,000
		Periodic O&M Cost	$0	$1,400,000	$1,400,000
		Total Non-Discounted Cost	$0	$53,400,000	$53,400,000
		Total Present Value of Alternative	$0	$51,900,000	$51,900,000
			Alternative 01	**Alternative 02**	**Alternative 03**
		Capital Cost	$0	$24,300,000	$37,800,000
		Annual O&M Cost	$0	$183,000,000	$216,000,000
		Periodic O&M Cost	$0	$6,500,000	$8,100,000
		Total Non-Discounted Cost	$0	$214,000,000	$261,000,000
		Total Present Value of Alternative	$0	$199,000,000	$245,000,000

Appendix C

Estimate Detail

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C1 Introduction

Detailed cost estimating worksheets for each of the 200-BP-5 and 200-PO-1 Operable Unit alternatives are provided in this appendix.

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Table C-1. Alternative 2 Cost Estimate Details

Alternative 02
Alternative 2 - 25 Years P&T at B Complex and 10 Years P&T at WMA C

Location:	200 BP-5/200-PO-1 Groundwater OU	**Base Year:**	2018
Phase:	Interim Action	**Date:**	8/30/2018
Description:	25 Years P&T at B Complex and 10 Years P&T at WMA C		

CAPITAL COSTS

WBS SITE	SITE NAME	Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
							$0					
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	extraction pipeline
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	06 Training	0.50	LS	$30,000	$15,000	OTHER	0	0	1	training cost allocated betweeen the B-Complex (50%) and WMA-C (50%) areas
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	1001 SOW Crew	80	Team/hr	$276	$22,084	OTHER	0	0	1	assume 80 hours to write SOW
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	126	team hr	$585	$73,708	OTHER	0	0	1	extraction pipeline, 50 ft/hr
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	6299	LF	$10	$62,992	OTHER	0	0	1	extraction pipeline
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	17 Freight for HDPE Pipe	3.00	trip	$2,500	$7,500	OTHER	0	0	1	extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
2	B-Complex	Extraction well pump & equipment	287 Subcontract power pole & power distribution	2000	LF	$7	$14,580	OTHER	0	0	1	Extr Disconnect Box
2	B-Complex	Extraction well pump & equipment	273 Tray Cable #10 4C THHN	6299	LF	$3	$21,921	OTHER	0	0	1	Extr Electrical Hookup allowance
2	B-Complex	Extraction well pump & equipment	286 Power Pole Allowance	1	EA	$1,848	$1,848	OTHER	0	0	1	power cable laying and power pole construction
2	B-Complex	Extraction well pump & equipment	289 Landing Plate	1	EA	$350	$350	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	271 Riser Pipe	300	LF	$50	$14,862	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	279 Disconnect Boxes	1	EA	$400	$400	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	285 Pump Setting Crew	20	Team/Hr	$262	$5,235	OTHER	0	0	1	1 extraction well pump
2	B-Complex	Extraction well pump & equipment	280 Allowance for Electrical Hookups	1	EA	$228	$228	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	266 #10/4C THHN (tray cable)	6299	LF	$2	$9,575	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	278 Transformer	1	EA	$0	$0	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	259 Transformers pole brackets	1	EA	$423	$423	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	275 Pump Assembly	1	EA	$3,200	$3,200	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	06 Training	1.0	LS	$30,000	$30,000	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	1001 SOW Crew	80	Team/hr	$276	$22,084	OTHER	0	0	1	
2	B-Complex	Extraction Well Racks	284 Extraction rack	1	EA	$40,000	$40,000	HISTORICAL	0	0	1	
2	B-Complex	Extraction Wells	11 Drilling & Construction (per foot)	300.00	LF	$546	$163,800	OTHER	0	0	1	1 new extraction well to 300 ft
2	B-Complex	Extraction Wells	10 Drilling Mobilization, completion, cleanup and demob	2.00	per well	$36,250	$72,500	OTHER	0	0	1	1 new extraction well to 300 ft
2	B-Complex	Fiber Optic Cable (transfer building to injection wells)	260 Fiber-optic cable and interfaces	4921	FT	$1	$6,545	OTHER	0	0	1	Injection wells
2	B-Complex	Injection pipelines (transfer building to injection wells)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	no new injection wells in B Complex
2	B-Complex	Injection pipelines (transfer building to injection wells)	06 Training	1.00	LS	$30,000	$30,000	OTHER	0	0	1	(training cost allocated betweeen the GAP, B-Complex, and WMA-
2	B-Complex	Injection pipelines (transfer building to injection wells)	1050 Pipe Fusion Crew (includes testing)	11	team hr	$585	$6,411	OTHER	0	0	1	Injection well pipe runs
2	B-Complex	Injection pipelines (transfer building to injection wells)	16 HDPE Dual Containment (6x10)	548	LF	$35	$19,155	OTHER	0	0	1	Allowance for 6-inch Injection well pipe runs for 1 new injection wells at 200 West allocated to B Complex
2	B-Complex	Injection pipelines (transfer building to injection wells)	1001 SOW Crew	0	Team/hr	$276	$0	OTHER	0	0	1	taken care of in extraction well
2	B-Complex	Injection pipelines (transfer building to injection wells)	17 Freight for HDPE Pipe	1	trip	$2,500	$2,500	OTHER	0	0	1	Injection & extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
2	B-Complex	Injection well equipment	289 Landing Plate	1	EA	$350	$350	OTHER	0	0	1	carbon steel landing plate
2	B-Complex	Injection well equipment	271 Riser Pipe	300	LF	$50	$14,862	OTHER	0	0	1	stainless steel riser pipes
2	B-Complex	Injection Well Racks	283 Injection Rack	1	EA	$17,000	$17,000	HISTORICAL	0	0	1	
2	B-Complex	Injection Well Racks	285 Pump Setting Crew	10	Team/Hr	$262	$2,617	OTHER	0	0	1	1 10 hr day (to set the rack) per well
2	B-Complex	Injection Wells	11 Drilling & Construction (per foot)	300.00	LF	$546	$163,800	OTHER	0	0	1	3 injection wells (50 gpm each), 1 for B Complex flow
2	B-Complex	Injection Wells	10 Drilling Mobilization, completion, cleanup and demob	2.00	per well	$36,250	$72,500	OTHER	0	0	1	3 injection wells (50 gpm each), 1 for B Complex flow
2	B-Complex	Pipeline Road Crossings	270 Road Crossings	3	Sleeve	$15,000	$45,000	OTHER	0	0	1	Note: assume road crossings from B-complex for wells 268 and 360 are included and no cost. Additional sleeves to cross 12th street are required for B-complex to gain access to the GAP.
2	B-Complex	Power & Fiber Optic Cable (transfer building to extraction wells)	260 Fiber-optic cable and interfaces	6299	FT	$1	$8,378	OTHER	0	0	1	Fiber optic cable for extraction well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	10.00	EA	$1,800	$18,000	OTHER	0	0	1	1 new Extraction wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	13	Team/Hr	$258	$3,219	OTHER	0	0	1	assume 10 samples x 1.25 hrs per sample (Extraction wells)
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	10	EA	$50	$500	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	10	EA	$50	$500	OTHER	0	0	1	1 new Extraction well - 10 samples per well

CAPITAL MARKUPS

MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	5%	Remedial Design Percent	6%	Construction Management Percent	6%	SUBTOTAL	CHPRC G&A 19.26%	COST PER YEAR
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
$1,500	$16,500	$2,475	$1,650	**$20,625**	$1,774	**$22,399**	$3,360	$2,240	**$27,998**		$1,400		$1,680		$1,680	**$32,758**	$6,309	**$39,067**
$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	**$57,516**
$7,371	$81,079	$12,162	$8,108	**$101,349**	$8,716	**$110,065**	$16,510	$11,006	**$137,581**		$6,879		$8,255		$8,255	**$160,969**	$31,003	**$191,972**
$6,299	$69,291	$10,394	$6,929	**$86,614**	$7,449	**$94,063**	$14,109	$9,406	**$117,579**		$5,879		$7,055		$7,055	**$137,567**	$26,495	**$164,063**
$750	$8,250	$1,238	$825	**$10,313**	$887	**$11,199**	$1,680	$1,120	**$13,999**		$700		$840		$840	**$16,379**	$3,155	**$19,534**
$1,458	$16,038	$2,406	$1,604	**$20,048**	$1,724	**$21,772**	$3,266	$2,177	**$27,214**		$1,361		$1,633		$1,633	**$31,841**	$6,133	**$37,974**
$2,192	$24,113	$3,617	$2,411	**$30,142**	$2,592	**$32,734**	$4,910	$3,273	**$40,917**		$2,046		$2,455		$2,455	**$47,873**	$9,220	**$57,094**
$185	$2,033	$305	$203	**$2,541**	$219	**$2,760**	$414	$276	**$3,449**		$172		$207		$207	**$4,036**	$777	**$4,813**
$35	$385	$58	$39	**$481**	$41	**$523**	$78	$52	**$653**		$33		$39		$39	**$764**	$147	**$912**
$1,486	$16,348	$2,452	$1,635	**$20,435**	$1,757	**$22,193**	$3,329	$2,219	**$27,741**		$1,387		$1,664		$1,664	**$32,457**	$6,251	**$38,708**
$40	$440	$66	$44	**$550**	$47	**$597**	$90	$60	**$747**		$37		$45		$45	**$874**	$168	**$1,042**
$523	$5,758	$864	$576	**$7,198**	$619	**$7,817**	$1,173	$782	**$9,771**		$489		$586		$586	**$11,432**	$2,202	**$13,634**
$23	$251	$38	$25	**$314**	$27	**$340**	$51	$34	**$426**		$21		$26		$26	**$498**	$96	**$594**
$957	$10,532	$1,580	$1,053	**$13,165**	$1,132	**$14,298**	$2,145	$1,430	**$17,872**		$894		$1,072		$1,072	**$20,910**	$4,027	**$24,938**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$42	$465	$70	$47	**$582**	$50	**$632**	$95	$63	**$790**		$39		$47		$47	**$924**	$178	**$1,102**
$320	$3,520	$528	$352	**$4,400**	$378	**$4,778**	$717	$478	**$5,973**		$299		$358		$358	**$6,988**	$1,346	**$8,334**
$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	**$78,135**
$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	**$57,516**
$4,000	$44,000	$6,600	$4,400	**$55,000**	$4,730	**$59,730**	$8,960	$5,973	**$74,663**		$3,733		$4,480		$4,480	**$87,355**	$16,825	**$104,180**
$16,380	$180,180	$27,027	$18,018	**$225,225**	$19,369	**$244,594**	$36,689	$24,459	**$305,743**		$15,287		$18,345		$18,345	**$357,719**	$68,897	**$426,616**
$7,250	$79,750	$11,963	$7,975	**$99,688**	$8,573	**$108,261**	$16,239	$10,826	**$135,326**		$6,766		$8,120		$8,120	**$158,331**	$30,495	**$188,826**
$655	$7,200	$1,080	$720	**$9,000**	$774	**$9,774**	$1,466	$977	**$12,217**		$611		$733		$733	**$14,294**	$2,753	**$17,047**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	**$78,135**
$641	$7,052	$1,058	$705	**$8,815**	$758	**$9,573**	$1,436	$957	**$11,967**		$598		$718		$718	**$14,001**	$2,697	**$16,698**
$1,915	$21,070	$3,161	$2,107	**$26,338**	$2,265	**$28,603**	$4,290	$2,860	**$35,753**		$1,788		$2,145		$2,145	**$41,831**	$8,057	**$49,888**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$250	$2,750	$413	$275	**$3,438**	$296	**$3,733**	$560	$373	**$4,666**		$233		$280		$280	**$5,460**	$1,052	**$6,511**
$35	$385	$58	$39	**$481**	$41	**$523**	$78	$52	**$653**		$33		$39		$39	**$764**	$147	**$912**
$1,486	$16,348	$2,452	$1,635	**$20,435**	$1,757	**$22,193**	$3,329	$2,219	**$27,741**		$1,387		$1,664		$1,664	**$32,457**	$6,251	**$38,708**
$1,700	$18,700	$2,805	$1,870	**$23,375**	$2,010	**$25,385**	$3,808	$2,539	**$31,732**		$1,587		$1,904		$1,904	**$37,126**	$7,150	**$44,276**
$262	$2,879	$432	$288	**$3,599**	$310	**$3,908**	$586	$391	**$4,885**		$244		$293		$293	**$5,716**	$1,101	**$6,817**
$16,380	$180,180	$27,027	$18,018	**$225,225**	$19,369	**$244,594**	$36,689	$24,459	**$305,743**		$15,287		$18,345		$18,345	**$357,719**	$68,897	**$426,616**
$7,250	$79,750	$11,963	$7,975	**$99,688**	$8,573	**$108,261**	$16,239	$10,826	**$135,326**		$6,766		$8,120		$8,120	**$158,331**	$30,495	**$188,826**
$4,500	$49,500	$7,425	$4,950	**$61,875**	$5,321	**$67,196**	$10,079	$6,720	**$83,995**		$4,200		$5,040		$5,040	**$98,275**	$18,928	**$117,202**
$838	$9,216	$1,382	$922	**$11,520**	$991	**$12,510**	$1,877	$1,251	**$15,638**		$782		$938		$938	**$18,296**	$3,524	**$21,820**
$1,800	$19,800	$2,970	$1,980	**$24,750**	$2,129	**$26,879**	$4,032	$2,688	**$33,598**		$1,680		$2,016		$2,016	**$39,310**	$7,571	**$46,881**
$322	$3,541	$531	$354	**$4,426**	$381	**$4,807**	$721	$481	**$6,008**		$300		$360		$360	**$7,030**	$1,354	**$8,384**
$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	**$1,302**
$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	**$2,474**
$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	**$2,474**
$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	**$1,302**

CAPITAL COSTS

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
							$0					
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Water Level Monitoring Subsystem	288 Water Level Monitoring System	4	EA	$15,670	$62,680	OTHER	0	0	1	Water level monitoring system 4 per extraction or injection well (1 new ex well)
2	B-Complex	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10.00	Team Hr	$581	$5,809	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (extraction)
2	B-Complex	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	Injection wells, 10 hours per well
							$0					
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	mob demob for pipe laying crew
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	06 Training	0.50	LS	$30,000	$15,000	OTHER	0	0	1	training cost allocated betweeen the B-Complex (50%) and WMA-C (50%)
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	248	team hr	$585	$145,113	OTHER	0	0	1	extraction well pipe runs, 50 ft/hr
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	16 HDPE Dual Containment (6x10)	12402	LF	$35	$433,559	OTHER	0	0	1	extraction well pipe runs
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1001 SOW Crew	80	Team/hr	$276	$22,084	OTHER	0	0	1	assume 80 hours to write SOW
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	17 Freight for HDPE Pipe	5	trip	$2,500	$12,500	OTHER	0	0	1	extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
3	WMA-C	Extraction well pump & equipment	289 Landing Plate	3	EA	$350	$1,050	OTHER	0	0	1	carbon steel landing plate
3	WMA-C	Extraction well pump & equipment	271 Riser Pipe	900	LF	$50	$44,586	OTHER	0	0	1	stainless steel riser pipes
3	WMA-C	Extraction well pump & equipment	287 Subcontract power pole & power distribution	2000	LF	$7	$14,580	OTHER	0	0	1	power cable laying and power pole construction
3	WMA-C	Extraction well pump & equipment	275 Pump Assembly	3.00	EA	$3,200	$9,600	OTHER	0	0	1	1 pump for the extraction well * 2 wells
3	WMA-C	Extraction well pump & equipment	279 Disconnect Boxes	3	EA	$400	$1,200	OTHER	0	0	1	1 disconnect box for extraction well
3	WMA-C	Extraction well pump & equipment	280 Allowance for Electrical Hookups	3	EA	$228	$684	OTHER	0	0	1	electrical hookup for extraction well
3	WMA-C	Extraction well pump & equipment	266 #10/4C THHN (tray cable)	16831	LF	$2	$25,583	OTHER	0	0	1	tray cable for extraction well
3	WMA-C	Extraction well pump & equipment	278 Transformer	3	EA	$0	$0	OTHER	0	0	1	3 transformers for extraction well
3	WMA-C	Extraction well pump & equipment	259 Transformers pole brackets	3	EA	$423	$1,269	OTHER	0	0	1	1 pole bracket for extraction well
3	WMA-C	Extraction well pump & equipment	286 Power Pole Allowance	3	EA	$1,848	$5,544	OTHER	0	0	1	power pole for extraction well
3	WMA-C	Extraction well pump & equipment	273 Tray Cable #10 4C THHN	16831	LF	$3	$58,571	OTHER	0	0	1	tray cable for extraction well
3	WMA-C	Extraction well pump & equipment	285 Pump Setting Crew	60	Team/Hr	$262	$15,704	OTHER	0	0	1	2 10 hr days * 3wells
3	WMA-C	Extraction Well Racks	284 Extraction rack	3	EA	$40,000	$120,000	HISTORICAL	0	0	1	Extraction well rack
3	WMA-C	Extraction Wells	11 Drilling & Construction (per foot)	900.00	LF	$546	$491,400	OTHER	0	0	1	3 extraction wells to 300 ft each
3	WMA-C	Extraction Wells	10 Drilling Mobilization, completion, cleanup and demob	6.00	per well	$36,250	$217,500	OTHER	0	0	1	mob demob for extraction well drilling
3	WMA-C	Fiber Optic Cable (transfer building to injection wells)	260 Fiber-optic cable and interfaces	8750	FT	$1	$11,638	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	06 Training	1	LS	$30,000	$30,000	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	1050 Pipe Fusion Crew (includes testing)	22	team hr	$585	$12,784	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	16 HDPE Dual Containment (6x10)	1093	LF	$35	$38,194	OTHER	0	0	1	Allowance for 2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	17 Freight for HDPE Pipe	1	trip	$2,500	$2,500	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection well equipment	289 Landing Plate	2	EA	$350	$700	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection well equipment	271 Riser Pipe	600	LF	$50	$29,724	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Well Racks	283 Injection Rack	2	EA	$17,000	$34,000	HISTORICAL	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Well Racks	285 Pump Setting Crew	20	Team/Hr	$262	$5,235	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Wells	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Wells	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Pipeline Road Crossings	270 Road Crossings	9	Sleeve	$15,000	$135,000	OTHER	0	0	1	sleeves are required to cross Baltimore to gain access to WMA-C.
3	WMA-C	Power & Fiber Optic Cable (transfer building to extraction wells)	260 Fiber-optic cable and interfaces	16831	FT	$1	$22,385	OTHER	0	0	1	fiber optic cable for extraction well
3	WMA-C	Transfer Bldg - CAT/ATP	303 Outdoor Transfer StationCAT/ATP	1.00	0	$25,000	$25,000	OTHER	0	0	1	transfer building for injection at 200W P&T and 1 new transfer building at WMA C.
3	WMA-C	Transfer Building Structure	302 Outdoor Transfer Station	1.00	LS	$500,000	$500,000	OTHER	0	0	1	transfer building for injection at 200W P&T and 1 new transfer building at WMA C.
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	30.00	EA	$1,800	$54,000	OTHER	0	0	1	10 samples per well for 3 new extraction wells. Driller charge per sample for sample collection
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	38	Team/Hr	$258	$9,657	OTHER	0	0	1	1.25 hrs per sample (extraction wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	30	EA	$50	$1,500	OTHER	0	0	1	assume 10 samples x 3 wells (extraction wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	30	EA	$95	$2,850	OTHER	0	0	1	assume 10 samples x 3 wells (extraction wells)
3	WMA-C	Water Level Monitoring Subsystem	288 Water Level Monitoring System	12	EA	$15,670	$188,040	OTHER	0	0	1	per extraction or injection well (3 ex wells)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	pipe laying

