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Limited Field Investigation for the 200-UP-1 Operable Unit

United States
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Richland, Washington

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EXECUTIVE SUMMARY

This limited field investigation (LFI) is based on the process set forth in the *Hanford Past-Practice Strategy* (DOE-RL 1991) and recommendations in the *200 West Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1993a). The LFI process is implemented within the 200-UP-1 Operable Unit to refine the site conceptual model developed in the *U Plant Aggregate Area Management Study Report* (DOE-RL 1992b) and provide data for performance of a risk assessment. The LFI is conducted in accordance with the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1994c). The Remedial Investigation/Feasibility Study (RI/FS) work plan provides background information and direction for conducting the LFI in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process.

The 200-UP-1 Groundwater Operable Unit is located in the southern portion of the 200 West Area on the Hanford Site in Washington State. The operable unit is located adjacent to the 200-ZP-1 Groundwater Operable Unit and underlies a significant part of seven source operable units: 200-RO-1, 200-RO-2, 200-RO-3, 200-RO-4, 200-SS-2, 200-UP-2, and 200-UP-3. Remedial efforts in the 200-ZP-1 Operable Unit focus on addressing volatile organic contamination (e.g., carbon tetrachloride) in the aquifer. The focus of the 200-UP-1 LFI is on contaminated aquifer soils and groundwater within its boundary, with the exception of uranium and technetium-99 plumes, which are addressed by an existing 200-UP-1 interim remedial measure (IRM).

The LFI approach is driven by general and specific data needs required to refine the site conceptual model and conduct a risk assessment. Activities supporting the LFI include drilling, well construction, sampling and analysis, data validation, geologic and geophysical logging, aquifer testing, measuring depth to water, and evaluating geodetic survey and existing analytical data.

Thirteen of twenty-six high-priority groundwater contaminants were detected in the 200-UP-1 Operable Unit that exceed *Safe Drinking Water Act*, *Model Toxics Control Act*, and *Uranium Mill Tailings Radiation Control Act* groundwater standards. High-priority contaminants exceeding groundwater standards include 1,1-dichloroethene, 1,2-dichloroethane, arsenic, cadmium, carbon tetrachloride, chloroform, chromium, fluoride, iodine-129, strontium-90, technetium-99, trichloroethene, and uranium. The distribution of these contaminants in groundwater occurs as well-defined plumes and sporadic occurrences. The distribution of the remaining 13 contaminants is characterized as undetects, one-time detections, below background, or below applicable groundwater standards. Evaluation of the vertical extent of the technetium-99 and uranium plumes suggests that contamination extends to a depth of about 30 m (100 ft) below the water table. Carbon tetrachloride is distributed similarly in the upper aquifer; however, elevated levels were also detected immediately above and below the Ringold lower mud unit (confining unit). Detection of the three contaminants at depth correlates strongly with groundwater monitoring wells lacking annular seals.

The risk assessment addresses current and future human health risk associated with exposure to chemical and radionuclides in the groundwater. The commercial/industrial ingestion scenario was used to estimate current risks, whereas the commercial/industrial and residential ingestion scenarios were used to estimate future risks. As applicable to future risks, the commercial/ industrial scenario was employed within the area designated as the "hypothetical future-use boundary." Outside this boundary, the residential scenario was assumed for the risk assessment.

Application of the risk assessment suggests that the predominant current and future risks are attributed to carbon tetrachloride. Current conditions for carbon tetrachloride suggest there is significant noncarcinogenic risk (hazard quotient >1); the incremental lifetime cancer risk ($>1 \times 10^{-4}$) suggests there is also significant carcinogenic risk. An assessment of future conditions suggests that only carbon tetrachloride will reach the hypothetical future-use boundary at concentrations indicative of significant noncarcinogenic and carcinogenic risk.

A qualitative evaluation of ecological risk was performed using a benchmarking method to assess potential ecological effects on aquatic life. The analysis suggests that carbon tetrachloride may present a significant ecological risk to aquatic life when the plume eventually reaches the river. The evaluation also suggests that the concentration of chromium at the river also indicates significant risk to aquatic life. However, chromium was eliminated as a contaminant of potential concern because dilution within near-shore aquifer sediments was not considered in the analysis. Investigation in the 100 Areas of the Hanford Site suggests that dilution in near-shore aquifer sediments would reduce chromium concentrations below the established benchmark.

200-UP-1 high-priority groundwater contaminants are not recommended for IRM designation because fate and transport analysis suggests that concentrations present little risk at the hypothetical future-use boundary, with the exception of carbon tetrachloride. It is recommended that carbon tetrachloride be addressed as part of the 200-ZP-1 Operable Unit remedial effort to address this 200 West Area-wide concern.