CAPITAL MARKUPS

SITE	MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	Project Management 5%	Remedial Design Percent	Remedial Design 6%	Construction Management Percent	Construction Management 6%	SUBTOTAL	CHPRC G&A 19.26%	COST PER YEAR
	$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
	$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	**$2,474**
	$6,268	$68,948	$10,342	$6,895	**$86,185**	$7,412	**$93,597**	$14,040	$9,360	**$116,996**		$5,850		$7,020		$7,020	**$136,885**	$26,364	**$163,250**
	$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	**$15,130**
	$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	**$15,130**
	$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
	$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
	$1,500	$16,500	$2,475	$1,650	**$20,625**	$1,774	**$22,399**	$3,360	$2,240	**$27,998**		$1,400		$1,680		$1,680	**$32,758**	$6,309	**$39,067**
	$14,511	$159,624	$23,944	$15,962	**$199,530**	$17,160	**$216,690**	$32,503	$21,669	**$270,862**		$13,543		$16,252		$16,252	**$316,909**	$61,037	**$377,945**
	$43,356	$476,915	$71,537	$47,691	**$596,144**	$51,268	**$647,412**	$97,112	$64,741	**$809,265**		$40,463		$48,556		$48,556	**$946,840**	$182,361	**$1,129,202**
	$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	**$57,516**
	$1,250	$13,750	$2,063	$1,375	**$17,188**	$1,478	**$18,666**	$2,800	$1,867	**$23,332**		$1,167		$1,400		$1,400	**$27,298**	$5,258	**$32,556**
$162,667	$105	$1,155	$173	$116	**$1,444**	$124	**$1,568**	$235	$157	**$1,960**		$98		$118		$118	**$2,293**	$442	**$2,735**
	$4,459	$49,045	$7,357	$4,904	**$61,306**	$5,272	**$66,578**	$9,987	$6,658	**$83,223**		$4,161		$4,993		$4,993	**$97,370**	$18,754	**$116,124**
	$1,458	$16,038	$2,406	$1,604	**$20,048**	$1,724	**$21,772**	$3,266	$2,177	**$27,214**		$1,361		$1,633		$1,633	**$31,841**	$6,133	**$37,974**
	$960	$10,560	$1,584	$1,056	**$13,200**	$1,135	**$14,335**	$2,150	$1,434	**$17,919**		$896		$1,075		$1,075	**$20,965**	$4,038	**$25,003**
	$120	$1,320	$198	$132	**$1,650**	$142	**$1,792**	$269	$179	**$2,240**		$112		$134		$134	**$2,621**	$505	**$3,125**
	$68	$752	$113	$75	**$941**	$81	**$1,021**	$153	$102	**$1,277**		$64		$77		$77	**$1,494**	$288	**$1,781**
	$2,558	$28,141	$4,221	$2,814	**$35,176**	$3,025	**$38,201**	$5,730	$3,820	**$47,752**		$2,388		$2,865		$2,865	**$55,869**	$10,760	**$66,630**
	$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
	$127	$1,396	$209	$140	**$1,745**	$150	**$1,895**	$284	$189	**$2,369**		$118		$142		$142	**$2,771**	$534	**$3,305**
	$554	$6,098	$915	$610	**$7,623**	$656	**$8,279**	$1,242	$828	**$10,348**		$517		$621		$621	**$12,107**	$2,332	**$14,439**
	$5,857	$64,428	$9,664	$6,443	**$80,535**	$6,926	**$87,461**	$13,119	$8,746	**$109,326**		$5,466		$6,560		$6,560	**$127,912**	$24,636	**$152,547**
	$1,570	$17,275	$2,591	$1,727	**$21,593**	$1,857	**$23,450**	$3,518	$2,345	**$29,313**		$1,466		$1,759		$1,759	**$34,296**	$6,605	**$40,901**
	$12,000	$132,000	$19,800	$13,200	**$165,000**	$14,190	**$179,190**	$26,879	$17,919	**$223,988**		$11,199		$13,439		$13,439	**$262,065**	$50,474	**$312,539**
	$49,140	$540,540	$81,081	$54,054	**$675,675**	$58,108	**$733,783**	$110,067	$73,378	**$917,229**		$45,861		$55,034		$55,034	**$1,073,158**	$206,690	**$1,279,848**
	$21,750	$239,250	$35,888	$23,925	**$299,063**	$25,719	**$324,782**	$48,717	$32,478	**$405,977**		$20,299		$24,359		$24,359	**$474,993**	$91,484	**$566,477**
	$1,164	$12,801	$1,920	$1,280	**$16,002**	$1,376	**$17,378**	$2,607	$1,738	**$21,722**		$1,086		$1,303		$1,303	**$25,415**	$4,895	**$30,310**
	$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
	$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	**$78,135**
	$1,278	$14,062	$2,109	$1,406	**$17,578**	$1,512	**$19,089**	$2,863	$1,909	**$23,862**		$1,193		$1,432		$1,432	**$27,918**	$5,377	**$33,295**
	$3,819	$42,014	$6,302	$4,201	**$52,517**	$4,516	**$57,034**	$8,555	$5,703	**$71,292**		$3,565		$4,278		$4,278	**$83,412**	$16,065	**$99,477**
	$250	$2,750	$413	$275	**$3,438**	$296	**$3,733**	$560	$373	**$4,666**		$233		$280		$280	**$5,460**	$1,052	**$6,511**
	$70	$770	$116	$77	**$963**	$83	**$1,045**	$157	$105	**$1,307**		$65		$78		$78	**$1,529**	$294	**$1,823**
	$2,972	$32,696	$4,904	$3,270	**$40,871**	$3,515	**$44,385**	$6,658	$4,439	**$55,482**		$2,774		$3,329		$3,329	**$64,914**	$12,502	**$77,416**
	$3,400	$37,400	$5,610	$3,740	**$46,750**	$4,021	**$50,771**	$7,616	$5,077	**$63,463**		$3,173		$3,808		$3,808	**$74,252**	$14,301	**$88,553**
	$523	$5,758	$864	$576	**$7,198**	$619	**$7,817**	$1,173	$782	**$9,771**		$489		$586		$586	**$11,432**	$2,202	**$13,634**
	$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	**$853,232**
	$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	**$377,651**
	$13,500	$148,500	$22,275	$14,850	**$185,625**	$15,964	**$201,589**	$30,238	$20,159	**$251,986**		$12,599		$15,119		$15,119	**$294,824**	$56,783	**$351,607**
	$2,238	$24,623	$3,693	$2,462	**$30,779**	$2,647	**$33,426**	$5,014	$3,343	**$41,783**		$2,089		$2,507		$2,507	**$48,886**	$9,415	**$58,301**
	$2,500	$27,500	$4,125	$2,750	**$34,375**	$2,956	**$37,331**	$5,600	$3,733	**$46,664**		$2,333		$2,800		$2,800	**$54,597**	$10,515	**$65,112**
	$50,000	$550,000	$82,500	$55,000	**$687,500**	$59,125	**$746,625**	$111,994	$74,663	**$933,281**		$46,664		$55,997		$55,997	**$1,091,939**	$210,307	**$1,302,247**
	$5,400	$59,400	$8,910	$5,940	**$74,250**	$6,386	**$80,636**	$12,095	$8,064	**$100,794**		$5,040		$6,048		$6,048	**$117,929**	$22,713	**$140,643**
	$966	$10,622	$1,593	$1,062	**$13,278**	$1,142	**$14,420**	$2,163	$1,442	**$18,025**		$901		$1,081		$1,081	**$21,089**	$4,062	**$25,151**
	$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
	$285	$3,135	$470	$314	**$3,919**	$337	**$4,256**	$638	$426	**$5,320**		$266		$319		$319	**$6,224**	$1,199	**$7,423**
	$18,804	$206,844	$31,027	$20,684	**$258,555**	$22,236	**$280,791**	$42,119	$28,079	**$350,988**		$17,549		$21,059		$21,059	**$410,656**	$79,092	**$489,749**
	$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	**$30,260**

CAPITAL COSTS

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
							$0					
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	extraction wells (1)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	Injection wells (2)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (extraction)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (injection)
3	WMA-C	Pump & Treat Modifications	296 Technetium-99 Treatment Train	1.00	LS	$719,000	$719,000	OTHER	0	0	1	TC99 treatment train
3	WMA-C	Pump & Treat Modifications	305 New Air Stripper	1.00	LS	$3,800,000	$3,800,000	OTHER	0	0	1	
2	B-Complex	Pump & Treat Modifications	298 SC Labor for installation	0.00	LS	$2,500,000	$0	OTHER	0	0	1	
2	B-Complex	Pump & Treat Modifications	299 Construction management and design	0.00	LS	$600,000	$0	OTHER	0	0	1	
2	B-Complex	well drilling	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new monitoring wells to 300 ft each
2	B-Complex	well drilling	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new monitoring wells to 300 ft each
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	20.00	EA	$1,800	$36,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	25	Team/Hr	$258	$6,438	OTHER	0	0	1	1.25 hrs per sample (monitoring wells)
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	well drilling	285 Pump Setting Crew	40	Team/Hr	$262	$10,469	OTHER	0	0	1	20 hours per well
2	B-Complex	well drilling	275 Pump Assembly	2	EA	$3,200	$6,400	OTHER	0	0	1	1 pump assembly per well
							$0					
3	WMA-C	well drilling	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new monitoring wells to 300 ft each
3	WMA-C	well drilling	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new monitoring wells to 300 ft each
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	20.00	EA	$1,800	$36,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	25	Team/Hr	$258	$6,438	OTHER	0	0	1	1.25 hrs per sample (monitoring wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	well drilling	285 Pump Setting Crew	40	Team/Hr	$262	$10,469	OTHER	0	0	1	20 hours per well
3	WMA-C	well drilling	275 Pump Assembly	2	EA	$3,200	$6,400	OTHER	0	0	1	1 pump assembly per well
							$0					
3	WMA-C	Pipelines (Extraction wells to transfe	29 3-inch diameter HDPE	4429	LF	$10	$44,291	OTHER	0	0	1	extraction wells
3	WMA-C	Pipelines (Extraction wells to transfe	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	
3	WMA-C	Pipelines (Extraction wells to transfe	1050 Pipe Fusion Crew (includes testing)	89	team hr	$585	$51,826	OTHER	0	0	1	50 ft/hr
							$0					
3	WMA-C	Pump & Treat Transfer Building	300 10000 Gallon Norwesco Plastic Potable Water Storage Tank	1	LS	$6,000	$6,000	OTHER	0	0	1	for extraction
							$0					
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	8750	LF	$10	$87,500	OTHER	0	0	1	Allowance for 200W Injection wells
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	175	team hr	$585	$102,385	OTHER	0	0	1	Allowance for 200W Injection wells
							$0					
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	4373	LF	$10	$43,734	OTHER	0	0	1	Allowance for 200W Injection wells
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	87	team hr	$585	$51,173	OTHER	0	0	1	Allowance for 200W Injection wells
							$0					
3	WMA-C	Pump & Treat Modifications	307 Modutank Modifications	1	LS	$250,000	$250,000	OTHER	0	0	1	
							$0					

CAPITAL MARKUPS

MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	5%	Remedial Design Percent	6%	Construction Management Percent	6%	SUBTOTAL	CHPRC G&A 19.26%	COST PER YEAR
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	**$15,130**
$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	**$30,260**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	**$15,130**
$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	**$30,260**
$71,900	$790,900	$118,635	$79,090	**$988,625**	$85,022	**$1,073,647**	$161,047	$107,365	**$1,342,058**		$67,103		$80,524		$80,524	**$1,570,208**	$302,422	**$1,872,631**
$0	$3,800,000	$0	$0	**$3,800,000**	$0	**$3,800,000**	$570,000	$380,000	**$4,750,000**		$237,500		$285,000		$285,000	**$5,557,500**	$1,070,375	**$6,627,875**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	**$853,232**
$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	**$377,651**
$3,600	$39,600	$5,940	$3,960	**$49,500**	$4,257	**$53,757**	$8,064	$5,376	**$67,196**		$3,360		$4,032		$4,032	**$78,620**	$15,142	**$93,762**
$644	$7,082	$1,062	$708	**$8,852**	$761	**$9,613**	$1,442	$961	**$12,017**		$601		$721		$721	**$14,059**	$2,708	**$16,767**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$1,047	$11,516	$1,727	$1,152	**$14,395**	$1,238	**$15,633**	$2,345	$1,563	**$19,542**		$977		$1,173		$1,173	**$22,864**	$4,404	**$27,268**
$640	$7,040	$1,056	$704	**$8,800**	$757	**$9,557**	$1,434	$956	**$11,946**		$597		$717		$717	**$13,977**	$2,692	**$16,669**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	**$853,232**
$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	**$377,651**
$3,600	$39,600	$5,940	$3,960	**$49,500**	$4,257	**$53,757**	$8,064	$5,376	**$67,196**		$3,360		$4,032		$4,032	**$78,620**	$15,142	**$93,762**
$644	$7,082	$1,062	$708	**$8,852**	$761	**$9,613**	$1,442	$961	**$12,017**		$601		$721		$721	**$14,059**	$2,708	**$16,767**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	**$4,949**
$1,047	$11,516	$1,727	$1,152	**$14,395**	$1,238	**$15,633**	$2,345	$1,563	**$19,542**		$977		$1,173		$1,173	**$22,864**	$4,404	**$27,268**
$640	$7,040	$1,056	$704	**$8,800**	$757	**$9,557**	$1,434	$956	**$11,946**		$597		$717		$717	**$13,977**	$2,692	**$16,669**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$4,429	$48,720	$7,308	$4,872	**$60,901**	$5,237	**$66,138**	$9,921	$6,614	**$82,673**		$4,134		$4,960		$4,960	**$96,727**	$18,630	**$115,356**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	**$3,907**
$5,183	$57,009	$8,551	$5,701	**$71,261**	$6,128	**$77,389**	$11,608	$7,739	**$96,736**		$4,837		$5,804		$5,804	**$113,182**	$21,799	**$134,980**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$600	$6,600	$990	$660	**$8,250**	$710	**$8,960**	$1,344	$896	**$11,199**		$560		$672		$672	**$13,103**	$2,524	**$15,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$8,750	$96,250	$14,438	$9,625	**$120,313**	$10,347	**$130,659**	$19,599	$13,066	**$163,324**		$8,166		$9,799		$9,799	**$191,089**	$36,804	**$227,893**
$10,239	$112,624	$16,894	$11,262	**$140,780**	$12,107	**$152,887**	$22,933	$15,289	**$191,108**		$9,555		$11,466		$11,466	**$223,597**	$43,065	**$266,661**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$4,373	$48,107	$7,216	$4,811	**$60,134**	$5,171	**$65,305**	$9,796	$6,531	**$81,631**		$4,082		$4,898		$4,898	**$95,509**	$18,395	**$113,904**
$5,117	$56,291	$8,444	$5,629	**$70,363**	$6,051	**$76,415**	$11,462	$7,641	**$95,518**		$4,776		$5,731		$5,731	**$111,756**	$21,524	**$133,281**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**
$25,000	$275,000	$41,250	$27,500	**$343,750**	$29,563	**$373,313**	$55,997	$37,331	**$466,641**		$23,332		$27,998		$27,998	**$545,970**	$105,154	**$651,123**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	**$0**

ANNUAL O&M COST

SITE	SITE NAME	WBS Top Tier	WBS DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
2	B-Complex	2WP&T Treatment O&M	372 P&T effluent 2WP&T	105120000	$/gal	$0.0231	$2,423,981	OTHER	1	25	1	Based on 2016 P&T annual report
2	B-Complex	Annual Performance Monitoring Report	902 Remedy Performance Monitoring & Reporting	0.67	EA	$36,634	$24,423	OTHER	1	25	1	1 report each year as a review, based on 360 hrs of geologist. 2/3 cost to B complex, 1/3 cost to WMA C
2	B-Complex	Annual Performance Monitoring Report	1004 Report Writing/Publishing	64	Team/hr	$382	$24,427	OTHER	1	27	1	Assume 1 month level of effort divided between the 7 COPCs for progress review
2	B-Complex	P&T Remedy Performance GW Monitoring	903 Data Reduction and Reporting	40.0	Team/hr	$333	$13,338	OTHER	1	25	1	assume 2 weeks required for drafting and approval of reports
3	WMA-C	2WP&T Treatment O&M	372 P&T effluent 2WP&T	52560000	$/gal	$0.0231	$1,211,991	OTHER	1	10	1	Based on 2016 P&T annual report
3	WMA-C	Annual Performance Monitoring Report	902 Remedy Performance Monitoring & Reporting	0.33	EA	$36,634	$12,210	OTHER	1	25	1	1 report each year as a review, based on 360 hrs of geologist. 2/3 cost to B complex, 1/3 cost to WMA C
3	WMA-C	Annual Performance Monitoring Report	1004 Report Writing/Publishing	64.00	Team/hr	$382	$24,427	OTHER	1	25	1	Assume 1 month level of effort divided between the 7 COCs for progress review
							$0				1	
2	B-Complex	Groundwater Monitoring	02 Sampling Crew	40.00	team/hr	$258	$10,301	OTHER	1	1	1	2 wells, quarterly sampling, 1 day sampling per event
2	B-Complex	Groundwater Monitoring	05 NO2/NO3	8.00	EA	$29	$229	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	03 Total Uranium	8	EA	$97	$773	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	04 Technetium-99	8	EA	$86	$688	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	8.00	EA	$98	$781	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	06 Total Cyanide	8	EA	$33	$267	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	09 Iodine-129	8	EA	$96	$768	OTHER	1	1	1	2 samples per well, 4 sampling events
							$0				1	
2	B-Complex	Groundwater Monitoring	02 Sampling Crew	20.00	team/hr	$258	$5,150	OTHER	2	27	1	2 wells, semi-annual sampling, years 2 to 27 (year 2 to 25 P&T monitoring), years 26 and 27 post P&T
2	B-Complex	Groundwater Monitoring	05 NO2/NO3	4	EA	$29	$115	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	03 Total Uranium	4.00	EA	$97	$387	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	04 Technetium-99	4	EA	$86	$344	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	4	EA	$98	$391	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	06 Total Cyanide	4	EA	$33	$133	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	09 Iodine-129	4	EA	$96	$384	OTHER	2	27	1	
							$0				1	
3	WMA-C	Groundwater Monitoring	02 Sampling Crew	40.00	team/hr	$258	$10,301	OTHER	1	1	1	2 wells, quarterly sampling, 1 day sampling per event
3	WMA-C	Groundwater Monitoring	05 NO2/NO3	8.00	EA	$29	$229	OTHER	1	1	1	2 samples per well, 4 sampling events
3	WMA-C	Groundwater Monitoring	04 Technetium-99	8	EA	$86	$688	OTHER	1	1	1	2 samples per well, 4 sampling events
							$0				1	
3	WMA-C	Groundwater Monitoring	02 Sampling Crew	20.00	team/hr	$258	$5,150	OTHER	2	27	1	2 wells, semi-annual sampling, years 2 to 27 (year 2 to 25 P&T monitoring), years 26 and 27 post P&T
3	WMA-C	Groundwater Monitoring	05 NO2/NO3	4.00	EA	$29	$115	OTHER	2	27	1	
3	WMA-C	Groundwater Monitoring	04 Technetium-99	4	EA	$86	$344	OTHER	2	27	1	
							$0				1	

ANNUAL O&M MARKUPS

MDBI 0%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Technical Support Services Percent	Technical Support Services Subtotal	SUBTOTAL	CHPRC G&A 19.26%	COST PER YEAR
$0	$2,423,981	$363,597	$242,398	**$3,029,977**	$260,578	**$3,290,555**	$493,583	$329,055	**$4,113,193**	19%	$781,507	**$4,894,700**	$942,719	**$5,837,419**
$0	$24,423	$3,663	$2,442	**$30,528**	$2,625	**$33,154**	$4,973	$3,315	**$41,442**	45%	$18,649	**$60,092**	$11,574	**$71,665**
$0	$24,427	$3,664	$2,443	**$30,533**	$0	**$30,533**	$4,580	$3,053	**$38,167**	45%	$17,175	**$55,341**	$10,659	**$66,000**
$0	$13,338	$2,001	$1,334	**$16,672**	$1,434	**$18,106**	$2,716	$1,811	**$22,633**	45%	$10,185	**$32,817**	$6,321	**$39,138**
$0	$1,211,991	$181,799	$121,199	**$1,514,988**	$130,289	**$1,645,277**	$246,792	$164,528	**$2,056,597**	19%	$390,753	**$2,447,350**	$471,360	**$2,918,710**
$0	$12,210	$1,832	$1,221	**$15,263**	$1,313	**$16,575**	$2,486	$1,658	**$20,719**	45%	$9,324	**$30,043**	$5,786	**$35,829**
$0	$24,427	$3,664	$2,443	**$30,533**	$0	**$30,533**	$4,580	$3,053	**$38,167**	45%	$17,175	**$55,341**	$10,659	**$66,000**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$10,301	$1,545	$1,030	**$12,876**	$1,107	**$13,983**	$2,097	$1,398	**$17,479**	45%	$7,865	**$25,344**	$4,881	**$30,225**
$0	$229	$34	$23	**$287**	$25	**$311**	$47	$31	**$389**	45%	$175	**$564**	$109	**$673**
$0	$773	$116	$77	**$967**	$83	**$1,050**	$157	$105	**$1,312**	45%	$591	**$1,903**	$366	**$2,269**
$0	$688	$103	$69	**$860**	$74	**$934**	$140	$93	**$1,167**	45%	$525	**$1,693**	$326	**$2,019**
$0	$781	$117	$78	**$977**	$84	**$1,061**	$159	$106	**$1,326**	45%	$597	**$1,922**	$370	**$2,293**
$0	$267	$40	$27	**$333**	$29	**$362**	$54	$36	**$453**	45%	$204	**$656**	$126	**$782**
$0	$768	$115	$77	**$960**	$83	**$1,043**	$156	$104	**$1,303**	45%	$586	**$1,890**	$364	**$2,254**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$5,150	$773	$515	**$6,438**	$554	**$6,991**	$1,049	$699	**$8,739**	45%	$3,933	**$12,672**	$2,441	**$15,113**
$0	$115	$17	$11	**$143**	$12	**$156**	$23	$16	**$195**	45%	$88	**$282**	$54	**$336**
$0	$387	$58	$39	**$483**	$42	**$525**	$79	$52	**$656**	45%	$295	**$951**	$183	**$1,135**
$0	$344	$52	$34	**$430**	$37	**$467**	$70	$47	**$584**	45%	$263	**$846**	$163	**$1,009**
$0	$391	$59	$39	**$488**	$42	**$530**	$80	$53	**$663**	45%	$298	**$961**	$185	**$1,146**
$0	$133	$20	$13	**$167**	$14	**$181**	$27	$18	**$226**	45%	$102	**$328**	$63	**$391**
$0	$384	$58	$38	**$480**	$41	**$521**	$78	$52	**$652**	45%	$293	**$945**	$182	**$1,127**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$10,301	$1,545	$1,030	**$12,876**	$1,107	**$13,983**	$2,097	$1,398	**$17,479**	45%	$7,865	**$25,344**	$4,881	**$30,225**
$0	$229	$34	$23	**$287**	$25	**$311**	$47	$31	**$389**	45%	$175	**$564**	$109	**$673**
$0	$688	$103	$69	**$860**	$74	**$934**	$140	$93	**$1,167**	45%	$525	**$1,693**	$326	**$2,019**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$5,150	$773	$515	**$6,438**	$554	**$6,991**	$1,049	$699	**$8,739**	45%	$3,933	**$12,672**	$2,441	**$15,113**
$0	$115	$17	$11	**$143**	$12	**$156**	$23	$16	**$195**	45%	$88	**$282**	$54	**$336**
$0	$344	$52	$34	**$430**	$37	**$467**	$70	$47	**$584**	45%	$263	**$846**	$163	**$1,009**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**

PERIODIC O&M COST

SITE	SITE NAME	WBS Top Tier	WBS DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
							$0					
2	B-Complex	5-Year Review Report (Site Specific)	1006 Fate & Transport Contract	0.67	LS	$60,000	$40,000	OTHER	5	25	5	every 5 years, additional effort for 5 year reviews
2	B-Complex	5-Year Review Report (Site Specific)	1005 5th Year Summary Report	20.00	Team/hr	$480	$9,603	OTHER	5	25	5	every 5 years a report with fate and transport revisions
2	B-Complex	5-Year Review Report (Site Specific)	361 Update Fate & Transport Model	0.67	5/yr	$65,000	$43,333	OTHER	5	25	5	updating the fate and transport model, used cost similar to 100-F/IU and SSPA agreement
							$0					
3	WMA-C	5-Year Review Report (Site Specific)	1006 Fate & Transport Contract	0.33	LS	$60,000	$20,000	OTHER	5	25	5	every 5 years, additional effort for 5 year reviews
3	WMA-C	5-Year Review Report (Site Specific)	1005 5th Year Summary Report	20.00	Team/hr	$480	$9,603	OTHER	5	25	5	every 5 years a report with fate and transport revisions
3	WMA-C	5-Year Review Report (Site Specific)	361 Update Fate & Transport Model	0.33	5/yr	$65,000	$21,666	OTHER	5	25	5	updating the fate and transport model, used cost similar to 100-F/IU and SSPA agreement
							$0					
2	B-Complex	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	2	EA	$4,499	$8,998	OTHER	10	25	10	2 monitoring wells
2	B-Complex	well maintenance	351 Well Maintenance Crew	4	Team/Hr	$1,122	$4,488	OTHER	10	25	10	2 hours per well (2 monitoring wells)
2	B-Complex	well maintenance	351 Well Maintenance Crew	20.00	Team/Hr	$1,122	$22,438	OTHER	10	25	10	Monitoring well rehab (10 hours per well, 2 wells)
							$0					
2	B-Complex	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	3	EA	$4,499	$13,497	OTHER	5	25	5	3 extraction wells
2	B-Complex	well maintenance	351 Well Maintenance Crew	6	Team/Hr	$1,122	$6,731	OTHER	5	25	5	2 hours per well (3 extraction wells)
2	B-Complex	well maintenance	351 Well Maintenance Crew	30.00	Team/Hr	$1,122	$33,657	OTHER	5	25	5	Monitoring well rehab (10 hours per well, 3 wells)
							$0					
3	WMA-C	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	2	EA	$4,499	$8,998	OTHER	10	25	10	2 monitoring wells
3	WMA-C	well maintenance	351 Well Maintenance Crew	4	Team/Hr	$1,122	$4,488	OTHER	10	25	10	2 hours per well (2 monitoring wells)
3	WMA-C	well maintenance	351 Well Maintenance Crew	20.00	Team/Hr	$1,122	$22,438	OTHER	10	25	10	Monitoring well rehab (10 hours per well, 2 wells)
							$0					
3	WMA-C	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	3	EA	$4,499	$13,497	OTHER	5	10	5	3 extraction wells
3	WMA-C	well maintenance	351 Well Maintenance Crew	6	Team/Hr	$1,122	$6,731	OTHER	5	10	5	2 hours per well (3 extraction wells)
3	WMA-C	well maintenance	351 Well Maintenance Crew	30.00	Team/Hr	$1,122	$33,657	OTHER	5	10	5	Monitoring well rehab (10 hours per well, 3 wells)
							$0					
2	B-Complex	Replacement GW Monitoring Wells	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	4.00	EA	$4,499	$17,996	OTHER	15	25	15	new pump during injection well replacement for 200W wells (4 wells in 200W allocated to B Complex, 2 to WMA C). B complex allocation assumes 3 existing at 50 gpm for current 150 gpm removal action, and 1 new for the additional 50 gpm
2	B-Complex	Replacement GW Monitoring Wells	355 Drilling Mobilization, completion, cleanup and demob	8	per well	$36,250	$290,000	OTHER	15	25	15	4 new injection wells
2	B-Complex	Replacement GW Monitoring Wells	356 Drilling & Construction (per foot)	1200	LF	$546	$655,200	OTHER	15	25	15	4 new injection wells to 300 ft each
2	B-Complex	Replacement GW Monitoring Wells	365 In process GW samples	40	EA	$1,800	$72,000	0	15	25	15	10 samples per well during drilling
2	B-Complex	Replacement GW Monitoring Wells	367 Sampling Crew	80	Hr	$258	$20,601	OTHER	15	25	15	2 hours per sample
2	B-Complex	Replacement GW Monitoring Wells	369 Technetium-99	40	EA	$86	$3,440	OTHER	15	25	15	10 samples per well during drilling
2	B-Complex	Replacement GW Monitoring Wells	370 NO2/NO3	40	EA	$29	$1,160	OTHER	15	25	15	10 samples per well during drilling
							$0					
3	WMA-C	Replacement GW Monitoring Wells	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	0.00	EA	$4,499	$0	OTHER	15	25	15	new pump during injection well replacement for 200W wells (4 well allocated to B Complex, 2 to WMA C)
3	WMA-C	Replacement GW Monitoring Wells	355 Drilling Mobilization, completion, cleanup and demob	0	per well	$36,250	$0	OTHER	15	25	15	1 new injection wells
3	WMA-C	Replacement GW Monitoring Wells	356 Drilling & Construction (per foot)	0	LF	$546	$0	OTHER	15	25	15	1 new injection wells to 300 ft each
3	WMA-C	Replacement GW Monitoring Wells	365 In process GW samples	0	EA	$1,800	$0	0	15	25	15	10 samples per well during drilling
3	WMA-C	Replacement GW Monitoring Wells	367 Sampling Crew	0	Hr	$258	$0	OTHER	15	25	15	2 hours per sample
3	WMA-C	Replacement GW Monitoring Wells	369 Technetium-99	0	EA	$86	$0	OTHER	15	25	15	10 samples per well during drilling
3	WMA-C	Replacement GW Monitoring Wells	370 NO2/NO3	0	EA	$29	$0	OTHER	15	25	15	10 samples per well during drilling
							$0					
2	B-Complex	well maintenance	351 Well Maintenance Crew	10	Team/Hr	$1,122	$11,219	OTHER	2	10	2	injection well maintenance
							$0					
3	WMA-C	well maintenance	351 Well Maintenance Crew	10	Team/Hr	$1,122	$11,219	OTHER	2	10	2	injection well maintenance
							$0					

PERIODIC O&M MARKUPS

MDBI 0%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Contingency 15%	10%	SUBTOTAL	Technical Support Services Percent	Subtotal	SUBTOTAL	CHPRC G&A 19.26%	COST PER YEAR
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$40,000	$6,000	$4,000	**$50,000**	$0	**$50,000**	$7,500	$5,000	**$62,500**	45%	$28,125	**$90,625**	$17,454	**$108,080**
$0	$9,603	$1,440	$960	**$12,004**	$0	**$12,004**	$1,801	$1,200	**$15,005**	45%	$6,752	**$21,757**	$4,190	**$25,948**
$0	$43,333	$6,500	$4,333	**$54,167**	$4,658	**$58,825**	$8,824	$5,883	**$73,531**	45%	$33,089	**$106,620**	$20,535	**$127,155**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$20,000	$3,000	$2,000	**$25,000**	$0	**$25,000**	$3,750	$2,500	**$31,250**	45%	$14,062	**$45,312**	$8,727	**$54,039**
$0	$9,603	$1,440	$960	**$12,004**	$0	**$12,004**	$1,801	$1,200	**$15,005**	45%	$6,752	**$21,757**	$4,190	**$25,948**
$0	$21,666	$3,250	$2,167	**$27,083**	$2,329	**$29,412**	$4,412	$2,941	**$36,765**	45%	$16,544	**$53,310**	$10,267	**$63,577**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$8,998	$1,350	$900	**$11,248**	$967	**$12,215**	$1,832	$1,221	**$15,268**	45%	$6,871	**$22,139**	$4,264	**$26,403**
$0	$4,488	$673	$449	**$5,610**	$0	**$5,610**	$841	$561	**$7,012**	45%	$3,155	**$10,167**	$1,958	**$12,125**
$0	$22,438	$3,366	$2,244	**$28,048**	$0	**$28,048**	$4,207	$2,805	**$35,060**	45%	$15,777	**$50,836**	$9,791	**$60,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$13,497	$2,025	$1,350	**$16,871**	$1,451	**$18,322**	$2,748	$1,832	**$22,903**	45%	$10,306	**$33,209**	$6,396	**$39,605**
$0	$6,731	$1,010	$673	**$8,414**	$0	**$8,414**	$1,262	$841	**$10,518**	45%	$4,733	**$15,251**	$2,937	**$18,188**
$0	$33,657	$5,049	$3,366	**$42,071**	$0	**$42,071**	$6,311	$4,207	**$52,589**	45%	$23,665	**$76,254**	$14,687	**$90,941**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$8,998	$1,350	$900	**$11,248**	$967	**$12,215**	$1,832	$1,221	**$15,268**	45%	$6,871	**$22,139**	$4,264	**$26,403**
$0	$4,488	$673	$449	**$5,610**	$0	**$5,610**	$841	$561	**$7,012**	45%	$3,155	**$10,167**	$1,958	**$12,125**
$0	$22,438	$3,366	$2,244	**$28,048**	$0	**$28,048**	$4,207	$2,805	**$35,060**	45%	$15,777	**$50,836**	$9,791	**$60,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$13,497	$2,025	$1,350	**$16,871**	$1,451	**$18,322**	$2,748	$1,832	**$22,903**	45%	$10,306	**$33,209**	$6,396	**$39,605**
$0	$6,731	$1,010	$673	**$8,414**	$0	**$8,414**	$1,262	$841	**$10,518**	45%	$4,733	**$15,251**	$2,937	**$18,188**
$0	$33,657	$5,049	$3,366	**$42,071**	$0	**$42,071**	$6,311	$4,207	**$52,589**	45%	$23,665	**$76,254**	$14,687	**$90,941**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$17,996	$2,699	$1,800	**$22,495**	$1,935	**$24,430**	$3,664	$2,443	**$30,537**	45%	$13,742	**$44,279**	$8,528	**$52,807**
$0	$290,000	$43,500	$29,000	**$362,500**	$31,175	**$393,675**	$59,051	$39,368	**$492,094**	33%	$162,391	**$654,485**	$126,054	**$780,538**
$0	$655,200	$98,280	$65,520	**$819,000**	$70,434	**$889,434**	$133,415	$88,943	**$1,111,793**	26%	$289,066	**$1,400,859**	$269,805	**$1,670,664**
$0	$72,000	$10,800	$7,200	**$90,000**	$7,740	**$97,740**	$14,661	$9,774	**$122,175**	33%	$40,318	**$162,493**	$31,296	**$193,789**
$0	$20,601	$3,090	$2,060	**$25,751**	$2,215	**$27,966**	$4,195	$2,797	**$34,957**	45%	$15,731	**$50,688**	$9,763	**$60,451**
$0	$3,440	$516	$344	**$4,300**	$370	**$4,670**	$700	$467	**$5,837**	45%	$2,627	**$8,464**	$1,630	**$10,094**
$0	$1,160	$174	$116	**$1,450**	$125	**$1,575**	$236	$157	**$1,968**	45%	$886	**$2,854**	$550	**$3,404**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$11,219	$1,683	$1,122	**$14,024**	$0	**$14,024**	$2,104	$1,402	**$17,530**	45%	$7,888	**$25,418**	$4,896	**$30,314**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**
$0	$11,219	$1,683	$1,122	**$14,024**	$0	**$14,024**	$2,104	$1,402	**$17,530**	45%	$7,888	**$25,418**	$4,896	**$30,314**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	**$0**

Table C-2. Alternative 3 Cost Estimate Details

Alternative 03
Alternative 3 - 25 Years P&T at B Complex, and 10 Years P&T at WMA C and Gable Gap

Location:	OU	**Base Year:**	2018
Phase:	Interim Action	**Date:**	8/30/2018
Description:	25 Years P&T at B Complex, and 10 Years P&T at WMA C and Gable Gap		