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ACRONYMS AND ABBREVIATIONS

AAMSR	aggregate area management study report
ARAR	applicable or relevant and appropriate requirement(s)
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COPC	contaminant(s) of potential concern
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
FSUWG	Future Site Uses Working Group
HSRAM	Hanford Site Risk Assessment Methodology
ILCR	incremental lifetime cancer risk
IRM	interim remedial measure
LFI	limited field investigation
MCL	maximum contaminant level
MTCA	*Model Toxics Control Act*
NTU	nephelometric turbidity unit
PNNL	Pacific Northwest National Laboratory
RBDA	risk-based decision analysis
RCRA	*Resource Conservation and Recovery Act of 1976*
RI/FS	remedial investigation/feasibility study
VOA	volatile organics analysis

1.0 INTRODUCTION

This report summarizes results of the 200-UP-1 Operable Unit limited field investigation (LFI). The general approach for this investigation is based on the process set forth in the *Hanford Past-Practice Strategy* (DOE-RL 1991) and recommendations in the *200 West Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1993a). The *Hanford Past-Practice Strategy* identifies the need to accelerate the cleanup process by favoring interim cleanup activities for high-priority groundwater plumes. The 200 West AAMSR focuses the Hanford Past-Practice Strategy by identifying high-priority groundwater contamination to be addressed by an LFI or interim remedial measure (IRM).

The LFI process is implemented within the 200-UP-1 Operable Unit to refine the site conceptual model and provide data for performance of a risk assessment. The LFI is conducted in accordance with the *Remedial Investigation/Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1994c). The remedial investigation/feasibility study (RI/FS) work plan provides background information and direction for conducting the LFI in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) process. The investigative approach described in the RI/FS work plan is approved by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) as set forth in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994).

1.1 PURPOSE AND SCOPE

The primary objective of this 200-UP-1 Groundwater Operable Unit LFI is to provide enough information on the aquifer and high-priority groundwater contaminants to refine the site conceptual model and conduct a risk assessment. Conceptual model refinement involves expanding knowledge of the site related to six general data needs (i.e., hydrostratigraphy, aquifer properties, groundwater flow, source contributions, nature and extent of contamination, and groundwater geochemistry) as defined in the RI/FS work plan (DOE-RL 1994c). The risk assessment relies on the development of the conceptual model following guidelines presented in the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1995c) and the *Risk-Based Decision Analysis for 200 Area Groundwater Operable Units* (RBDA) (BHI 1995b). The site conceptual model and risk assessment are used to identify high-priority groundwater contaminants recommended for IRM designation, to support the existing IRM, and to establish interim action goals.

Twenty-six high-priority groundwater contaminants are identified within the 200-UP-1 Groundwater Operable Unit (DOE-RL 1994c). High-priority groundwater contaminants include the following:

- Fifteen organic compounds: 1,2-dichloroethane, 1,1-dichloroethylene, pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, heptachlor), bis(2-ethylhexyl)phthalate, carbon tetrachloride, chloroform, trichloroethylene, and n-nitrosodimethylamine
- Six radionuclides: iodine-129, potassium-40, plutonium-238, strontium-90, technetium-99, and uranium
- Five inorganic contaminants: arsenic, cadmium, chromium, fluoride, and selenium.

1.2 SITE LOCATION AND DESCRIPTION

The 200-UP-1 Groundwater Operable Unit is located in the 200 West Area of the Hanford Site in Washington State (Figure 1-1). The operable unit is located adjacent to the 200-ZP-1 Groundwater Operable Unit and underlies a significant part of seven source operable units: 200-RO-1, 200-RO-2, 200-RO-3, 200-RO-4, 200-SS-2, 200-UP-2, and 200-UP-3. The 200-UP-1 Groundwater Operable Unit includes all contamination found in the aquifer soils and water within its boundary. Source operable units include facilities and unplanned release sites that are potential sources of contamination. An LFI for the 200-UP-2 Operable Unit (DOE-RL 1995e) has been prepared to address contamination in the 200-UP-2 source area. The strategy to address contamination in the six remaining source units is being developed.

1.3 OPERABLE UNIT BACKGROUND AND SETTING

A summary description of the 200-UP-1 Operable Unit background and setting is presented in Section 2.0 of the RI/FS Work Plan (DOE-RL 1994c).

1.4 EXISTING IRM IN THE 200-UP-1 OPERABLE UNIT

An existing IRM is being implemented in the 200-UP-1 Groundwater Operable Unit to accelerate cleanup of uranium and technetium-99 in the groundwater. The objectives of the IRM are to focus on the areas of high uranium and technetium-99 contamination, prevent movement of contaminants in those areas, and provide input to select a final remedy. The two high-concentration/target IRM plumes correspond to an area of contamination approximately defined by the 600-ppb uranium and 9,000-pCi/L technetium-99 contour intervals (see Figures 1-2 and 1-3, respectively). A discussion of the existing 200-UP-1 IRM is described in *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford, Washington* (DOE-RL 1995d).

A risk assessment for the target IRM and peripheral concentrations of the plumes is presented in Appendix B, "Risk-Based Decision Analysis for the 200-UP-1 Operable Unit," of the *Engineering Evaluation/Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure* (BHI 1996b). Uranium and technetium-99 in this area of the operable unit are not addressed as part of this LFI report. Only the uranium and technetium-99 located outside of the main body of the plumes and other contaminants identified in Section 1.1 are evaluated in this LFI report.

1.5 REPORT ORGANIZATION

This report contains six sections. Section 1.0 describes the rationale for conducting the 200-UP-1 LFI, background information, and the organization of the report. Section 2.0 provides a summary of data needs and LFI activities. Results of the LFI are presented in Section 3.0. Section 4.0 summarizes the site conceptual model and discusses applicable or relevant and appropriate requirements (ARARs). Section 5.0 summarizes the risk assessment. Recommendations and conclusions are presented in Section 6.0. Section 7.0 lists references cited in this report. Appendix A contains 200 National Priorities List agreements. Appendix B contains the risk assessment report.

Figure 1-1. Operable Unit Location Map.

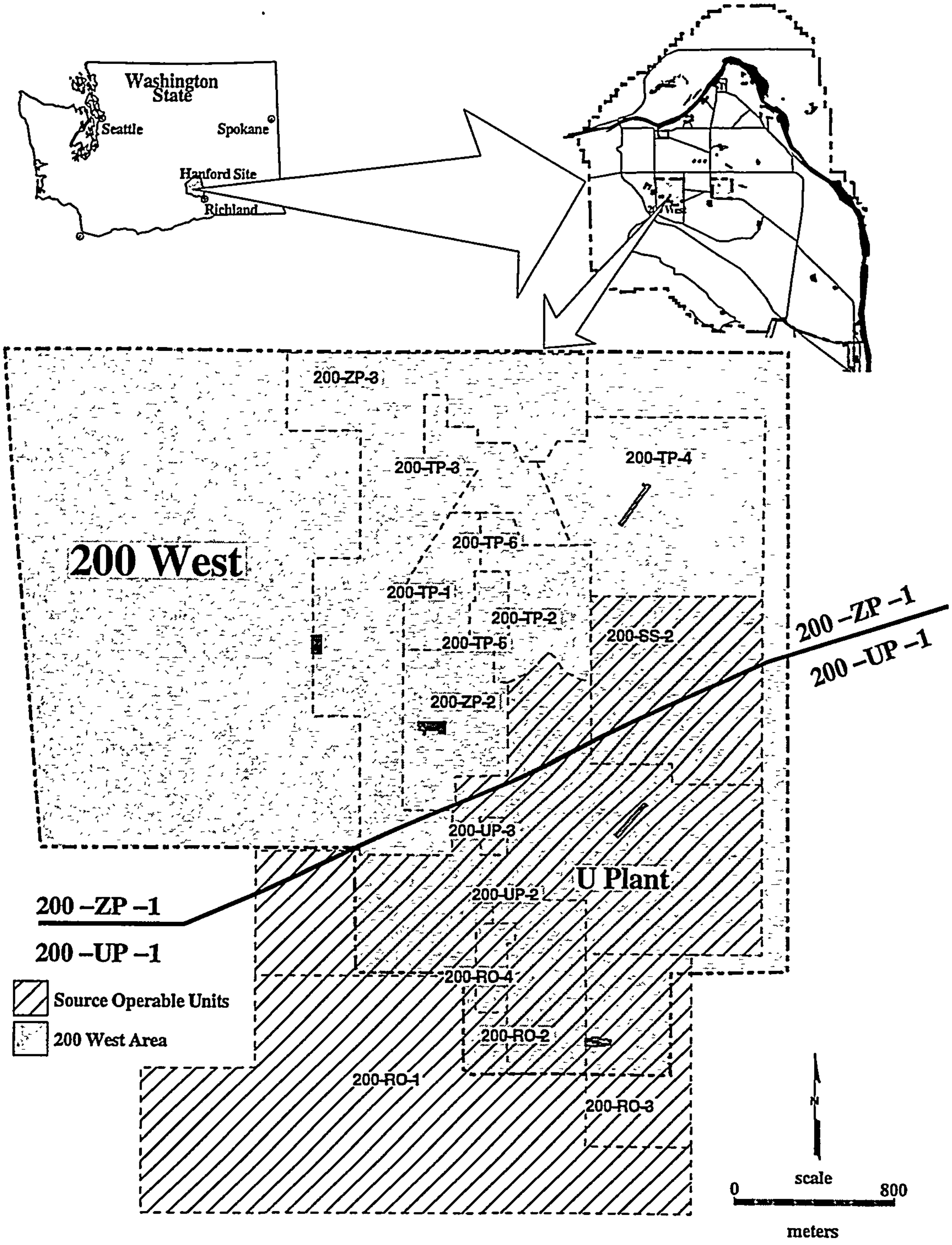


Figure 1-2. Concentration Isopleths for Uranium (in μg/L).