CAPITAL COSTS

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
1	GAP	Cross-site Transfer Line	03 Cross Site Pipeline	1.00	LS	$2,600,000	$2,600,000	OTHER	0	0	1	Cross-site line for Injection
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	Extraction wells
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	06 Training	1.00	LS	$30,000	$30,000	OTHER	0	0	1	Training associated with GAP pipe fusion crew
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	311.02	team hr	$585	$181,967	OTHER	0	0	1	extraction well pipe runs
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	15551.18	LF	$10	$155,512	OTHER	0	0	1	extraction well pipe runs
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	1001 SOW Crew	80.00	Team/hr	$276	$22,084	OTHER	0	0	1	assume 80 hours to write SOW
1	GAP	Extraction Pipelines (Extraction wells to transfer station)	17 Freight for HDPE Pipe	6.00	trip	$2,500	$15,000	OTHER	0	0	1	extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
1	GAP	Extraction well pump & equipment	275 Pump Assembly	1.00	EA	$3,200	$3,200	OTHER	0	0	1	1 new ext well
1	GAP	Extraction well pump & equipment	266 #10/4C THHN (tray cable)	15551.18	LF	$2	$23,638	OTHER	0	0	1	Extr Tray Cable
1	GAP	Extraction well pump & equipment	278 Transformer	1.00	EA	$0	$0	OTHER	0	0	1	31 extr well transformers
1	GAP	Extraction well pump & equipment	259 Transformers pole brackets	1.00	EA	$423	$423	OTHER	0	0	1	1 extr well pole brackets for transformers
1	GAP	Extraction well pump & equipment	286 Power Pole Allowance	1.00	EA	$1,848	$1,848	OTHER	0	0	1	Allowance for 1 power pole for extr well
1	GAP	Extraction well pump & equipment	273 Tray Cable #10 4C THHN	15551.18	LF	$3	$54,118	OTHER	0	0	1	
1	GAP	Extraction well pump & equipment	285 Pump Setting Crew	10.00	Team/Hr	$262	$2,617	OTHER	0	0	1	10 hr per well (1 new extraction well
1	GAP	Extraction well pump & equipment	289 Landing Plate	1.00	EA	$350	$350	OTHER	0	0	1	carbon steel landing plate
1	GAP	Extraction well pump & equipment	271 Riser Pipe	300.00	LF	$50	$14,862	OTHER	0	0	1	stainless steel riser pipes
1	GAP	Extraction well pump & equipment	279 Disconnect Boxes	1.00	EA	$400	$400	OTHER	0	0	1	
1	GAP	Extraction well pump & equipment	280 Allowance for Electrical Hookups	1.00	EA	$228	$228	OTHER	0	0	1	
1	GAP	Extraction well pump & equipment	287 Subcontract power pole & power distribution	2000.00	LF	$7	$14,580	OTHER	0	0	1	power cable laying and power pole construction
1	GAP	Extraction Well Racks	284 Extraction rack	1.00	EA	$40,000	$40,000	HISTORICAL	0	0	1	Extr well rack
1	GAP	Extraction Wells	11 Drilling & Construction (per foot)	300.00	LF	$546	$163,800	OTHER	0	0	1	Extraction wells - 1 well to 300 ft
1	GAP	Extraction Wells	10 Drilling Mobilization, completion, cleanup and demob	2.00	per well	$36,250	$72,500	OTHER	0	0	1	1 extraction well
1	GAP	Fiber Optic Cable (transfer building to injection wells)	260 Fiber-optic cable and interfaces	6824.15	FT	$1	$9,076	OTHER	0	0	1	Injection wells
1	GAP	Injection pipelines (transfer building to injection wells)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	Injection wells, assume 1 mobilization for 2 wells
1	GAP	Injection pipelines (transfer building to injection wells)	06 Training	1.00	LS	$30,000	$30,000	OTHER	0	0	1	taken care of in extraction well (training cost allocated betweeen the GAP, B-Complex, and WMA-C areas)
1	GAP	Injection pipelines (transfer building to injection wells)	1050 Pipe Fusion Crew (includes testing)	136.48	team hr	$585	$79,850	OTHER	0	0	1	Injection well pipe runs
1	GAP	Injection pipelines (transfer building to injection wells)	29 3-inch diameter HDPE	6824.15	LF	$10	$68,241	OTHER	0	0	1	Injection well pipe runs
1	GAP	Injection pipelines (transfer building to injection wells)	17 Freight for HDPE Pipe	3.00	trip	$2,500	$7,500	OTHER	0	0	1	Injection & extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
1	GAP	Injection well equipment	289 Landing Plate	2.00	EA	$350	$700	OTHER	0	0	1	carbon steel landing plate
1	GAP	Injection well equipment	271 Riser Pipe	600.00	LF	$50	$29,724	OTHER	0	0	1	stainless steel riser pipes
1	GAP	Injection Well Racks	283 Injection Rack	1.00	EA	$17,000	$17,000	HISTORICAL	0	0	1	Inj well rack
1	GAP	Injection Well Racks	285 Pump Setting Crew	10.00	Team/Hr	$262	$2,617	OTHER	0	0	1	1 10 hr day * 1 inj wells
1	GAP	Injection Wells	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 injection wells to 300 ft
1	GAP	Injection Wells	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 injection wells
1	GAP	Pipeline Road Crossings	270 Road Crossings	2.00	Sleeve	$15,000	$30,000	OTHER	0	0	1	Additional sleeves are required to cross (Rt. 11) to the GAP
1	GAP	Power & Fiber Optic Cable (transfer building to extraction wells)	260 Fiber-optic cable and interfaces	15551.18	FT	$1	$20,683	OTHER	0	0	1	Extraction well pipeline
1	GAP	Transfer Bldg - CAT/ATP	303 Outdoor Transfer StationCAT/ATP	1.00	0	$25,000	$25,000	OTHER	0	0	1	
1	GAP	Transfer Building Structure	302 Outdoor Transfer Station	1.00	LS	$500,000	$500,000	OTHER	0	0	1	1 new station to return water for injection, 1 new needed at B complex to convey extraction water
1	GAP	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	10.00	EA	$1,800	$18,000	OTHER	0	0	1	1 extraction well * 10 samples per well
1	GAP	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	20.00	EA	$1,800	$36,000	OTHER	0	0	1	2 Injection wells * 20 samples per well
1	GAP	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	13.00	Team/Hr	$258	$3,348	OTHER	0	0	1	assume 10 samples x 1.25 hrs per sample (extraction wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	26.00	Team/Hr	$258	$6,695	OTHER	0	0	1	assume 10 samples x 1.25 hrs per sample (Injection wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	10.00	EA	$50	$500	OTHER	0	0	1	assume 10 samples x 1 well (extraction wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	10.00	EA	$95	$950	OTHER	0	0	1	assume 10 samples x 1 well (extraction wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	10.00	EA	$95	$950	OTHER	0	0	1	Not needed for GAP
1	GAP	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	10.00	EA	$50	$500	OTHER	0	0	1	Not needed for GAP
1	GAP	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	10.00	EA	$95	$950	OTHER	0	0	1	Not needed for GAP
1	GAP	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	20.00	EA	$50	$1,000	OTHER	0	0	1	assume 10 samples x 2 well (injection wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	20.00	EA	$95	$1,900	OTHER	0	0	1	assume 10 samples x 2 well (injection wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	20.00	EA	$95	$1,900	OTHER	0	0	1	Not needed for GAP
1	GAP	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	20.00	EA	$50	$1,000	OTHER	0	0	1	Not needed for GAP
1	GAP	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	20.00	EA	$95	$1,900	OTHER	0	0	1	Not needed for GAP
1	GAP	Water Level Monitoring Subsystem	288 Water Level Monitoring System	12.00	EA	$15,670	$188,040	OTHER	0	0	1	Water level monitoring system 4 per production well
1	GAP	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10.00	Team Hr	$581	$5,809	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (extraction)
1	GAP	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10.00	Team Hr	$581	$5,809	OTHER	0	0	1	1 10 hour day (extraction wells)
1	GAP	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20.00	Team Hr	$581	$11,618	OTHER	0	0	1	1 10 hour day per (injection wells)
1	GAP	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20.00	Team Hr	$581	$11,618	OTHER	0	0	1	1, 10 hour days for OTP/ATP for cross site pipe and transfer station - assoc with inj wells
							$0					

CAPITAL MARKUPS

SITE	MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	5%	Remedial Design Percent	6%	Construction Management Percent	6%	SUBTOTAL	CHPRC G&A 19.26%	Institutional Controls	COST PER YEAR
1	$0	$2,600,000	$0	$0	**$2,600,000**	$0	**$2,600,000**	$390,000	$260,000	**$3,250,000**		$162,500		$195,000		$195,000	**$3,802,500**	$732,362	$0	**$4,534,862**
1	$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
1	$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
1	$18,197	$200,163	$30,025	$20,016	**$250,204**	$21,518	**$271,722**	$40,758	$27,172	**$339,652**		$16,983		$20,379		$20,379	**$397,393**	$76,538	$0	**$473,931**
1	$15,551	$171,063	$25,659	$17,106	**$213,829**	$18,389	**$232,218**	$34,833	$23,222	**$290,273**		$14,514		$17,416		$17,416	**$339,619**	$65,411	$0	**$405,029**
1	$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	$0	**$57,516**
1	$1,500	$16,500	$2,475	$1,650	**$20,625**	$1,774	**$22,399**	$3,360	$2,240	**$27,998**		$1,400		$1,680		$1,680	**$32,758**	$6,309	$0	**$39,067**
1	$320	$3,520	$528	$352	**$4,400**	$378	**$4,778**	$717	$478	**$5,973**		$299		$358		$358	**$6,988**	$1,346	$0	**$8,334**
1	$2,364	$26,002	$3,900	$2,600	**$32,502**	$2,795	**$35,297**	$5,295	$3,530	**$44,121**		$2,206		$2,647		$2,647	**$51,622**	$9,942	$0	**$61,564**
1	$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
1	$42	$465	$70	$47	**$582**	$50	**$632**	$95	$63	**$790**		$39		$47		$47	**$924**	$178	$0	**$1,102**
1	$185	$2,033	$305	$203	**$2,541**	$219	**$2,760**	$414	$276	**$3,449**		$172		$207		$207	**$4,036**	$777	$0	**$4,813**
1	$5,412	$59,530	$8,929	$5,953	**$74,412**	$6,399	**$80,812**	$12,122	$8,081	**$101,015**		$5,051		$6,061		$6,061	**$118,187**	$22,763	$0	**$140,950**
1	$262	$2,879	$432	$288	**$3,599**	$310	**$3,908**	$586	$391	**$4,885**		$244		$293		$293	**$5,716**	$1,101	$0	**$6,817**
1	$35	$385	$58	$39	**$481**	$41	**$523**	$78	$52	**$653**		$33		$39		$39	**$764**	$147	$0	**$912**
1	$1,486	$16,348	$2,452	$1,635	**$20,435**	$1,757	**$22,193**	$3,329	$2,219	**$27,741**		$1,387		$1,664		$1,664	**$32,457**	$6,251	$0	**$38,708**
1	$40	$440	$66	$44	**$550**	$47	**$597**	$90	$60	**$747**		$37		$45		$45	**$874**	$168	$0	**$1,042**
1	$23	$251	$38	$25	**$314**	$27	**$340**	$51	$34	**$426**		$21		$26		$26	**$498**	$96	$0	**$594**
1	$1,458	$16,038	$2,406	$1,604	**$20,048**	$1,724	**$21,772**	$3,266	$2,177	**$27,214**		$1,361		$1,633		$1,633	**$31,841**	$6,133	$0	**$37,974**
1	$4,000	$44,000	$6,600	$4,400	**$55,000**	$4,730	**$59,730**	$8,960	$5,973	**$74,663**		$3,733		$4,480		$4,480	**$87,355**	$16,825	$0	**$104,180**
1	$16,380	$180,180	$27,027	$18,018	**$225,225**	$19,369	**$244,594**	$36,689	$24,459	**$305,743**		$15,287		$18,345		$18,345	**$357,719**	$68,897	$0	**$426,616**
1	$7,250	$79,750	$11,963	$7,975	**$99,688**	$8,573	**$108,261**	$16,239	$10,826	**$135,326**		$6,766		$8,120		$8,120	**$158,331**	$30,495	$0	**$188,826**
1	$908	$9,984	$1,498	$998	**$12,480**	$1,073	**$13,553**	$2,033	$1,355	**$16,941**		$847		$1,016		$1,016	**$19,821**	$3,818	$0	**$23,639**
1	$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
1	$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
1	$7,985	$87,835	$13,175	$8,784	**$109,794**	$9,442	**$119,237**	$17,885	$11,924	**$149,046**		$7,452		$8,943		$8,943	**$174,384**	$33,586	$0	**$207,970**
1	$6,824	$75,066	$11,260	$7,507	**$93,832**	$8,070	**$101,902**	$15,285	$10,190	**$127,377**		$6,369		$7,643		$7,643	**$149,031**	$28,703	$0	**$177,734**
1	$750	$8,250	$1,238	$825	**$10,313**	$887	**$11,199**	$1,680	$1,120	**$13,999**		$700		$840		$840	**$16,379**	$3,155	$0	**$19,534**
1	$70	$770	$116	$77	**$963**	$83	**$1,045**	$157	$105	**$1,307**		$65		$78		$78	**$1,529**	$294	$0	**$1,823**
1	$2,972	$32,696	$4,904	$3,270	**$40,871**	$3,515	**$44,385**	$6,658	$4,439	**$55,482**		$2,774		$3,329		$3,329	**$64,914**	$12,502	$0	**$77,416**
1	$1,700	$18,700	$2,805	$1,870	**$23,375**	$2,010	**$25,385**	$3,808	$2,539	**$31,732**		$1,587		$1,904		$1,904	**$37,126**	$7,150	$0	**$44,276**
1	$262	$2,879	$432	$288	**$3,599**	$310	**$3,908**	$586	$391	**$4,885**		$244		$293		$293	**$5,716**	$1,101	$0	**$6,817**
1	$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	$0	**$853,232**
1	$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	$0	**$377,651**
1	$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
1	$2,068	$22,751	$3,413	$2,275	**$28,439**	$2,446	**$30,885**	$4,633	$3,088	**$38,606**		$1,930		$2,316		$2,316	**$45,169**	$8,700	$0	**$53,869**
1	$2,500	$27,500	$4,125	$2,750	**$34,375**	$2,956	**$37,331**	$5,600	$3,733	**$46,664**		$2,333		$2,800		$2,800	**$54,597**	$10,515	$0	**$65,112**
1	$50,000	$550,000	$82,500	$55,000	**$687,500**	$59,125	**$746,625**	$111,994	$74,663	**$933,281**		$46,664		$55,997		$55,997	**$1,091,939**	$210,307	$0	**$1,302,247**
1	$1,800	$19,800	$2,970	$1,980	**$24,750**	$2,129	**$26,879**	$4,032	$2,688	**$33,598**		$1,680		$2,016		$2,016	**$39,310**	$7,571	$0	**$46,881**
1	$3,600	$39,600	$5,940	$3,960	**$49,500**	$4,257	**$53,757**	$8,064	$5,376	**$67,196**		$3,360		$4,032		$4,032	**$78,620**	$15,142	$0	**$93,762**
1	$335	$3,682	$552	$368	**$4,603**	$396	**$4,999**	$750	$500	**$6,249**		$312		$375		$375	**$7,311**	$1,408	$0	**$8,719**
1	$670	$7,365	$1,105	$736	**$9,206**	$792	**$9,998**	$1,500	$1,000	**$12,497**		$625		$750		$750	**$14,622**	$2,816	$0	**$17,438**
1	$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	$0	**$1,302**
1	$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
1	$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
1	$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	$0	**$1,302**
1	$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
1	$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
1	$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
1	$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
1	$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
1	$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
1	$18,804	$206,844	$31,027	$20,684	**$258,555**	$22,236	**$280,791**	$42,119	$28,079	**$350,988**		$17,549		$21,059		$21,059	**$410,656**	$79,092	$0	**$489,749**
1	$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
1	$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
1	$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	$0	**$30,260**
1	$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	$0	**$30,260**
	$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**

CAPITAL COSTS

WBS SITE	WBS SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	extraction pipeline
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	06 Training	0.50	LS	$30,000	$15,000	OTHER	0	0	1	training cost allocated betweeen the B-Complex (50%) and WMA-C (50%) areas
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	1001 SOW Crew	80	Team/Hr	$276	$22,084	OTHER	0	0	1	assume 80 hours to write SOW
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	126	team hr	$585	$73,708	OTHER	0	0	1	extraction pipeline, 50 ft/hr
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	6299	LF	$10	$62,992	OTHER	0	0	1	extraction pipeline
2	B-Complex	Extraction Pipelines (Extraction wells to transfer station)	17 Freight for HDPE Pipe	3.00	trip	$2,500	$7,500	OTHER	0	0	1	extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
2	B-Complex	Extraction well pump & equipment	287 Subcontract power pole & power distribution	2000	LF	$7	$14,580	OTHER	0	0	1	Extr Disconnect Box
2	B-Complex	Extraction well pump & equipment	273 Tray Cable #10 4C THHN	6299	LF	$3	$21,921	OTHER	0	0	1	Extr Electrical Hookup allowance
2	B-Complex	Extraction well pump & equipment	286 Power Pole Allowance	1	EA	$1,848	$1,848	OTHER	0	0	1	power cable laying and power pole construction
2	B-Complex	Extraction well pump & equipment	289 Landing Plate	1	EA	$350	$350	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	271 Riser Pipe	300	LF	$50	$14,862	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	279 Disconnect Boxes	1	EA	$400	$400	OTHER	0	0	1	new extraction well down to 300 ft
2	B-Complex	Extraction well pump & equipment	285 Pump Setting Crew	20	Team/Hr	$262	$5,235	OTHER	0	0	1	1 extraction well pump
2	B-Complex	Extraction well pump & equipment	280 Allowance for Electrical Hookups	1	EA	$228	$228	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	266 #10/4C THHN (tray cable)	6299	LF	$2	$9,575	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	278 Transformer	1	EA	$0	$0	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	259 Transformers pole brackets	1	EA	$423	$423	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	275 Pump Assembly	1	EA	$3,200	$3,200	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	06 Training	1.0	LS	$30,000	$30,000	OTHER	0	0	1	
2	B-Complex	Extraction well pump & equipment	1001 SOW Crew	80	Team/hr	$276	$22,084	OTHER	0	0	1	
2	B-Complex	Extraction Well Racks	284 Extraction rack	1	EA	$40,000	$40,000	HISTORICAL	0	0	1	
2	B-Complex	Extraction Wells	11 Drilling & Construction (per foot)	300.00	LF	$546	$163,800	OTHER	0	0	1	1 new extraction well to 300 ft
2	B-Complex	Extraction Wells	10 Drilling Mobilization, completion, cleanup and demob	2.00	per well	$36,250	$72,500	OTHER	0	0	1	1 new extraction well to 300 ft
2	B-Complex	Fiber Optic Cable (transfer building to injection wells)	260 Fiber-optic cable and interfaces	4921	FT	$1	$6,545	OTHER	0	0	1	Injection wells
2	B-Complex	Injection pipelines (transfer building to injection wells)	19 Mobilization for pipeline crew	1.00	LS	$1,500	$1,500	OTHER	0	0	1	no new injection wells in B Complex
2	B-Complex	Injection pipelines (transfer building to injection wells)	06 Training	1.00	LS	$30,000	$30,000	OTHER	0	0	1	taken care of in extraction well (training cost allocated betweeen the GAP, B-Complex, and WMA-C areas)
2	B-Complex	Injection pipelines (transfer building to injection wells)	1050 Pipe Fusion Crew (includes testing)	11	team hr	$585	$6,411	OTHER	0	0	1	Injection well pipe runs
2	B-Complex	Injection pipelines (transfer building to injection wells)	16 HDPE Dual Containment (6x10)	548	LF	$35	$19,155	OTHER	0	0	1	Allowance for 6-inch Injection well pipe runs for 1 new injection wells at 200 West allocated to B Complex
2	B-Complex	Injection pipelines (transfer building to injection wells)	17 Freight for HDPE Pipe	1	trip	$2,500	$2,500	OTHER	0	0	1	Injection & extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
2	B-Complex	Injection well equipment	289 Landing Plate	1	EA	$350	$350	OTHER	0	0	1	carbon steel landing plate
2	B-Complex	Injection well equipment	271 Riser Pipe	300	LF	$50	$14,862	OTHER	0	0	1	stainless steel riser pipes
2	B-Complex	Injection Well Racks	283 Injection Rack	1	EA	$17,000	$17,000	HISTORICAL	0	0	1	
2	B-Complex	Injection Well Racks	285 Pump Setting Crew	10	Team/Hr	$262	$2,617	OTHER	0	0	1	1 10 hr day (to set the rack) per well
2	B-Complex	Injection Wells	11 Drilling & Construction (per foot)	300.00	LF	$546	$163,800	OTHER	0	0	1	no inj well
2	B-Complex	Injection Wells	10 Drilling Mobilization, completion, cleanup and demob	2.00	per well	$36,250	$72,500	OTHER	0	0	1	no inj well
2	B-Complex	Pipeline Road Crossings	270 Road Crossings	3	Sleeve	$15,000	$45,000	OTHER	0	0	1	Note: assume road crossings from B-complex for wells 268 and 360 are included and no cost. Additional sleeves to cross 12th street are required for B-complex to gain access to the GAP.
2	B-Complex	Power & Fiber Optic Cable (transfer building to extraction wells)	260 Fiber-optic cable and interfaces	6299	FT	$1	$8,378	OTHER	0	0	1	3101 lf of fiber optic cable for extraction well
2	B-Complex	Transfer Bldg - CAT/ATP	290 Transfer Building CAT/ATP	0.00	LS	$110,529	$0	OTHER	0	0	1	
2	B-Complex	Transfer Building Structure	281 Transfer Station (extraction & injection station)	0.00	LS	$2,210,576	$0	OTHER	0	0	1	Cost to cover 50% of new transfer station for injection water from 200W P&T
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	10.00	EA	$1,800	$18,000	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	13	Team/Hr	$258	$3,219	OTHER	0	0	1	assume 10 samples x 1.25 hrs per sample (Extraction wells)
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	10	EA	$50	$500	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	10	EA	$50	$500	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	10	EA	$95	$950	OTHER	0	0	1	1 new Extraction well - 10 samples per well
2	B-Complex	Water Level Monitoring Subsystem	288 Water Level Monitoring System	4	EA	$15,670	$62,680	OTHER	0	0	1	Water level monitoring system 4 per extraction or injection well (1 new ex well)
2	B-Complex	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10.00	Team Hr	$581	$5,809	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (extraction)
2	B-Complex	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	Injection wells, 10 hours per well
							$0					
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	mob demob for pipe laying crew
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	06 Training	0.50	LS	$30,000	$15,000	OTHER	0	0	1	training cost allocated betweeen the B-Complex (50%) and WMA-C (50%)
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	248	team hr	$585	$145,113	OTHER	0	0	1	extraction well pipe runs, 50 ft/hr
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	16 HDPE Dual Containment (6x10)	12402	LF	$35	$433,559	OTHER	0	0	1	extraction well pipe runs
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1001 SOW Crew	80	Team/hr	$276	$22,084	OTHER	0	0	1	assume 80 hours to write SOW
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	17 Freight for HDPE Pipe	5	trip	$2,500	$12,500	OTHER	0	0	1	extraction well pipe runs (50 foot sticks) & 54 sticks per truck load
3	WMA-C	Extraction well pump & equipment	289 Landing Plate	3	EA	$350	$1,050	OTHER	0	0	1	carbon steel landing plate
3	WMA-C	Extraction well pump & equipment	271 Riser Pipe	900	LF	$50	$44,586	OTHER	0	0	1	stainless steel riser pipes
3	WMA-C	Extraction well pump & equipment	287 Subcontract power pole & power distribution	2000	LF	$7	$14,580	OTHER	0	0	1	power cable laying and power pole construction