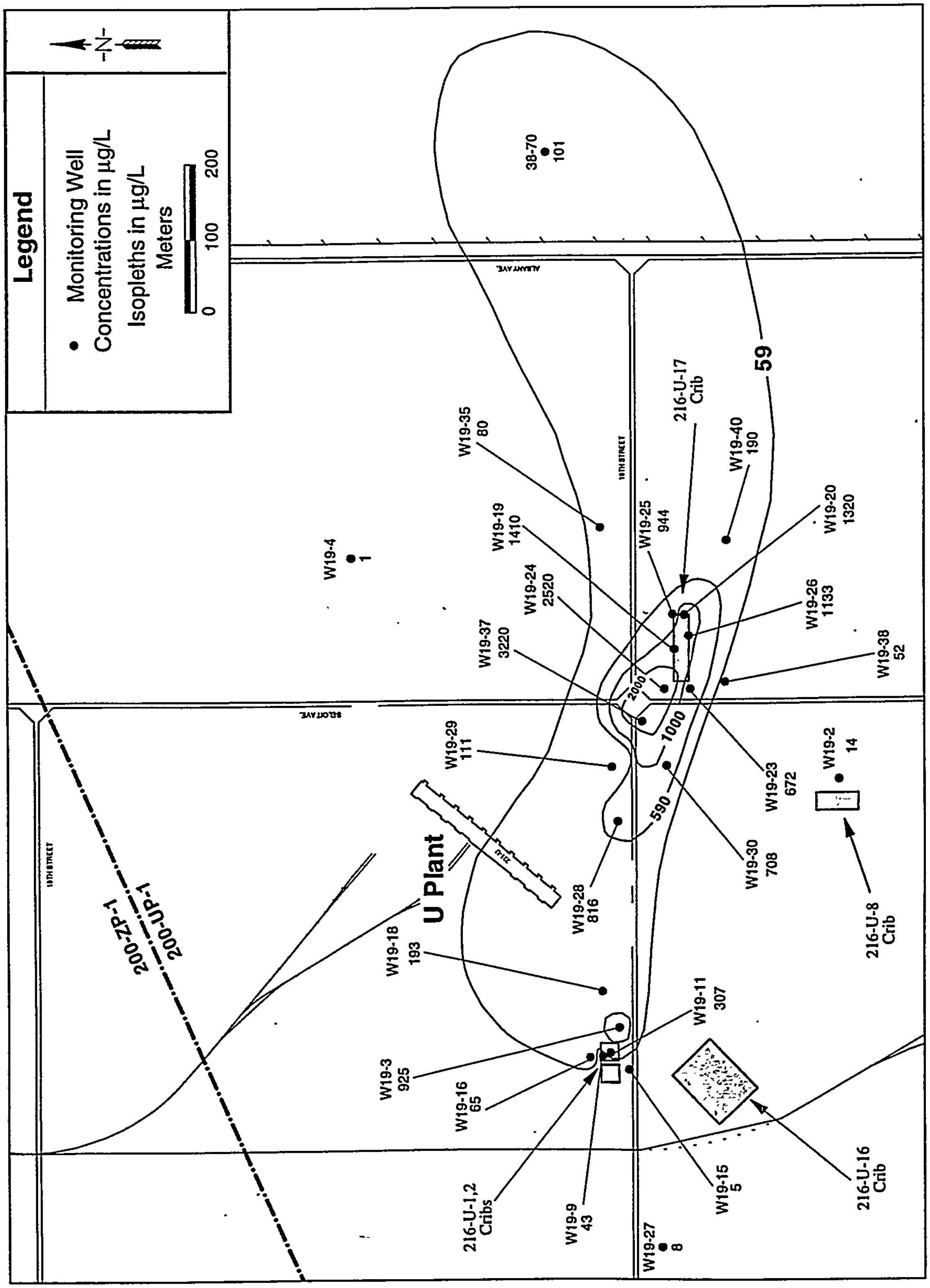
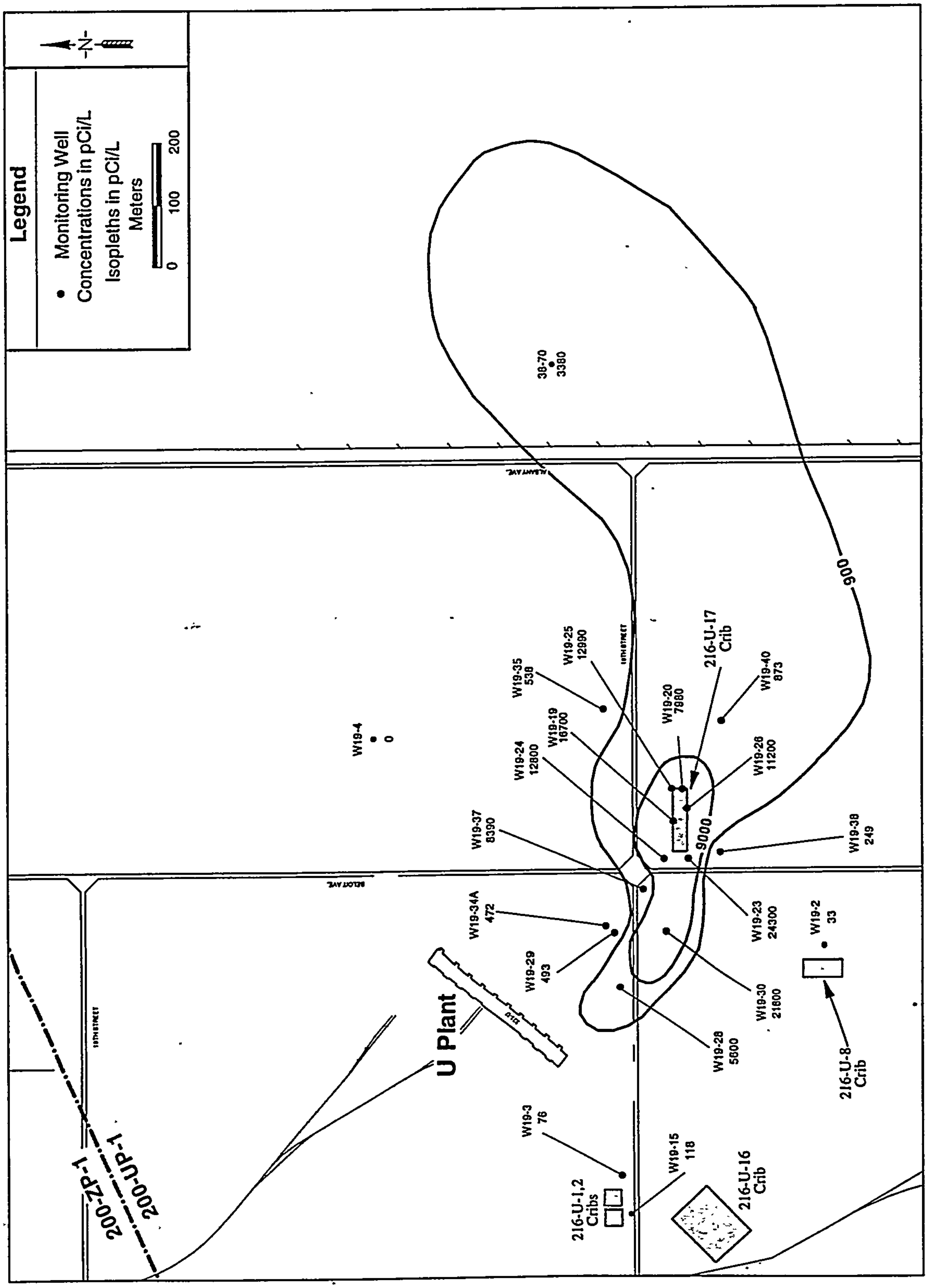


Figure 1-3. Concentration Isopleths for Technetium-99 (in µg/L).



2.0 LIMITED FIELD INVESTIGATION DATA NEEDS AND ACTIVITIES

This section provides a brief discussion of 200-UP-1 LFI data needs and activities. The most important aspect of the LFI is to further define the nature and extent of contamination in the groundwater system. Secondary objectives of the LFI include the need to further define aquifer properties, groundwater flow direction, groundwater chemistry, hydrostratigraphy, and source contribution. LFI data needs and investigation activities are summarized in Figure 2-1. A comprehensive discussion of data needs and data quality objectives is presented in the RI/FS work plan (DOE-RL 1994c). Activities supporting the LFI were performed according to approved site procedures (e.g., WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual*, and BHI-EE-01, *Environmental Investigation Procedures*).

2.1 NATURE AND EXTENT OF CONTAMINATION

The most important element of the 200-UP-1 LFI is determination of the nature and extent of contamination in the unconfined and confined aquifer. Four specific data needs must be fulfilled to address the nature and extent of contamination in the operable unit. Specific data needs require an assessment of existing groundwater data (i.e., analytical data review), verification of monitoring well design (to include verification of geodetic survey data), and determination of the maximum concentrations and the horizontal and vertical extent of contamination in the aquifer system. Activities conducted to assess the nature and extent of contamination include an analytical data review, evaluation of geodetic surveys, verification of well design, drilling and well construction, geophysical logging, and groundwater sampling and analysis.