CAPITAL MARKUPS

MDBI 10%	MDBI SUBTOTAL	Overhead 15%	Profit 10%	Profit SUBTOTAL	WA States Sales Tax 8.6%	WA States Sales Tax SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	Bid Contingency SUBTOTAL	Project Management Percent	Project Management 5%	Remedial Design Percent	Remedial Design 6%	Construction Management Percent	Construction Management 6%	SUBTOTAL	CHPRC G&A 19.26%	Institutional Controls	COST PER YEAR
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$1,500	$16,500	$2,475	$1,650	**$20,625**	$1,774	**$22,399**	$3,360	$2,240	**$27,998**		$1,400		$1,680		$1,680	**$32,758**	$6,309	$0	**$39,067**
$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	$0	**$57,516**
$7,371	$81,079	$12,162	$8,108	**$101,349**	$8,716	**$110,065**	$16,510	$11,006	**$137,581**		$6,879		$8,255		$8,255	**$160,969**	$31,003	$0	**$191,972**
$6,299	$69,291	$10,394	$6,929	**$86,614**	$7,449	**$94,063**	$14,109	$9,406	**$117,579**		$5,879		$7,055		$7,055	**$137,567**	$26,495	$0	**$164,063**
$750	$8,250	$1,238	$825	**$10,313**	$887	**$11,199**	$1,680	$1,120	**$13,999**		$700		$840		$840	**$16,379**	$3,155	$0	**$19,534**
$1,458	$16,038	$2,406	$1,604	**$20,048**	$1,724	**$21,772**	$3,266	$2,177	**$27,214**		$1,361		$1,633		$1,633	**$31,841**	$6,133	$0	**$37,974**
$2,192	$24,113	$3,617	$2,411	**$30,142**	$2,592	**$32,734**	$4,910	$3,273	**$40,917**		$2,046		$2,455		$2,455	**$47,873**	$9,220	$0	**$57,094**
$185	$2,033	$305	$203	**$2,541**	$219	**$2,760**	$414	$276	**$3,449**		$172		$207		$207	**$4,036**	$777	$0	**$4,813**
$35	$385	$58	$39	**$481**	$41	**$523**	$78	$52	**$653**		$33		$39		$39	**$764**	$147	$0	**$912**
$1,486	$16,348	$2,452	$1,635	**$20,435**	$1,757	**$22,193**	$3,329	$2,219	**$27,741**		$1,387		$1,664		$1,664	**$32,457**	$6,251	$0	**$38,708**
$40	$440	$66	$44	**$550**	$47	**$597**	$90	$60	**$747**		$37		$45		$45	**$874**	$168	$0	**$1,042**
$523	$5,758	$864	$576	**$7,198**	$619	**$7,817**	$1,173	$782	**$9,771**		$489		$586		$586	**$11,432**	$2,202	$0	**$13,634**
$23	$251	$38	$25	**$314**	$27	**$340**	$51	$34	**$426**		$21		$26		$26	**$498**	$96	$0	**$594**
$957	$10,532	$1,580	$1,053	**$13,165**	$1,132	**$14,298**	$2,145	$1,430	**$17,872**		$894		$1,072		$1,072	**$20,910**	$4,027	$0	**$24,938**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$42	$465	$70	$47	**$582**	$50	**$632**	$95	$63	**$790**		$39		$47		$47	**$924**	$178	$0	**$1,102**
$320	$3,520	$528	$352	**$4,400**	$378	**$4,778**	$717	$478	**$5,973**		$299		$358		$358	**$6,988**	$1,346	$0	**$8,334**
$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	$0	**$57,516**
$4,000	$44,000	$6,600	$4,400	**$55,000**	$4,730	**$59,730**	$8,960	$5,973	**$74,663**		$3,733		$4,480		$4,480	**$87,355**	$16,825	$0	**$104,180**
$16,380	$180,180	$27,027	$18,018	**$225,225**	$19,369	**$244,594**	$36,689	$24,459	**$305,743**		$15,287		$18,345		$18,345	**$357,719**	$68,897	$0	**$426,616**
$7,250	$79,750	$11,963	$7,975	**$99,688**	$8,573	**$108,261**	$16,239	$10,826	**$135,326**		$6,766		$8,120		$8,120	**$158,331**	$30,495	$0	**$188,826**
$655	$7,200	$1,080	$720	**$9,000**	$774	**$9,774**	$1,466	$977	**$12,217**		$611		$733		$733	**$14,294**	$2,753	$0	**$17,047**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
$641	$7,052	$1,058	$705	**$8,815**	$758	**$9,573**	$1,436	$957	**$11,967**		$598		$718		$718	**$14,001**	$2,697	$0	**$16,698**
$1,915	$21,070	$3,161	$2,107	**$26,338**	$2,265	**$28,603**	$4,290	$2,860	**$35,753**		$1,788		$2,145		$2,145	**$41,831**	$8,057	$0	**$49,888**
$250	$2,750	$413	$275	**$3,438**	$296	**$3,733**	$560	$373	**$4,666**		$233		$280		$280	**$5,460**	$1,052	$0	**$6,511**
$35	$385	$58	$39	**$481**	$41	**$523**	$78	$52	**$653**		$33		$39		$39	**$764**	$147	$0	**$912**
$1,486	$16,348	$2,452	$1,635	**$20,435**	$1,757	**$22,193**	$3,329	$2,219	**$27,741**		$1,387		$1,664		$1,664	**$32,457**	$6,251	$0	**$38,708**
$1,700	$18,700	$2,805	$1,870	**$23,375**	$2,010	**$25,385**	$3,808	$2,539	**$31,732**		$1,587		$1,904		$1,904	**$37,126**	$7,150	$0	**$44,276**
$262	$2,879	$432	$288	**$3,599**	$310	**$3,908**	$586	$391	**$4,885**		$244		$293		$293	**$5,716**	$1,101	$0	**$6,817**
$16,380	$180,180	$27,027	$18,018	**$225,225**	$19,369	**$244,594**	$36,689	$24,459	**$305,743**		$15,287		$18,345		$18,345	**$357,719**	$68,897	$0	**$426,616**
$7,250	$79,750	$11,963	$7,975	**$99,688**	$8,573	**$108,261**	$16,239	$10,826	**$135,326**		$6,766		$8,120		$8,120	**$158,331**	$30,495	$0	**$188,826**
$4,500	$49,500	$7,425	$4,950	**$61,875**	$5,321	**$67,196**	$10,079	$6,720	**$83,995**		$4,200		$5,040		$5,040	**$98,275**	$18,928	$0	**$117,202**
$838	$9,216	$1,382	$922	**$11,520**	$991	**$12,510**	$1,877	$1,251	**$15,638**		$782		$938		$938	**$18,296**	$3,524	$0	**$21,820**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$1,800	$19,800	$2,970	$1,980	**$24,750**	$2,129	**$26,879**	$4,032	$2,688	**$33,598**		$1,680		$2,016		$2,016	**$39,310**	$7,571	$0	**$46,881**
$322	$3,541	$531	$354	**$4,426**	$381	**$4,807**	$721	$481	**$6,008**		$300		$360		$360	**$7,030**	$1,354	$0	**$8,384**
$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	$0	**$1,302**
$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
$50	$550	$83	$55	**$688**	$59	**$747**	$112	$75	**$933**		$47		$56		$56	**$1,092**	$210	$0	**$1,302**
$95	$1,045	$157	$105	**$1,306**	$112	**$1,419**	$213	$142	**$1,773**		$89		$106		$106	**$2,075**	$400	$0	**$2,474**
$6,268	$68,948	$10,342	$6,895	**$86,185**	$7,412	**$93,597**	$14,040	$9,360	**$116,996**		$5,850		$7,020		$7,020	**$136,885**	$26,364	$0	**$163,250**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$1,500	$16,500	$2,475	$1,650	**$20,625**	$1,774	**$22,399**	$3,360	$2,240	**$27,998**		$1,400		$1,680		$1,680	**$32,758**	$6,309	$0	**$39,067**
$14,511	$159,624	$23,944	$15,962	**$199,530**	$17,160	**$216,690**	$32,503	$21,669	**$270,862**		$13,543		$16,252		$16,252	**$316,909**	$61,037	$0	**$377,945**
$43,356	$476,915	$71,537	$47,691	**$596,144**	$51,268	**$647,412**	$97,112	$64,741	**$809,265**		$40,463		$48,556		$48,556	**$946,840**	$182,361	$0	**$1,129,202**
$2,208	$24,292	$3,644	$2,429	**$30,365**	$2,611	**$32,976**	$4,946	$3,298	**$41,220**		$2,061		$2,473		$2,473	**$48,228**	$9,289	$0	**$57,516**
$1,250	$13,750	$2,063	$1,375	**$17,188**	$1,478	**$18,666**	$2,800	$1,867	**$23,332**		$1,167		$1,400		$1,400	**$27,298**	$5,258	$0	**$32,556**
$105	$1,155	$173	$116	**$1,444**	$124	**$1,568**	$235	$157	**$1,960**		$98		$118		$118	**$2,293**	$442	$0	**$2,735**
$4,459	$49,045	$7,357	$4,904	**$61,306**	$5,272	**$66,578**	$9,987	$6,658	**$83,223**		$4,161		$4,993		$4,993	**$97,370**	$18,754	$0	**$116,124**
$1,458	$16,038	$2,406	$1,604	**$20,048**	$1,724	**$21,772**	$3,266	$2,177	**$27,214**		$1,361		$1,633		$1,633	**$31,841**	$6,133	$0	**$37,974**

CAPITAL COSTS

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
3	WMA-C	Extraction well pump & equipment	275 Pump Assembly	3.00	EA	$3,200	$9,600	OTHER	0	0	1	1 pump for the extraction well * 2 wells
3	WMA-C	Extraction well pump & equipment	279 Disconnect Boxes	3	EA	$400	$1,200	OTHER	0	0	1	1 disconnect box for extraction well
3	WMA-C	Extraction well pump & equipment	280 Allowance for Electrical Hookups	3	EA	$228	$684	OTHER	0	0	1	electrical hookup for extraction well
3	WMA-C	Extraction well pump & equipment	266 #10/4C THHN (tray cable)	16831	LF	$2	$25,583	OTHER	0	0	1	tray cable for extraction well
3	WMA-C	Extraction well pump & equipment	278 Transformer	3	EA	$0	$0	OTHER	0	0	1	3 transformers for extraction well
3	WMA-C	Extraction well pump & equipment	259 Transformers pole brackets	3	EA	$423	$1,269	OTHER	0	0	1	1 pole bracket for extraction well
3	WMA-C	Extraction well pump & equipment	286 Power Pole Allowance	3	EA	$1,848	$5,544	OTHER	0	0	1	power pole for extraction well
3	WMA-C	Extraction well pump & equipment	273 Tray Cable #10 4C THHN	16831	LF	$3	$58,571	OTHER	0	0	1	tray cable for extraction well
3	WMA-C	Extraction well pump & equipment	285 Pump Setting Crew	60	Team/Hr	$262	$15,704	OTHER	0	0	1	2 10 hr days * 3wells
3	WMA-C	Extraction Well Racks	284 Extraction rack	3	EA	$40,000	$120,000	HISTORICAL	0	0	1	Extraction well rack
3	WMA-C	Extraction Wells	11 Drilling & Construction (per foot)	900.00	LF	$546	$491,400	OTHER	0	0	1	3 extraction wells to 300 ft each
3	WMA-C	Extraction Wells	10 Drilling Mobilization, completion, cleanup and demob	6.00	per well	$36,250	$217,500	OTHER	0	0	1	mob demob for extraction well drilling
3	WMA-C	Fiber Optic Cable (transfer building to injection wells)	260 Fiber-optic cable and interfaces	8750	FT	$1	$11,638	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	06 Training	1	LS	$30,000	$30,000	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	1050 Pipe Fusion Crew (includes testing)	22	team hr	$585	$12,784	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	16 HDPE Dual Containment (6x10)	1093	LF	$35	$38,194	OTHER	0	0	1	Allowance for 2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection pipelines (transfer building to injection wells)	17 Freight for HDPE Pipe	1	trip	$2,500	$2,500	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection well equipment	289 Landing Plate	2	EA	$350	$700	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection well equipment	271 Riser Pipe	600	LF	$50	$29,724	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Well Racks	283 Injection Rack	2	EA	$17,000	$34,000	HISTORICAL	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Well Racks	285 Pump Setting Crew	20	Team/Hr	$262	$5,235	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Wells	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Injection Wells	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new injection wells at 200W (50 gpm each)
3	WMA-C	Pipeline Road Crossings	270 Road Crossings	9	Sleeve	$15,000	$135,000	OTHER	0	0	1	sleeves are required to cross Baltimore to gain access to WMA-C.
3	WMA-C	Power & Fiber Optic Cable (transfer building to extraction wells)	260 Fiber-optic cable and interfaces	16831	FT	$1	$22,385	OTHER	0	0	1	fiber optic cable for extraction well
3	WMA-C	Transfer Bldg - CAT/ATP	303 Outdoor Transfer StationCAT/ATP	1.00	0	$25,000	$25,000	OTHER	0	0	1	injection at 200W P&T and 1 new
3	WMA-C	Transfer Building Structure	302 Outdoor Transfer Station	1.00	LS	$500,000	$500,000	OTHER	0	0	1	injection at 200W P&T and 1 new transfer building at WMA C.
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	30.00	EA	$1,800	$54,000	OTHER	0	0	1	extraction wells. no inj well. Driller charge per sample for sample
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	0.00	EA	$1,800	$0	OTHER	0	0	1	Assumes no sampling during drilling of injection wells installed in 200 West
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	38	Team/Hr	$258	$9,657	OTHER	0	0	1	1.25 hrs per sample (extraction wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	30	EA	$50	$1,500	OTHER	0	0	1	assume 10 samples x 3 wells (extraction wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	30	EA	$95	$2,850	OTHER	0	0	1	assume 10 samples x 3 wells (extraction wells)
3	WMA-C	Water Level Monitoring Subsystem	288 Water Level Monitoring System	12	EA	$15,670	$188,040	OTHER	0	0	1	per extraction or injection well (3 ex wells)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	pipe laying
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	extraction wells
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	no inj well
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	10	Team Hr	$581	$5,809	OTHER	0	0	1	(pipe laying) 10 hours for each of the pipe runs (extraction)
3	WMA-C	Well Rack/Pipeline CAT/ATP	1000 ATP/OTP Crew	20	Team Hr	$581	$11,618	OTHER	0	0	1	no new injection wells
2	B-Complex	Cross-site Transfer Line	02 Injection Cross Site Pipeline	0.00	LS	$2,744,317	$0	OTHER	0	0	1	TC99 Line from 200 E to 200W
2	B-Complex	Pump & Treat Modifications	296 Technetium-99 Treatment Train	0.00	LS	$719,000	$0	OTHER	0	0	1	TC99 treatment train
2	B-Complex	Pump & Treat Modifications	297 installation completion materials	0.00	LS	$570,000	$0	OTHER	0	0	1	TC99 treatment train
2	B-Complex	Pump & Treat Modifications	298 SC Labor for installation	0.00	LS	$2,500,000	$0	OTHER	0	0	1	TC99 treatment train
2	B-Complex	Pump & Treat Modifications	299 Construction management and design	0.00	LS	$600,000	$0	OTHER	0	0	1	TC99 treatment train
2	B-Complex	well drilling	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new monitoring wells to 300 ft each
2	B-Complex	well drilling	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new monitoring wells to 300 ft each
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	20.00	EA	$1,800	$36,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	25	Team/Hr	$258	$6,438	OTHER	0	0	1	assume 10 sample per wells x 1.25 hrs per sample (monitoring wells)
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
2	B-Complex	well drilling	285 Pump Setting Crew	40	Team/Hr	$262	$10,469	OTHER	0	0	1	20 hours per well
2	B-Complex	well drilling	275 Pump Assembly	2	EA	$3,200	$6,400	OTHER	0	0	1	1 pump assembly per well
							$0					
3	WMA-C	well drilling	11 Drilling & Construction (per foot)	600.00	LF	$546	$327,600	OTHER	0	0	1	2 new monitoring wells to 300 ft each
3	WMA-C	well drilling	10 Drilling Mobilization, completion, cleanup and demob	4.00	per well	$36,250	$145,000	OTHER	0	0	1	2 new monitoring wells to 300 ft each

CAPITAL MARKUPS

MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	5%	Remedial Design Percent	6%	Construction Management Percent	6%	SUBTOTAL	CHPRC G&A 19.26%	Institutional Controls	COST PER YEAR
$960	$10,560	$1,584	$1,056	**$13,200**	$1,135	**$14,335**	$2,150	$1,434	**$17,919**		$896		$1,075		$1,075	**$20,965**	$4,038	$0	**$25,003**
$120	$1,320	$198	$132	**$1,650**	$142	**$1,792**	$269	$179	**$2,240**		$112		$134		$134	**$2,621**	$505	$0	**$3,125**
$68	$752	$113	$75	**$941**	$81	**$1,021**	$153	$102	**$1,277**		$64		$77		$77	**$1,494**	$288	$0	**$1,781**
$2,558	$28,141	$4,221	$2,814	**$35,176**	$3,025	**$38,201**	$5,730	$3,820	**$47,752**		$2,388		$2,865		$2,865	**$55,869**	$10,760	$0	**$66,630**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$127	$1,396	$209	$140	**$1,745**	$150	**$1,895**	$284	$189	**$2,369**		$118		$142		$142	**$2,771**	$534	$0	**$3,305**
$554	$6,098	$915	$610	**$7,623**	$656	**$8,279**	$1,242	$828	**$10,348**		$517		$621		$621	**$12,107**	$2,332	$0	**$14,439**
$5,857	$64,428	$9,664	$6,443	**$80,535**	$6,926	**$87,461**	$13,119	$8,746	**$109,326**		$5,466		$6,560		$6,560	**$127,912**	$24,636	$0	**$152,547**
$1,570	$17,275	$2,591	$1,727	**$21,593**	$1,857	**$23,450**	$3,518	$2,345	**$29,313**		$1,466		$1,759		$1,759	**$34,296**	$6,605	$0	**$40,901**
$12,000	$132,000	$19,800	$13,200	**$165,000**	$14,190	**$179,190**	$26,879	$17,919	**$223,988**		$11,199		$13,439		$13,439	**$262,065**	$50,474	$0	**$312,539**
$49,140	$540,540	$81,081	$54,054	**$675,675**	$58,108	**$733,783**	$110,067	$73,378	**$917,229**		$45,861		$55,034		$55,034	**$1,073,158**	$206,690	$0	**$1,279,848**
$21,750	$239,250	$35,888	$23,925	**$299,063**	$25,719	**$324,782**	$48,717	$32,478	**$405,977**		$20,299		$24,359		$24,359	**$474,993**	$91,484	$0	**$566,477**
$1,164	$12,801	$1,920	$1,280	**$16,002**	$1,376	**$17,378**	$2,607	$1,738	**$21,722**		$1,086		$1,303		$1,303	**$25,415**	$4,895	$0	**$30,310**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$3,000	$33,000	$4,950	$3,300	**$41,250**	$3,548	**$44,798**	$6,720	$4,480	**$55,997**		$2,800		$3,360		$3,360	**$65,516**	$12,618	$0	**$78,135**
$1,278	$14,062	$2,109	$1,406	**$17,578**	$1,512	**$19,089**	$2,863	$1,909	**$23,862**		$1,193		$1,432		$1,432	**$27,918**	$5,377	$0	**$33,295**
$3,819	$42,014	$6,302	$4,201	**$52,517**	$4,516	**$57,034**	$8,555	$5,703	**$71,292**		$3,565		$4,278		$4,278	**$83,412**	$16,065	$0	**$99,477**
$250	$2,750	$413	$275	**$3,438**	$296	**$3,733**	$560	$373	**$4,666**		$233		$280		$280	**$5,460**	$1,052	$0	**$6,511**
$70	$770	$116	$77	**$963**	$83	**$1,045**	$157	$105	**$1,307**		$65		$78		$78	**$1,529**	$294	$0	**$1,823**
$2,972	$32,696	$4,904	$3,270	**$40,871**	$3,515	**$44,385**	$6,658	$4,439	**$55,482**		$2,774		$3,329		$3,329	**$64,914**	$12,502	$0	**$77,416**
$3,400	$37,400	$5,610	$3,740	**$46,750**	$4,021	**$50,771**	$7,616	$5,077	**$63,463**		$3,173		$3,808		$3,808	**$74,252**	$14,301	$0	**$88,553**
$523	$5,758	$864	$576	**$7,198**	$619	**$7,817**	$1,173	$782	**$9,771**		$489		$586		$586	**$11,432**	$2,202	$0	**$13,634**
$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	$0	**$853,232**
$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	$0	**$377,651**
$13,500	$148,500	$22,275	$14,850	**$185,625**	$15,964	**$201,589**	$30,238	$20,159	**$251,986**		$12,599		$15,119		$15,119	**$294,824**	$56,783	$0	**$351,607**
$2,238	$24,623	$3,693	$2,462	**$30,779**	$2,647	**$33,426**	$5,014	$3,343	**$41,783**		$2,089		$2,507		$2,507	**$48,886**	$9,415	$0	**$58,301**
$2,500	$27,500	$4,125	$2,750	**$34,375**	$2,956	**$37,331**	$5,600	$3,733	**$46,664**		$2,333		$2,800		$2,800	**$54,597**	$10,515	$0	**$65,112**
$50,000	$550,000	$82,500	$55,000	**$687,500**	$59,125	**$746,625**	$111,994	$74,663	**$933,281**		$46,664		$55,997		$55,997	**$1,091,939**	$210,307	$0	**$1,302,247**
$5,400	$59,400	$8,910	$5,940	**$74,250**	$6,386	**$80,636**	$12,095	$8,064	**$100,794**		$5,040		$6,048		$6,048	**$117,929**	$22,713	$0	**$140,643**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$966	$10,622	$1,593	$1,062	**$13,278**	$1,142	**$14,420**	$2,163	$1,442	**$18,025**		$901		$1,081		$1,081	**$21,089**	$4,062	$0	**$25,151**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$285	$3,135	$470	$314	**$3,919**	$337	**$4,256**	$638	$426	**$5,320**		$266		$319		$319	**$6,224**	$1,199	$0	**$7,423**
$18,804	$206,844	$31,027	$20,684	**$258,555**	$22,236	**$280,791**	$42,119	$28,079	**$350,988**		$17,549		$21,059		$21,059	**$410,656**	$79,092	$0	**$489,749**
$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	$0	**$30,260**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	$0	**$30,260**
$581	$6,390	$959	$639	**$7,988**	$687	**$8,674**	$1,301	$867	**$10,843**		$542		$651		$651	**$12,686**	$2,443	$0	**$15,130**
$1,162	$12,780	$1,917	$1,278	**$15,975**	$1,374	**$17,349**	$2,602	$1,735	**$21,686**		$1,084		$1,301		$1,301	**$25,373**	$4,887	$0	**$30,260**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	$0	**$853,232**
$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	$0	**$377,651**
$3,600	$39,600	$5,940	$3,960	**$49,500**	$4,257	**$53,757**	$8,064	$5,376	**$67,196**		$3,360		$4,032		$4,032	**$78,620**	$15,142	$0	**$93,762**
$644	$7,082	$1,062	$708	**$8,852**	$761	**$9,613**	$1,442	$961	**$12,017**		$601		$721		$721	**$14,059**	$2,708	$0	**$16,767**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$1,047	$11,516	$1,727	$1,152	**$14,395**	$1,238	**$15,633**	$2,345	$1,563	**$19,542**		$977		$1,173		$1,173	**$22,864**	$4,404	$0	**$27,268**
$640	$7,040	$1,056	$704	**$8,800**	$757	**$9,557**	$1,434	$956	**$11,946**		$597		$717		$717	**$13,977**	$2,692	$0	**$16,669**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$32,760	$360,360	$54,054	$36,036	**$450,450**	$38,739	**$489,189**	$73,378	$48,919	**$611,486**		$30,574		$36,689		$36,689	**$715,438**	$137,793	$0	**$853,232**
$14,500	$159,500	$23,925	$15,950	**$199,375**	$17,146	**$216,521**	$32,478	$21,652	**$270,652**		$13,533		$16,239		$16,239	**$316,662**	$60,989	$0	**$377,651**

CAPITAL COSTS

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	20.00	EA	$1,800	$36,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	25	Team/Hr	$258	$6,438	OTHER	0	0	1	assume 10 sample per wells x 1.25 hrs per sample (monitoring wells)
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	23 Total Cyanide	20	EA	$50	$1,000	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	Vertical Sampling and Analysis during Well Drilling	26 Iodine-129	20	EA	$95	$1,900	OTHER	0	0	1	2 new monitoring wells - 10 samples per well
3	WMA-C	well drilling	285 Pump Setting Crew	40	Team/Hr	$262	$10,469	OTHER	0	0	1	20 hours per well
3	WMA-C	well drilling	275 Pump Assembly	2	EA	$3,200	$6,400	OTHER	0	0	1	1 pump assembly per well
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	29 3-inch diameter HDPE	4429	LF	$10	$0 $44,291	OTHER	0	0	1	
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	19 Mobilization for pipeline crew	1	LS	$1,500	$1,500	OTHER	0	0	1	
3	WMA-C	Extraction Pipelines (Extraction wells to transfer station)	1050 Pipe Fusion Crew (includes testing)	89	team hr	$585	$51,826	OTHER	0	0	1	50 ft/hr
3	WMA-C	Pump & Treat Transfer Building	300 10000 Gallon Norwesco Plastic Potable Water Storage Tank	1	LS	$6,000	$0 $6,000	OTHER	0	0	1	
1	GAP	Pump & Treat Transfer Building	300 10000 Gallon Norwesco Plastic Potable Water Storage Tank	1	LS	$6,000	$0 $6,000	OTHER	0	0	1	
1	GAP	well drilling	11 Drilling & Construction (per foot)	1200	LF	$546	$0 $655,200	OTHER	0	0	1	4 new monitoring wells to 300 ft each
1	GAP	well drilling	10 Drilling Mobilization, completion, cleanup and demob	8	per well	$36,250	$290,000	OTHER	0	0	1	4 new monitoring wells to 300 ft each
1	GAP	Vertical Sampling and Analysis during Well Drilling	13 In process GW samples	40	EA	$1,800	$72,000	OTHER	0	0	1	4 new monitoring wells - 10 samples per well
1	GAP	Vertical Sampling and Analysis during Well Drilling	252 Sampling Crew	50	Team/Hr	$258	$12,876	OTHER	0	0	1	1.25 hrs per sample (monitoring wells)
1	GAP	Vertical Sampling and Analysis during Well Drilling	22 NO2/NO3	40	EA	$50	$2,000	OTHER	0	0	1	4 new monitoring wells - 10 samples per well
1	GAP	Vertical Sampling and Analysis during Well Drilling	21 Technetium-99	40	EA	$95	$3,800	OTHER	0	0	1	4 new monitoring wells - 10 samples per well
1	GAP	Vertical Sampling and Analysis during Well Drilling	25 Strontium-89, 90 - Total Radioactive Sr	40	EA	$95	$3,800	OTHER	0	0	1	4 new monitoring wells - 10 samples per well
1	GAP	well drilling	285 Pump Setting Crew	80	Team/Hr	$262	$20,939	OTHER	0	0	1	20 hours per well
1	GAP	well drilling	275 Pump Assembly	4	EA	$3,200	$12,800	OTHER	0	0	1	1 pump assembly per well
3	WMA-C	Pump & Treat Modifications	296 Technetium-99 Treatment Train	1	LS	$719,000	$719,000	OTHER	0	0	1	New Tc-99 Train
3	WMA-C	Pipelines (Extraction wells to transf	29 3-inch diameter HDPE	8750	LF	$10	$87,500	OTHER	0	0	1	Allowance for 200W Injection well
3	WMA-C	Pipelines (Extraction wells to transf	1050 Pipe Fusion Crew (includes testing)	175	team hr	$585	$102,385	OTHER	0	0	1	Allowance for 200W Injection well
3	WMA-C	Pump & Treat Modifications	305 New Air Stripper	1	LS	$3,800,000	$3,800,000	OTHER	0	0	1	
2	B-Complex	Pipelines (Extraction wells to transf	29 3-inch diameter HDPE	4373	LF	$10	$43,734	OTHER	0	0	1	Allowance for 200W Injection well
2	B-Complex	Pipelines (Extraction wells to transf	1050 Pipe Fusion Crew (includes testing)	87	team hr	$585	$51,173	OTHER	0	0	1	Allowance for 200W Injection well
3	WMA-C	Pump & Treat Modifications	307 Modutank Modifications	1	LS	$250,000	$250,000	OTHER	0	0	1	

CAPITAL MARKUPS

MDBI 10%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Project Management Percent	5%	Remedial Design Percent	6%	Construction Management Percent	6%	SUBTOTAL	CHPRC G&A 19.26%	Institutional Controls	COST PER YEAR
$3,600	$39,600	$5,940	$3,960	**$49,500**	$4,257	**$53,757**	$8,064	$5,376	**$67,196**		$3,360		$4,032		$4,032	**$78,620**	$15,142	$0	**$93,762**
$644	$7,082	$1,062	$708	**$8,852**	$761	**$9,613**	$1,442	$961	**$12,017**		$601		$721		$721	**$14,059**	$2,708	$0	**$16,767**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$100	$1,100	$165	$110	**$1,375**	$118	**$1,493**	$224	$149	**$1,867**		$93		$112		$112	**$2,184**	$421	$0	**$2,604**
$190	$2,090	$314	$209	**$2,613**	$225	**$2,837**	$426	$284	**$3,546**		$177		$213		$213	**$4,149**	$799	$0	**$4,949**
$1,047	$11,516	$1,727	$1,152	**$14,395**	$1,238	**$15,633**	$2,345	$1,563	**$19,542**		$977		$1,173		$1,173	**$22,864**	$4,404	$0	**$27,268**
$640 $0	$7,040 $0	$1,056 $0	$704 $0	**$8,800** **$0**	$757 $0	**$9,557** **$0**	$1,434 $0	$956 $0	**$11,946** **$0**		$597 $0		$717 $0		$717 $0	**$13,977** **$0**	$2,692 $0	$0 $0	**$16,669** **$0**
$4,429	$48,720	$7,308	$4,872	**$60,901**	$5,237	**$66,138**	$9,921	$6,614	**$82,673**		$4,134		$4,960		$4,960	**$96,727**	$18,630	$0	**$115,356**
$150	$1,650	$248	$165	**$2,063**	$177	**$2,240**	$336	$224	**$2,800**		$140		$168		$168	**$3,276**	$631	$0	**$3,907**
$5,183	$57,009	$8,551	$5,701	**$71,261**	$6,128	**$77,389**	$11,608	$7,739	**$96,736**		$4,837		$5,804		$5,804	**$113,182**	$21,799	$0	**$134,980**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$600	$6,600	$990	$660	**$8,250**	$710	**$8,960**	$1,344	$896	**$11,199**		$560		$672		$672	**$13,103**	$2,524	$0	**$15,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**		$0		$0		$0	**$0**	$0	$0	**$0**
$600 $0	$6,600 $0	$990 $0	$660 $0	**$8,250** **$0**	$710 $0	**$8,960** **$0**	$1,344 $0	$896 $0	**$11,199** **$0**		$560 $0		$672 $0		$672 $0	**$13,103** **$0**	$2,524 $0	$0 $0	**$15,627** **$0**
$65,520	$720,720	$108,108	$72,072	**$900,900**	$77,477	**$978,377**	$146,757	$97,838	**$1,222,972**		$61,149		$73,378		$73,378	**$1,430,877**	$275,587	$0	**$1,706,464**
$29,000	$319,000	$47,850	$31,900	**$398,750**	$34,293	**$433,043**	$64,956	$43,304	**$541,303**		$27,065		$32,478		$32,478	**$633,325**	$121,978	$0	**$755,303**
$7,200	$79,200	$11,880	$7,920	**$99,000**	$8,514	**$107,514**	$16,127	$10,751	**$134,393**		$6,720		$8,064		$8,064	**$157,239**	$30,284	$0	**$187,523**
$1,288	$14,163	$2,124	$1,416	**$17,704**	$1,523	**$19,227**	$2,884	$1,923	**$24,033**		$1,202		$1,442		$1,442	**$28,119**	$5,416	$0	**$33,535**
$200	$2,200	$330	$220	**$2,750**	$237	**$2,987**	$448	$299	**$3,733**		$187		$224		$224	**$4,368**	$841	$0	**$5,209**
$380	$4,180	$627	$418	**$5,225**	$449	**$5,674**	$851	$567	**$7,093**		$355		$426		$426	**$8,299**	$1,598	$0	**$9,897**
$380	$4,180	$627	$418	**$5,225**	$449	**$5,674**	$851	$567	**$7,093**		$355		$426		$426	**$8,299**	$1,598	$0	**$9,897**
$2,094	$23,033	$3,455	$2,303	**$28,791**	$2,476	**$31,267**	$4,690	$3,127	**$39,084**		$1,954		$2,345		$2,345	**$45,728**	$8,807	$0	**$54,535**
$1,280	$14,080	$2,112	$1,408	**$17,600**	$1,514	**$19,114**	$2,867	$1,911	**$23,892**		$1,195		$1,434		$1,434	**$27,954**	$5,384	$0	**$33,338**
$71,900	$790,900	$118,635	$79,090	**$988,625**	$85,022	**$1,073,647**	$161,047	$107,365	**$1,342,058**		$67,103		$80,524		$80,524	**$1,570,208**	$302,422	$0	**$1,872,631**
$8,750	$96,250	$14,438	$9,625	**$120,313**	$10,347	**$130,659**	$19,599	$13,066	**$163,324**		$8,166		$9,799		$9,799	**$191,089**	$36,804	$0	**$227,893**
$10,239	$112,624	$16,894	$11,262	**$140,780**	$12,107	**$152,887**	$22,933	$15,289	**$191,108**		$9,555		$11,466		$11,466	**$223,597**	$43,065	$0	**$266,661**
$0	$3,800,000	$0	$0	**$3,800,000**	$0	**$3,800,000**	$570,000	$380,000	**$4,750,000**		$237,500		$285,000		$285,000	**$5,557,500**	$1,070,375	$0	**$6,627,875**
$4,373	$48,107	$7,216	$4,811	**$60,134**	$5,171	**$65,305**	$9,796	$6,531	**$81,631**		$4,082		$4,898		$4,898	**$95,509**	$18,395	$0	**$113,904**
$5,117	$56,291	$8,444	$5,629	**$70,363**	$6,051	**$76,415**	$11,462	$7,641	**$95,518**		$4,776		$5,731		$5,731	**$111,756**	$21,524	$0	**$133,281**
$25,000	$275,000	$41,250	$27,500	**$343,750**	$29,563	**$373,313**	$55,997	$37,331	**$466,641**		$23,332		$27,998		$27,998	**$545,970**	$105,154	$0	**$651,123**