2.1.1 Analytical Data Review

The RI/FS work plan for the 200-UP-1 Groundwater Operable Unit (DOE-RL 1994c) presents a historical evaluation of groundwater data for high-priority groundwater contaminants from 56 wells. This process consisted of evaluating contaminant trends and existing plume maps to identify possible data gaps. Results of the evaluation identified wells that should be resampled to verify trend analysis and better define the extent of contamination in the operable unit. As part of the LFI, a similar activity was completed to confirm findings in the RI/FS work plan and streamline the sampling and analysis program. The LFI data review was focused to address the following questions.

1. Are data available for the target high-priority groundwater contaminants identified in the work plan? Is sufficient analytical information available to establish data trends?
2. Are the target constituents above the federal maximum contaminant level (MCL)?

3. What monitoring programs are currently using wells to support their monitoring networks?

4. Can information obtained from other monitoring programs be used to support or supplement data needed for the characterization of high-priority groundwater contaminants, thus avoiding the duplication of sampling information?

5. Are the available data of sufficient quality to allow their use for LFI characterization?

6. Can the construction design of the monitoring wells impact sample quality and can the monitoring wells be remediated to increase the value of sample results?

Plume maps and trend plots were prepared that incorporate all available data to verify previous results, identify data gaps, and focus LFI sampling and analysis activities. Results of this activity led to the identification of 24 wells to be sampled in support of LFI activities. Sampling activities at these wells are described in Section 2.1.5.1.

2.1.2 Fitness-for-Use Determination

Fifty-six groundwater monitoring wells were evaluated to assess their fitness for use in the 200-UP-1 Operable Unit in support of IRM/LFI activities. The objectives of the activity were to identify and correct deficiencies associated with geodetic surveys and well construction design. The evaluation began by reviewing well construction documentation (e.g., depth to bottom, screen interval and type, filter pack, annular seal and casing material). Construction data were verified in the field (where possible) by performing field inspections and camera surveys. Based on the construction review and field inspections, an appropriate maintenance activity (e.g., scrubbing, sand pumping, redevelopment) was initiated. Wells were removed from an original well list or retained for use as groundwater monitoring wells during the last three rounds of sampling based on the fitness determination. Only well 699-40-63 was not suitable to support sampling. Table 2-1 identifies groundwater monitoring wells used to support the fitness-for-use determination and summarizes well evaluation activities. The final wells used to support LFI activities are identified in Section 2.1.5.1.

As part of the fitness-for-use determination, geodetic survey data were also checked to verify the vertical and horizontal position of monitoring wells. The data were checked by comparing recent surveys to the North America Vertical Datum of 1988 (NAVD88) and the National Geodetic Vertical Datum of 1929 (NGVD29). Surveys made to NAVD88 were performed by the U.S. Army Corps of Engineers and are accepted as the most accurate of the two data sets. A description of the recent survey activities and results are presented in Phase III, IV, and V Results for the Well Surveying Program at the U.S. Department of Energy Hanford Site, Vol. II, "Well Location Report" (DOE-RL 1993c, 1994b, 1995f).

2.1.3 Drilling and Well Construction

A significant part of the proposed 200-UP-1 Operable Unit field scope of work focuses on drilling and constructing 13 groundwater monitoring wells to satisfy LFI and IRM data needs. Only four wells (UP1-2, -3 -6, and -7) were drilled to support LFI/IRM activities. The final well designations for these wells are 299-W19-34A, 299-W19-34B, 299-W19-35, and 699-38-68A, respectively. Data needs for a fifth well were met by overdrilling and abandoning the lower section of well 299-W19-34B. The rationale for reducing the scope of field activities for other installations is documented on National Priorities List agreement/change control forms and meeting minutes (see Appendix A). Descriptions of recent drilling and well construction activities driven by 200-UP-1 LFI, IRM, and other site programs [e.g.,Westinghouse Hanford Company (WHC) operational drilling] in the operable unit are presented in the following reports.

- *Borehole Summary Report for 200-UP-1 Operable Unit, 200 West Area* (Kelty et al. 1995a). This report summarizes the results of drilling and related characterization activities performed in fiscal year 1994 in support of the groundwater LFI.

- *200-UP-1 Operable Unit Borehole Summary Report for FY 1995* (BHI 1996a). This report summarizes the results of drilling and related characterization activities performed in fiscal year 1995 in support of the groundwater LFI.

- *Borehole Summary Report for 200-UP-2 Operable Unit, 200 West Area* (Kelty et al. 1995b). This report summarizes drilling and characterization activities performed in support of the source investigation in the 200-UP-2 Operable Unit.

- *Groundwater Impact Assessment Report for the 216-U-14 Ditch* (Singleton and Lindsey 1994). This report assesses impacts on the groundwater and vadose zone from wastewater discharged to the 216-U-14 Ditch.

2.1.4 Geophysical Logging

The radionuclide logging system is used to identify the presence and relative activity of manmade gamma-emitting radionuclides. Twenty-one boreholes were logged in the study area to support operable unit and other site activities. Only four groundwater monitoring wells were logged to support the 200-UP-1 LFI/IRM. A description of logging activities is presented in the reports previously identified in Section 2.1.3. A summary description of results is presented in Section 3.4.4.

2.1.5 Groundwater Sampling and Analysis

2.1.5.1 Groundwater Sampling. To satisfy the groundwater monitoring data needs for the 200-UP-1 LFI, groundwater samples were collected by Environmental Restoration Contractor

(ERC) personnel from 24 wells shown in Table 2-2, and groundwater data were also obtained from another 81 wells. These 81 wells were sampled by the WHC RCRA/operational groundwater monitoring program, the Pacific Northwest National Laboratory (PNNL) sitewide groundwater monitoring program, and by ERC personnel for purposes other than the 200-UP-1 LFI. These wells were added to better define the spatial distribution of contaminants and risk throughout the operable unit. Construction data applicable to the 105 wells used in the assessment are provided in Table 2-3. The groundwater data from these wells are available from the Hanford Environmental Information System database, which is designated as the central repository for Hanford groundwater data. The PNNL annual reports of Hanford Site groundwater monitoring also provide compilations of these data (Evans et al. 1992a, 1992b; Dresel et al. 1993a, 1993b, 1993c, 1994, 1995; Merz and Dresel 1994). ERC groundwater data are also available in the Bechtel Hanford, Inc., project quality assurance files.

During the 200-UP-1 LFI, three rounds of groundwater sampling were performed using the set of wells listed in Table 2-2. Two of the wells, 299-W23-9 and 299-W23-11, were scheduled for one sampling round if the contaminant N-nitrosodimethylamine was detected in well 299-W23-10. It was not detected; therefore, these two wells were not sampled. Seven wells were scheduled for one sampling round, eight wells for two rounds, and seven wells for three rounds. Sampling was unsuccessful at one of the seven wells scheduled for one sampling round. This well, 299-W14-10, did not yield water after purging and remained dry. Single sampling rounds were missed because of pump problems in three wells: at one of the eight wells scheduled for two sampling rounds, and at two of the seven wells scheduled for three sampling rounds. A summary of each sampling round follows.

Nine wells were sampled between January 13, 1995 and February 14, 1995 during the first round. Wells 299-W22-9 and 299-W22-21 did not yield sufficient water for sampling; both were scheduled for three sampling rounds. The problems in both wells were corrected before the next sampling round. The *Data Validation Summary Report for the 200-UP-1 Round 1 Limited Field Investigation and Vertical Profile Groundwater Sampling Task* (BHI 1995a) includes summary tables of the analytical results for this round of sampling.

Eighteen wells were sampled between June 15, 1995 and July 26, 1995 during the second round. Samples could not be collected from wells 299-W14-10 and 299-W23-7. Well 299-W14-10 did not recover after purging; it remained dry. Well 299-W23-7 required additional well remediation, allowing it to be sampled in the third round. Vertical profile samples were collected from well 299-W23-4 in June 1995. The *Validation Summary Report for the 200-UP-1 Groundwater Round 2* (BHI 1996c) includes summary tables of the analytical results for this round of sampling.

Fourteen wells were sampled during the third round, which began on August 21, 1995 and ended on September 22, 1995. Well 299-W14-10 remained dry. There were no other problems during the sampling round. The Volatile Organic, Radiochemistry, Wet Chemistry and Inorganic Data Validation Reports for Data Package W0684-QES and Volatile Organic, Radiochemistry, and

Inorganic Data Validation Reports for Data Package W0711-QES9 include the analytical results for this round of sampling.

2.1.5.2 Vertical Profiling Activity. Groundwater samples were collected at various depths in several wells to evaluate the extent of carbon tetrachloride, technetium-99, and uranium concentrations with depth in the aquifer. A summary of these activities is presented in Section 3.4.3. Details of the activities are described in the *200-UP-1 Vertical Profiling Activity Summary Report* (Ford 1995).

2.1.5.3 Sample Analysis. The groundwater samples collected by ERC personnel for the 200-UP-1 LFI were analyzed by Quanterra Environmental Services using the following methods:

- Chromium (total) by inductively coupled plasma using EPA SW-846 method 6010
- Arsenic by atomic absorption using EPA SW-846 method 7060
- Volatile organic analysis Target Analyte List (VOA TCL) by EPA SW-846 method 8240
- Semivolatile organic compounds by EPA SW-846 method 8270
- NO_2 - NO_3 by EPA method 353.1
- Gross alpha and gross beta by Quanterra Environmental Services method ITAS-RD-3214 (based on EPA method 900.0)
- Total uranium by Quanterra Environmental Services method ITAS-RD-4200
- Iodine-129 by Quanterra Environmental Services method ITAS-RD-3229
- Technetium-99 by Quanterra Environmental Services method ITAS-IT-RS-0001
- Plutonium-238/239/240 by Quanterra Environmental Services method ITAS-IT-RS-320
- Anions by ion chromatography using EPA method 300.0
- Total organic carbon based on EPA method 415.1
- Total suspended solids by EPA method 160.2
- Total dissolved solids by EPA method 160.1
- Alkalinity by EPA method 310.1.