ANNUAL O&M COST

SITE	SITE NAME	WBS Top Tier	DESCRIPTION	QTY	UNIT	UNIT COST	SUBTOTAL	SOURCE	START YEAR	END YEAR	INTERVAL	NOTES
2	B-Complex	2WP&T Treatment O&M	372 P&T effluent 2WP&T	105120000	$/gal	$0.0231	$2,423,981	OTHER	1	25	1	Based on 2016 P&T annual report
2	B-Complex	Annual Performance Monitoring Report	902 Remedy Performance Monitoring & Reporting	0.67	EA	$36,634	$24,423	OTHER	1	25	1	1 report each year as a review, based on 360 hrs of geologist. 2/3 cost to B complex, 1/3 cost to WMA C
2	B-Complex	Annual Performance Monitoring Report	1004 Report Writing/Publishing	64	Team/hr	$382	$24,427	OTHER	1	27	1	
2	B-Complex	P&T Remedy Performance GW Monitoring	903 Data Reduction and Reporting	40.0	Team/hr	$333	$13,338	OTHER	1	25	1	assume 2 weeks required for drafting and approval of reports
							$0				1	
							$0				1	
3	WMA-C	2WP&T Treatment O&M	372 P&T effluent 2WP&T	52560000.00	$/gal	$0.0231	$1,211,991	OTHER	1	10	1	Based on 2016 P&T annual report
3	WMA-C	Annual Performance Monitoring Report	902 Remedy Performance Monitoring & Reporting	0.33	EA	$36,634	$12,210	OTHER	1	25	1	1 report each year as a review, based on 360 hrs of geologist. 2/3 cost to B complex, 1/3 cost to WMA C
3	WMA-C	Annual Performance Monitoring Report	1004 Report Writing/Publishing	64.00	Team/hr	$382	$24,427	OTHER	1	25	1	Assume 1 month level of effort divided between the 7 COCs for progress review
							$0				1	
2	B-Complex	Groundwater Monitoring	02 Sampling Crew	40.00	team/hr	$258	$10,301	OTHER	1	1	1	2 wells, quarterly sampling, 1 day sampling per event
2	B-Complex	Groundwater Monitoring	05 NO2/NO3	8.00	EA	$29	$229	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	03 Total Uranium	8	EA	$97	$773	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	04 Technetium-99	8	EA	$86	$688	OTHER	1	1	1	2 samples per well, 4 sampling events
2	B-Complex	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	8.00	EA	$98	$781	OTHER	1	1	1	events
2	B-Complex	Groundwater Monitoring	06 Total Cyanide	8	EA	$33	$267	OTHER	1	1	1	events
2	B-Complex	Groundwater Monitoring	09 Iodine-129	8	EA	$96	$768	OTHER	1	1	1	events
							$0				1	
2	B-Complex	Groundwater Monitoring	02 Sampling Crew	20.00	team/hr	$258	$5,150	OTHER	2	27	1	2 wells, semi-annual sampling, years 2 to 27 (year 2 to 25 P&T monitoring), years 26 and 27 post P&T
2	B-Complex	Groundwater Monitoring	05 NO2/NO3	4	EA	$29	$115	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	03 Total Uranium	4.00	EA	$97	$387	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	04 Technetium-99	4	EA	$86	$344	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	4	EA	$98	$391	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	06 Total Cyanide	4	EA	$33	$133	OTHER	2	27	1	
2	B-Complex	Groundwater Monitoring	09 Iodine-129	4	EA	$96	$384	OTHER	2	27	1	
							$0				1	
3	WMA-C	Groundwater Monitoring	02 Sampling Crew	40.00	team/hr	$258	$10,301	OTHER	1	1	1	2 wells, quarterly sampling, 1 day sampling per event
3	WMA-C	Groundwater Monitoring	05 NO2/NO3	8.00	EA	$29	$229	OTHER	1	1	1	2 samples per well, 4 sampling events
3	WMA-C	Groundwater Monitoring	04 Technetium-99	8	EA	$86	$688	OTHER	1	1	1	2 samples per well, 4 sampling events
							$0				1	
3	WMA-C	Groundwater Monitoring	02 Sampling Crew	20.00	team/hr	$258	$5,150	OTHER	2	27	1	2 wells, semi-annual sampling, years 2 to 27 (year 2 to 25 P&T monitoring), years 26 and 27 post P&T
3	WMA-C	Groundwater Monitoring	05 NO2/NO3	4.00	EA	$29	$115	OTHER	2	27	1	
3	WMA-C	Groundwater Monitoring	04 Technetium-99	4	EA	$86	$344	OTHER	2	27	1	
							$0				1	
							$0				1	
1	GAP	2WP&T Treatment O&M	372 P&T effluent 2WP&T	52560000.00	$/gal	$0.0231	$1,211,991	OTHER	1	10	1	Table 8.1, 150 gpm flow rate.
1	GAP	Annual Performance Monitoring Report	902 Remedy Performance Monitoring & Reporting	0.33	EA	$36,634	$12,210	OTHER	1	25	1	1 report each year as a review, based on 360 hrs of geologist. Shared cost between all 3 areas
1	GAP	Annual Performance Monitoring Report	1004 Report Writing/Publishing	64	Team/hr	$382	$24,427	OTHER	1	25	1	Assume 1 month level of effort divided between the 7 COCs for progress review
							$0				1	
1	GAP	Groundwater Monitoring	02 Sampling Crew	40.00	team/hr	$258	$10,301	OTHER	1	1	1	4 wells, quarterly sampling, 1 day sampling per event
1	GAP	Groundwater Monitoring	05 NO2/NO3	16.00	EA	$29	$459	OTHER	1	1	1	4 samples per well, 4 sampling events
1	GAP	Groundwater Monitoring	03 Total Uranium	16	EA	$97	$1,547	OTHER	1	1	1	4 samples per well, 4 sampling events
1	GAP	Groundwater Monitoring	04 Technetium-99	16	EA	$86	$1,376	OTHER	1	1	1	4 samples per well, 4 sampling events
1	GAP	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	16.00	EA	$98	$1,563	OTHER	1	1	1	4 samples per well, 4 sampling events
							$0				1	
1	GAP	Groundwater Monitoring	02 Sampling Crew	20.00	team/hr	$258	$5,150	OTHER	2	27	1	years 2 to 27 (year 2 to 25 P&T monitoring), years 26 and 27 post
1	GAP	Groundwater Monitoring	05 NO2/NO3	8	EA	$29	$229	OTHER	2	27	1	
1	GAP	Groundwater Monitoring	03 Total Uranium	8.00	EA	$97	$773	OTHER	2	27	1	
1	GAP	Groundwater Monitoring	04 Technetium-99	8	EA	$86	$688	OTHER	2	27	1	
1	GAP	Groundwater Monitoring	08 Strontium-89, 90 - Total Radioactive Sr	8	EA	$98	$781	OTHER	2	27	1	
							$0				1	

ANNUAL O&M MARKUPS

MDBI 0%	SUBTOTAL	Overhead 15%	Profit 10%	SUBTOTAL	WA States Sales Tax 8.6%	SUBTOTAL	Scope Contingency 15%	Bid Contingency 10%	SUBTOTAL	Technical Support Services Percent	Subtotal	SUBTOTAL	CHPRC G&A 19.26%	Institutional Controls	COST PER YEAR
$0	$2,423,981	$363,597	$242,398	**$3,029,977**	$260,578	**$3,290,555**	$493,583	$329,055	**$4,113,193**	19%	$781,507	**$4,894,700**	$942,719	$0	**$5,837,419**
$0	$24,423	$3,663	$2,442	**$30,528**	$2,625	**$33,154**	$4,973	$3,315	**$41,442**	45%	$18,649	**$60,092**	$11,574	$0	**$71,665**
$0	$24,427	$3,664	$2,443	**$30,533**	$0	**$30,533**	$4,580	$3,053	**$38,167**	45%	$17,175	**$55,341**	$10,659	$0	**$66,000**
$0	$13,338	$2,001	$1,334	**$16,672**	$1,434	**$18,106**	$2,716	$1,811	**$22,633**	45%	$10,185	**$32,817**	$6,321	$0	**$39,138**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$1,211,991	$181,799	$121,199	**$1,514,988**	$130,289	**$1,645,277**	$246,792	$164,528	**$2,056,597**	19%	$390,753	**$2,447,350**	$471,360	$0	**$2,918,710**
$0	$12,210	$1,832	$1,221	**$15,263**	$1,313	**$16,575**	$2,486	$1,658	**$20,719**	45%	$9,324	**$30,043**	$5,786	$0	**$35,829**
$0	$24,427	$3,664	$2,443	**$30,533**	$0	**$30,533**	$4,580	$3,053	**$38,167**	45%	$17,175	**$55,341**	$10,659	$0	**$66,000**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$10,301	$1,545	$1,030	**$12,876**	$1,107	**$13,983**	$2,097	$1,398	**$17,479**	45%	$7,865	**$25,344**	$4,881	$0	**$30,225**
$0	$229	$34	$23	**$287**	$25	**$311**	$47	$31	**$389**	45%	$175	**$564**	$109	$0	**$673**
$0	$773	$116	$77	**$967**	$83	**$1,050**	$157	$105	**$1,312**	45%	$591	**$1,903**	$366	$0	**$2,269**
$0	$688	$103	$69	**$860**	$74	**$934**	$140	$93	**$1,167**	45%	$525	**$1,693**	$326	$0	**$2,019**
$0	$781	$117	$78	**$977**	$84	**$1,061**	$159	$106	**$1,326**	45%	$597	**$1,922**	$370	$0	**$2,293**
$0	$267	$40	$27	**$333**	$29	**$362**	$54	$36	**$453**	45%	$204	**$656**	$126	$0	**$782**
$0	$768	$115	$77	**$960**	$83	**$1,043**	$156	$104	**$1,303**	45%	$586	**$1,890**	$364	$0	**$2,254**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$5,150	$773	$515	**$6,438**	$554	**$6,991**	$1,049	$699	**$8,739**	45%	$3,933	**$12,672**	$2,441	$0	**$15,113**
$0	$115	$17	$11	**$143**	$12	**$156**	$23	$16	**$195**	45%	$88	**$282**	$54	$0	**$336**
$0	$387	$58	$39	**$483**	$42	**$525**	$79	$52	**$656**	45%	$295	**$951**	$183	$0	**$1,135**
$0	$344	$52	$34	**$430**	$37	**$467**	$70	$47	**$584**	45%	$263	**$846**	$163	$0	**$1,009**
$0	$391	$59	$39	**$488**	$42	**$530**	$80	$53	**$663**	45%	$298	**$961**	$185	$0	**$1,146**
$0	$133	$20	$13	**$167**	$14	**$181**	$27	$18	**$226**	45%	$102	**$328**	$63	$0	**$391**
$0	$384	$58	$38	**$480**	$41	**$521**	$78	$52	**$652**	45%	$293	**$945**	$182	$0	**$1,127**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$10,301	$1,545	$1,030	**$12,876**	$1,107	**$13,983**	$2,097	$1,398	**$17,479**	45%	$7,865	**$25,344**	$4,881	$0	**$30,225**
$0	$229	$34	$23	**$287**	$25	**$311**	$47	$31	**$389**	45%	$175	**$564**	$109	$0	**$673**
$0	$688	$103	$69	**$860**	$74	**$934**	$140	$93	**$1,167**	45%	$525	**$1,693**	$326	$0	**$2,019**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$5,150	$773	$515	**$6,438**	$554	**$6,991**	$1,049	$699	**$8,739**	45%	$3,933	**$12,672**	$2,441	$0	**$15,113**
$0	$115	$17	$11	**$143**	$12	**$156**	$23	$16	**$195**	45%	$88	**$282**	$54	$0	**$336**
$0	$344	$52	$34	**$430**	$37	**$467**	$70	$47	**$584**	45%	$263	**$846**	$163	$0	**$1,009**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$1,211,991	$181,799	$121,199	**$1,514,988**	$130,289	**$1,645,277**	$246,792	$164,528	**$2,056,597**	19%	$390,753	**$2,447,350**	$471,360	$0	**$2,918,710**
$0	$12,210	$1,832	$1,221	**$15,263**	$1,313	**$16,575**	$2,486	$1,658	**$20,719**	45%	$9,324	**$30,043**	$5,786	$0	**$35,829**
$0	$24,427	$3,664	$2,443	**$30,533**	$0	**$30,533**	$4,580	$3,053	**$38,167**	45%	$17,175	**$55,341**	$10,659	$0	**$66,000**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$10,301	$1,545	$1,030	**$12,876**	$1,107	**$13,983**	$2,097	$1,398	**$17,479**	45%	$7,865	**$25,344**	$4,881	$0	**$30,225**
$0	$459	$69	$46	**$573**	$49	**$623**	$93	$62	**$778**	45%	$350	**$1,129**	$217	$0	**$1,346**
$0	$1,547	$232	$155	**$1,933**	$166	**$2,100**	$315	$210	**$2,625**	45%	$1,181	**$3,806**	$733	$0	**$4,538**
$0	$1,376	$206	$138	**$1,720**	$148	**$1,868**	$280	$187	**$2,335**	45%	$1,051	**$3,386**	$652	$0	**$4,038**
$0	$1,563	$234	$156	**$1,953**	$168	**$2,121**	$318	$212	**$2,652**	45%	$1,193	**$3,845**	$741	$0	**$4,585**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$5,150	$773	$515	**$6,438**	$554	**$6,991**	$1,049	$699	**$8,739**	45%	$3,933	**$12,672**	$2,441	$0	**$15,113**
$0	$229	$34	$23	**$287**	$25	**$311**	$47	$31	**$389**	45%	$175	**$564**	$109	$0	**$673**
$0	$773	$116	$77	**$967**	$83	**$1,050**	$157	$105	**$1,312**	45%	$591	**$1,903**	$366	$0	**$2,269**
$0	$688	$103	$69	**$860**	$74	**$934**	$140	$93	**$1,167**	45%	$525	**$1,693**	$326	$0	**$2,019**
$0	$781	$117	$78	**$977**	$84	**$1,061**	$159	$106	**$1,326**	45%	$597	**$1,922**	$370	$0	**$2,293**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**

PERIODIC O&M COST

WBS						UNIT			START	END		
SITE	SITE NAME	Top Tier	DESCRIPTION	QTY	UNIT	COST	SUBTOTAL	SOURCE	YEAR	YEAR	INTERVAL	NOTES
1	GAP	5-Year Review Report (Site Specific)	1006 Fate & Transport Contract	0.33	LS	$60,000	$20,000	OTHER	5	25	5	every 5 years, additional effort for 5 year reviews
1	GAP	5-Year Review Report (Site Specific)	361 Update Fate & Transport Model	0.33	5/yr	$65,000	$21,666	OTHER	5	25	5	updating the fate and transport model, used cost similar to 100-F/IU and SSPA agreement
1	GAP	5-Year Review Report (Site Specific)	1005 5th Year Summary Report	20	Team/hr	$480	$9,603	OTHER	5	25	5	every 5 years a report with fate and transport revisions
1	GAP						$0					
2	B-Complex	5-Year Review Report (Site Specific)	1006 Fate & Transport Contract	0.67	LS	$60,000	$40,000	OTHER	5	25	5	every 5 years, additional effort for 5 year reviews
							$0					
2	B-Complex	5-Year Review Report (Site Specific)	1005 5th Year Summary Report	20	Team/hr	$480	$9,603	OTHER	5	25	5	every 5 years a report with fate and transport revisions
2	B-Complex	5-Year Review Report (Site Specific)	361 Update Fate & Transport Model	0.67	5/yr	$65,000	$43,333	OTHER	5	25	5	updating the fate and transport model, used cost similar to 100-F/IU and Popadopolis agreement
							$0					
3	WMA-C	5-Year Review Report (Site Specific)	1006 Fate & Transport Contract	0.33	LS	$60,000	$20,000	OTHER	5	25	5	every 5 years, additional effort for 5 year reviews
3	WMA-C	5-Year Review Report (Site Specific)	1005 5th Year Summary Report	20	Team/hr	$480	$9,603	OTHER	5	25	5	every 5 years a report with fate and transport revisions
3	WMA-C	5-Year Review Report (Site Specific)	361 Update Fate & Transport Model	0.33	5/yr	$65,000	$21,666	OTHER	5	25	5	updating the fate and transport model, used cost similar to 100-F/IU and SSPA agreement
							$0					
2	B-Complex	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	2	EA	$4,499	$8,998	OTHER	10	25	10	2 monitoring wells
2	B-Complex	well maintenance	351 Well Maintenance Crew	4	Team/Hr	$1,122	$4,488	OTHER	10	25	10	2 hours per well (2 monitoring wells)
2	B-Complex	well maintenance	351 Well Maintenance Crew	20.00	Team/Hr	$1,122	$22,438	OTHER	10	25	10	Monitoring well rehab (10 hours per well, 2 wells)
							$0					
2	B-Complex	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	3	EA	$4,499	$13,497	OTHER	5	25	5	3 extraction wells
2	B-Complex	well maintenance	351 Well Maintenance Crew	6	Team/Hr	$1,122	$6,731	OTHER	5	25	5	2 hours per well (3 extraction wells)
2	B-Complex	well maintenance	351 Well Maintenance Crew	30.00	Team/Hr	$1,122	$33,657	OTHER	5	25	5	Monitoring well rehab (10 hours per well, 3 wells)
							$0					
3	WMA-C	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	2	EA	$4,499	$8,998	OTHER	10	25	10	2 monitoring wells
3	WMA-C	well maintenance	351 Well Maintenance Crew	4	Team/Hr	$1,122	$4,488	OTHER	10	25	10	2 hours per well (2 monitoring wells)
3	WMA-C	well maintenance	351 Well Maintenance Crew	20.00	Team/Hr	$1,122	$22,438	OTHER	10	25	10	Monitoring well rehab (10 hours per well, 2 wells)
							$0					
3	WMA-C	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	3	EA	$4,499	$13,497	OTHER	5	10	5	3 extraction wells
3	WMA-C	well maintenance	351 Well Maintenance Crew	6	Team/Hr	$1,122	$6,731	OTHER	5	10	5	2 hours per well (3 extraction wells)
3	WMA-C	well maintenance	351 Well Maintenance Crew	30.00	Team/Hr	$1,122	$33,657	OTHER	5	10	5	Monitoring well rehab (10 hours per well, 3 wells)
							$0					
1	GAP	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	4	EA	$4,499	$17,996	OTHER	10	25	10	4 monitoring wells
1	GAP	well maintenance	351 Well Maintenance Crew	8	Team/Hr	$1,122	$8,975	OTHER	10	25	10	2 hours per well (4 monitoring wells)
1	GAP	well maintenance	351 Well Maintenance Crew	40.00	Team/Hr	$1,122	$44,876	OTHER	10	25	10	Monitoring well rehab (10 hours per well, 4 wells)
							$0					
1	GAP	well maintenance	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	1	EA	$4,499	$4,499	OTHER	5	10	5	1 extraction wells
1	GAP	well maintenance	351 Well Maintenance Crew	2	Team/Hr	$1,122	$2,244	OTHER	5	10	5	2 hours per well (1 extraction wells)
1	GAP	well maintenance	351 Well Maintenance Crew	10.00	Team/Hr	$1,122	$11,219	OTHER	5	10	5	Monitoring well rehab (10 hours per well, 1 wells)
							$0					
1	GAP	well maintenance	351 Well Maintenance Crew	20	Team/Hr	$1,122	$22,438	OTHER	2	10	2	2 injection wells, 10 hours per well
							$0					
2	B-Complex	Replacement GW Monitoring Wells	350 Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	4.00	EA	$4,499	$17,996	OTHER	15	25	15	new pump during injection well replacement for 200W wells (4 well allocated to B Complex, 2 to WMA C)
2	B-Complex	Replacement GW Monitoring Wells	355 Drilling Mobilization, completion, cleanup and demob	8	per well	$36,250	$290,000	OTHER	15	25	15	4 new injection wells
2	B-Complex	Replacement GW Monitoring Wells	356 Drilling & Construction (per foot)	1200	LF	$546	$655,200	OTHER	15	25	15	4 new injection wells to 300 ft each
2	B-Complex	Replacement GW Monitoring Wells	365 In process GW samples	40	EA	$1,800	$72,000	0	15	25	15	10 samples per well during drilling
2	B-Complex	Replacement GW Monitoring Wells	367 Sampling Crew	80	Hr	$258	$20,601	OTHER	15	25	15	2 hours per sample
2	B-Complex	Replacement GW Monitoring Wells	369 Technetium-99	40	EA	$86	$3,440	OTHER	15	25	15	10 samples per well during drilling
2	B-Complex	Replacement GW Monitoring Wells	370 NO2/NO3	40	EA	$29	$1,160	OTHER	15	25	15	10 samples per well during drilling
							$0					
2	B-Complex	well maintenance	351 Well Maintenance Crew	10	Team/Hr	$1,122	$11,219	OTHER	2	10	2	injection well maintenance
							$0					
3	WMA-C	well maintenance	351 Well Maintenance Crew	10	Team/Hr	$1,122	$11,219	OTHER	2	10	2	injection well maintenance
							$0					

PERIODIC O&M MARKUPS

MDBI		Overhead	Profit		Sales Tax		Contingency			Technical Support Services			CHPRC G&A	Institutional	
0%	SUBTOTAL	15%	10%	SUBTOTAL	8.6%	SUBTOTAL	15%	10%	SUBTOTAL	Percent	Subtotal	SUBTOTAL	19.26%	Controls	COST PER YEAR
$0	$20,000	$3,000	$2,000	**$25,000**	$0	**$25,000**	$3,750	$2,500	**$31,250**	45%	$14,062	**$45,312**	$8,727	$0	**$54,039**
$0	$21,666	$3,250	$2,167	**$27,083**	$2,329	**$29,412**	$4,412	$2,941	**$36,765**	45%	$16,544	**$53,310**	$10,267	$0	**$63,577**
$0	$9,603	$1,440	$960	**$12,004**	$0	**$12,004**	$1,801	$1,200	**$15,005**	45%	$6,752	**$21,757**	$4,190	$0	**$25,948**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$40,000	$6,000	$4,000	**$50,000**	$0	**$50,000**	$7,500	$5,000	**$62,500**	45%	$28,125	**$90,625**	$17,454	$0	**$108,080**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$9,603	$1,440	$960	**$12,004**	$0	**$12,004**	$1,801	$1,200	**$15,005**	45%	$6,752	**$21,757**	$4,190	$0	**$25,948**
$0	$43,333	$6,500	$4,333	**$54,167**	$4,658	**$58,825**	$8,824	$5,883	**$73,531**	45%	$33,089	**$106,620**	$20,535	$0	**$127,155**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$20,000	$3,000	$2,000	**$25,000**	$0	**$25,000**	$3,750	$2,500	**$31,250**	45%	$14,062	**$45,312**	$8,727	$0	**$54,039**
$0	$9,603	$1,440	$960	**$12,004**	$0	**$12,004**	$1,801	$1,200	**$15,005**	45%	$6,752	**$21,757**	$4,190	$0	**$25,948**
$0	$21,666	$3,250	$2,167	**$27,083**	$2,329	**$29,412**	$4,412	$2,941	**$36,765**	45%	$16,544	**$53,310**	$10,267	$0	**$63,577**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$8,998	$1,350	$900	**$11,248**	$967	**$12,215**	$1,832	$1,221	**$15,268**	45%	$6,871	**$22,139**	$4,264	$0	**$26,403**
$0	$4,488	$673	$449	**$5,610**	$0	**$5,610**	$841	$561	**$7,012**	45%	$3,155	**$10,167**	$1,958	$0	**$12,125**
$0	$22,438	$3,366	$2,244	**$28,048**	$0	**$28,048**	$4,207	$2,805	**$35,060**	45%	$15,777	**$50,836**	$9,791	$0	**$60,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$13,497	$2,025	$1,350	**$16,871**	$1,451	**$18,322**	$2,748	$1,832	**$22,903**	45%	$10,306	**$33,209**	$6,396	$0	**$39,605**
$0	$6,731	$1,010	$673	**$8,414**	$0	**$8,414**	$1,262	$841	**$10,518**	45%	$4,733	**$15,251**	$2,937	$0	**$18,188**
$0	$33,657	$5,049	$3,366	**$42,071**	$0	**$42,071**	$6,311	$4,207	**$52,589**	45%	$23,665	**$76,254**	$14,687	$0	**$90,941**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$8,998	$1,350	$900	**$11,248**	$967	**$12,215**	$1,832	$1,221	**$15,268**	45%	$6,871	**$22,139**	$4,264	$0	**$26,403**
$0	$4,488	$673	$449	**$5,610**	$0	**$5,610**	$841	$561	**$7,012**	45%	$3,155	**$10,167**	$1,958	$0	**$12,125**
$0	$22,438	$3,366	$2,244	**$28,048**	$0	**$28,048**	$4,207	$2,805	**$35,060**	45%	$15,777	**$50,836**	$9,791	$0	**$60,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$13,497	$2,025	$1,350	**$16,871**	$1,451	**$18,322**	$2,748	$1,832	**$22,903**	45%	$10,306	**$33,209**	$6,396	$0	**$39,605**
$0	$6,731	$1,010	$673	**$8,414**	$0	**$8,414**	$1,262	$841	**$10,518**	45%	$4,733	**$15,251**	$2,937	$0	**$18,188**
$0	$33,657	$5,049	$3,366	**$42,071**	$0	**$42,071**	$6,311	$4,207	**$52,589**	45%	$23,665	**$76,254**	$14,687	$0	**$90,941**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$17,996	$2,699	$1,800	**$22,495**	$1,935	**$24,430**	$3,664	$2,443	**$30,537**	45%	$13,742	**$44,279**	$8,528	$0	**$52,807**
$0	$8,975	$1,346	$898	**$11,219**	$0	**$11,219**	$1,683	$1,122	**$14,024**	45%	$6,311	**$20,335**	$3,916	$0	**$24,251**
$0	$44,876	$6,731	$4,488	**$56,095**	$0	**$56,095**	$8,414	$5,610	**$70,119**	45%	$31,554	**$101,673**	$19,582	$0	**$121,255**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$4,499	$675	$450	**$5,624**	$484	**$6,107**	$916	$611	**$7,634**	45%	$3,435	**$11,070**	$2,132	$0	**$13,202**
$0	$2,244	$337	$224	**$2,805**	$0	**$2,805**	$421	$280	**$3,506**	45%	$1,578	**$5,084**	$979	$0	**$6,063**
$0	$11,219	$1,683	$1,122	**$14,024**	$0	**$14,024**	$2,104	$1,402	**$17,530**	45%	$7,888	**$25,418**	$4,896	$0	**$30,314**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$22,438	$3,366	$2,244	**$28,048**	$0	**$28,048**	$4,207	$2,805	**$35,060**	45%	$15,777	**$50,836**	$9,791	$0	**$60,627**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$17,996	$2,699	$1,800	**$22,495**	$1,935	**$24,430**	$3,664	$2,443	**$30,537**	45%	$13,742	**$44,279**	$8,528	$0	**$52,807**
$0	$290,000	$43,500	$29,000	**$362,500**	$31,175	**$393,675**	$59,051	$39,368	**$492,094**	33%	$162,391	**$654,485**	$126,054	$0	**$780,538**
$0	$655,200	$98,280	$65,520	**$819,000**	$70,434	**$889,434**	$133,415	$88,943	**$1,111,793**	26%	$289,066	**$1,400,859**	$269,805	$0	**$1,670,664**
$0	$72,000	$10,800	$7,200	**$90,000**	$7,740	**$97,740**	$14,661	$9,774	**$122,175**	33%	$40,318	**$162,493**	$31,296	$0	**$193,789**
$0	$20,601	$3,090	$2,060	**$25,751**	$2,215	**$27,966**	$4,195	$2,797	**$34,957**	45%	$15,731	**$50,688**	$9,763	$0	**$60,451**
$0	$3,440	$516	$344	**$4,300**	$370	**$4,670**	$700	$467	**$5,837**	45%	$2,627	**$8,464**	$1,630	$0	**$10,094**
$0	$1,160	$174	$116	**$1,450**	$125	**$1,575**	$236	$157	**$1,968**	45%	$886	**$2,854**	$550	$0	**$3,404**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$11,219	$1,683	$1,122	**$14,024**	$0	**$14,024**	$2,104	$1,402	**$17,530**	45%	$7,888	**$25,418**	$4,896	$0	**$30,314**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**
$0	$11,219	$1,683	$1,122	**$14,024**	$0	**$14,024**	$2,104	$1,402	**$17,530**	45%	$7,888	**$25,418**	$4,896	$0	**$30,314**
$0	$0	$0	$0	**$0**	$0	**$0**	$0	$0	**$0**	45%	$0	**$0**	$0	$0	**$0**

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Appendix D

Line Item Detail

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D1 Introduction

Capital and operations and maintenancegroups used in the estimate are provided in this appendix.

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Table D-1. Capital Unit Cost Summary

Location:	200 BP-5/200-PO-1 Groundwater OU
Phase:	Interim Action
Base Year:	2018
Date:	8/30/2018

	Item	Qty	Unit Cost	Units	Total	Source	Institutional Control?	Add OH and Profit?	Labor Only?	% of non-labor item to be taxed	Notes/References
	MOBILIZATION/DEMOBILIZATION; TEMPORARY UTILTIES AND FACILITIES: #1 - 49										
3	Cross Site Pipeline	3.00	$2,600,000	LS	$ 7,800,000	OTHER	NO	YES	NO	100%	This is a built up cost. See tab Design crew in the NitrateXsite tab for details
6	Training	13.00	$30,000	LS	$ 390,000	OTHER	NO	YES	NO	100%	estimation
10	Drilling Mobilization, completion, cleanup and demob	94.00	$36,250	per well	$ 3,407,500	OTHER	NO	YES	NO	100%	subcontract 56189 Release 1
11	Drilling & Construction (per foot)	19,500.00	$546	LF	$ 10,647,000	OTHER	NO	YES	NO	100%	subcontract 56189 Release 1
13	In process GW samples	588.00	$1,800	EA	$ 1,058,400	OTHER	NO	YES	NO	100%	subcontract 56189 Release 1
16	HDPE Dual Containment (6x10)	210,859.59	$35	LF	$ 7,371,651	OTHER	NO	YES	NO	100%	obtained from CP266/harington plastics
17	Freight for HDPE Pipe	117.00	$2,500	trip	$ 292,500	OTHER	NO	YES	NO	100%	26750 ft * 18 pounds/ft = 481,500# @ 40,000#/load that is 12 loads @ $2500/trip that is $30,094, say $35,000 freight cost
19	Mobilization for pipeline crew	26.00	$1,500	LS	$ 39,000	OTHER	NO	YES	NO	100%	Allowance
21	Technetium-99	370.00	$95	EA	$ 35,150	OTHER	NO	YES	NO	100%	
22	NO2/NO3	590.00	$50	EA	$ 29,500	OTHER	NO	YES	NO	100%	
23	Total Cyanide	160.00	$50	EA	$ 8,000	OTHER	NO	YES	NO	100%	
25	Strontium-89, 90 - Total Radioactive Sr	200.00	$95	EA	$ 19,000	OTHER	NO	YES	NO	100%	
26	Iodine-129	130.00	$95	EA	$ 12,350	OTHER	NO	YES	NO	100%	
29	3-inch diameter HDPE	70,078.74	$10	LF	$ 700,787	OTHER	NO	YES	NO	100%	From 200-UP-1 Southeast Cr Plume cost estimate
	GROUNDWATER EXTRACTION/INJECTION OR CONTAINMENT: #250 - 349										
252	Sampling Crew	289.00	$258	Team/Hr	$ 74,421	OTHER	NO	YES	NO	100%	Harrington 2154434 - Sept 2014
259	Transformers pole brackets	9.00	$423	EA	$ 3,807	OTHER	NO	YES	NO	100%	
260	Fiber-optic cable and interfaces	95,977.69	$1.33	FT	$ 127,650	OTHER	NO	YES	NO	100%	DOW Corning 006E8F-31131-A1
266	#10/4C THHN (tray cable)	61,811.02	$1.52	LF	$ 93,953	OTHER	NO	YES	NO	100%	Wire & cable to Go 5/19/15 quote
270	Road Crossings	26.00	$15,000	Sleeve	$ 390,000	OTHER	NO	YES	NO	100%	XXXXX need info
271	Riser Pipe	5,100.00	$50	LF	$ 252,654	OTHER	NO	YES	NO	100%	Grainger, Item 4TNL9
273	Tray Cable #10 4C THHN	61,811.02	$3	LF	$ 215,102	OTHER	NO	YES	NO	100%	Wire & cable to Go 5/19/15 quote
275	Pump Assembly	21.00	$3,200	EA	$ 67,200	OTHER	NO	YES	NO	100%	Grundfos 25C50-26 $3200/ea
279	Disconnect Boxes	9.00	$400	EA	$ 3,600	OTHER	NO	YES	NO	100%	place holder for disconnect
280	Allowance for Electrical Hookups	9.00	$228	EA	$ 2,052	OTHER	NO	YES	NO	100%	allowance (10% of cost of cable)
283	Injection Rack	7.00	$17,000	EA	$ 119,000	HISTORICAL	NO	YES	NO	100%	
284	Extraction rack	9.00	$40,000	EA	$ 360,000	HISTORICAL	NO	YES	NO	100%	
285	Pump Setting Crew	480.00	$262	Team/Hr	$ 125,633	OTHER	NO	YES	NO	100%	see pump setting crew list and hours in crewlist tab
286	Power Pole Allowance	9.00	$1,848	EA	$ 16,632	OTHER	NO	YES	NO	100%	UP1 estimate of 8/1/2012, (pole setting, guy rigging, insulators and switches, lightening arrester, conductors, splicers, fasters, etc.)
287	Subcontract power pole & power distribution	10,000.00	$7	LF	$ 72,900	OTHER	NO	YES	NO	100%	UP1 estimate of 8/1/2012,
288	Water Level Monitoring System	44.00	$15,670	EA	$ 689,480	OTHER	NO	YES	NO	100%	Estimated based upon change proposal 30-254 plus 80 hrs of instrument tech T070 for installation
289	Landing Plate	17.00	$350	EA	$ 5,950	OTHER	NO	YES	NO	100%	NA1100008921, 2/8/12 Rod Wordiman, Glen Cronister

	Item	Qty	Unit Cost	Units	Total	Source	Institutional Control?	Add OH and Profit?	Labor Only?	% of non-labor item to be taxed	Notes/References
	MOBILIZATION/DEMOBILIZATION; TEMPORARY UTILTIES AND FACILITIES: #1 - 49										
296	Technetium-99 Treatment Train	2.00	$719,000	LS	$ 1,438,000	OTHER	NO	YES	NO	100%	Tech treatment train
300	10000 Gallon Norwesco Plastic Potable Water Storage Tank	3.00	$6,000	LS	$ 18,000	OTHER	NO	YES	NO	100%	Cost from 100-BC Cost Estimate
302	Outdoor Transfer Station	3.00	$500,000	LS	$ 1,500,000	OTHER	NO	YES	NO	100%	Uriquidi 8/13 e-mail with excel file Harrington-cross- site and BP-5 system-r4.xlsx
303	Outdoor Transfer StationCAT/ATP	3.00	$25,000		$ 75,000	OTHER	NO	YES	NO	100%	5% of Transfer Station cost ($600,000*5% = $30,000)
305	New Air Stripper	2.00	$3,800,000	LS	$ 7,600,000	OTHER	NO	YES	NO	100%	From R. Harrison 9/11/2018 e-mail ($3,700,000) and 2 booster pumps $100,000 (Uriquidi 10/11/1028 e-mail)
307	Modutank Modifications	2.00	$250,000	LS	$ 500,000	OTHER	NO	YES	NO	100%	Middle of range from G. Berquist
	RESERVED: #1000 - 1049										
1000	ATP/OTP Crew	260.00	$581	Team Hr	$ 151,037	OTHER	NO	YES	NO	100%	BASED ON CP264-1490, FY 2015
1001	SOW Crew	560.00	$276	Team/hr	$ 154,585	OTHER	NO	YES	NO	100%	
	RESERVED FOR PROJECT-SPECIFIC UNIT COSTS: #1050 - 1999										
1050	Pipe Fusion Crew (includes testing)	1,963.25	$585	team hr	$ 1,148,618	OTHER	NO	YES	NO	100%	

Table D-2. O&M Unit Cost Summary

Location:	200 BP-5/200-PO-1 Groundwater OU
Phase:	Interim Action
Base Year:	2018
Date:	8/30/2018

	Item	Qty	Unit Cost	Units	Total	Source	Institutional Control?	Add OH and Profit?	Labor Only?	% of non-labor item to be taxed	Notes/References
	MONITORING, TESTING, SAMPLING & ANALYSIS: #1 - 199										
2	Sampling Crew	300.00	$258	team/hr	$ 77,254	OTHER	NO	YES	NO	100%	Built up labor cost
3	Total Uranium	48.00	$97	EA	$ 4,640	OTHER	NO	YES	NO	100%	Average of 3 labs cost for Uranium analysis.
4	Technetium-99	72.00	$86	EA	$ 6,192	OTHER	NO	YES	NO	100%	Average of 3 labs cost for Tc analysis.
5	NO2/NO3	72.00	$29	EA	$ 2,064	OTHER	NO	YES	NO	100%	Average of 3 labs cost for NO2 analysis.
6	Total Cyanide	24.00	$33	EA	$ 800	OTHER	NO	YES	NO	100%	
7	Tritium	-	$71	EA	$ -	OTHER	NO	YES	NO	100%	
8	Strontium-89, 90 - Total Radioactive Sr	48.00	$98	EA	$ 4,688	OTHER	NO	YES	NO	100%	
9	Iodine-129	24.00	$96	EA	$ 2,304	OTHER	NO	YES	NO	100%	
	GROUNDWATER EXTRACTION/INJECTION OR CONTAINMENT: #350 - 549										
350	Pump, submersible, 6in dia with 3 in discharge, 15 HP, 480 VAC	33.00	$4,499	EA	$ 148,467	OTHER	NO	YES	NO	100%	MFG: Grundfos, model number 150S150-7, Cat/Pcard ID: 0000668709. Unattached 3 phase Franklin motor P/N 236-613-4020 items is UL Recognized
351	Well Maintenance Crew	360.00	$1,122	Team/Hr	$ 403,886	OTHER	NO	YES	YES	100%	
355	Drilling Mobilization, completion, cleanup and demob	16.00	$36,250	per well	$ 580,000	OTHER	NO	YES	NO	100%	subcontract 56189 Release 1
356	Drilling & Construction (per foot)	2,400.00	$546	LF	$ 1,310,400	OTHER	NO	YES	NO	100%	subcontract 56189 Release 1
361	Update Fate & Transport Model	2.33	$65,000	5/yr	$ 151,666	OTHER	NO	YES	NO	100%	following F/IU-Popadopolis agreement
365	In process GW samples	80.00	$1,800	EA	$ 144,000		NO	YES	NO	100%	
367	Sampling Crew	160.00	$258	Hr	$ 41,202	OTHER	NO	YES	NO	100%	
369	Technetium-99	80.00	$86	EA	$ 6,880	OTHER	NO	YES	NO	100%	
370	NO2/NO3	80.00	$29	EA	$ 2,320	OTHER	NO	YES	NO	100%	
372	P&T effluent 2WP&T	367,920,000.00	$0.0231	$/gal	$ 8,483,934	OTHER	NO	YES	NO	100%	200WP&T 2016 unit costs from annual P&T report
	PROGRESS REVIEWS AND REPORTS: #900 - 949										
902	Remedy Performance Monitoring & Reporting	2.33	$36,634	EA	$ 85,476	OTHER	NO	YES	NO	100%	360 hrs of Geologist (S030) @rate = $101.73, per CP251 (UP-1)
903	Data Reduction and Reporting	80.00	$333	Team/hr	$ 26,676	OTHER	NO	YES	NO	100%	detail is found in CrewList
	RESERVED: #1000 - 1099										
1004	Report Writing/Publishing	320.00	$382	Team/hr	$ 122,133	OTHER	NO	YES	YES	100%	Built up labor cost
1005	5th Year Summary Report	100.00	$480	Team/hr	$ 48,017	OTHER	NO	YES	YES	100%	Built up labor cost
1006	Fate & Transport Contract	2.33	$60,000	LS	$ 140,000	OTHER	NO	YES	YES	100%	Contract - from F/IU ECE

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