Groundwater samples collected by the WHC RCRA/operational groundwater monitoring program were analyzed using standard methods such as EPA SW-846, ASTM D-4237 methods, and Quanterra Environmental Services radionuclide analysis procedures as summarized in the annual reports for groundwater monitoring projects at the Hanford Site (DOE-RL 1993b, 1994a, 1995a).

Groundwater samples collected by the PNNL sitewide groundwater monitoring program were analyzed using EPA SW-846 methods. Of the analytical results used in this report, 8% were analyzed using contract laboratory program procedures.

2.1.5.4 Data Validation. The 200-UP-1 LFI groundwater analytical data were validated in accordance with WHC procedures (WHC 1993a, 1993b) to data validation level C. In the validation process, sample documentation and results for the data package were reviewed to identify and correct any transcription errors in analytical results. Qualifiers were then applied to the analytical data as necessary. A data validation report was then prepared for the data package. These reports are retained in the Bechtel Hanford, Inc., 200-UP-1 project quality assurance record.

No major deficiencies were found during the validation of the VOA, metals, general chemistry, and radionuclide data from round 1; no data were qualified as unusable (BHI 1995a). Several minor deficiencies were found during validation, and consequently these results were qualified as estimated values by appending "J" qualifier codes to the data (BHI 1995a). Results of the validation process for round 1 are summarized in the *Data Validation Summary Report for the 200-UP-1 Round 1 Limited Field Investigation and Vertical Profile Groundwater Sampling Task* (BHI 1995a).

Two major deficiencies were found during the validation of the general chemistry data from sampling round 2; holding times were exceeded for the nitrite and phosphate analyses, so both results were qualified as unusable (BHI 1996c). Several minor deficiencies were found during validation, and consequently these results were qualified as estimated or nondetect by appending "J" or "U" qualifier codes to the data (BHI 1995a). Specifically, chloride and nitrate data were qualified as estimated, and methylene chloride and bromomethane data were qualified as nondetects. Results of the validation process for round 2 are presented in the *Validation Summary Report for the 200-UP-1 Groundwater Round 2* (BHI 1996c).

Results of data validation of round 3 groundwater samples are presented in Volatile Organic, Radiochemistry, Wet Chemistry and Inorganic Data Validation Reports for Data Package W0684-QES and Volatile Organic, Radiochemistry, and Inorganic Data Validation Reports for Data Package W0711-QES9. Two minor deficiencies were found during validation in data package W0684-QES; all iodine-129 analyses were qualified as nondetect by appending the "U" qualifier, and one chromium analysis was qualified as estimated by appending the "J" qualifier. One major deficiency was found in data package number W0684-QES; two chromium analyses were qualified as unusable by appending the "UR" qualifier. No deficiencies were found during validation of data package W0711-QES.

2.2 AQUIFER PROPERTIES

A determination of aquifer properties is important to improve the understanding of the groundwater flow system, assess issues of aquifer communication, and evaluate horizontal and vertical contaminant mobility. Four specific data needs and parameters are necessary to assess aquifer properties. Vertical and horizontal hydraulic conductivity, transmissivity, porosity, and bulk density data and grain size distribution are the main parameters of interest to assess aquifer properties.

Aquifer tests and physical analysis of sediments were conducted to assess aquifer properties. Single-well slug tests and a limited number of pumping tests were performed in wells that intersect the unconfined and confined aquifers. A description and results for parameters given above are presented in reports referenced in Section 2.1.3, *Aquifer Testing Reports for 1993 200-UP-1 Groundwater Operable Unit* (BHI 1994), and *Aquifer Test Results, 200-UP-1 Operable Unit IRM Plume: Wells 299-W19-39 and 299-W19-36* (Swanson 1996). The range of hydraulic conductivities and transmissivities for applicable hydrostratigraphic units is discussed in Section 3.3.

2.3 GROUNDWATER FLOW

An understanding of groundwater flow is a fundamental part of refining the conceptual model of the site. Three specific data needs and parameters are identified to assess groundwater flow. Specific data needs require an assessment of horizontal and vertical gradients in the confined and unconfined aquifer and an assessment of geodetic survey data. Water-level measurements were collected to assess groundwater flow.

Water-level measurements were obtained from unconfined and confined aquifer wells to evaluate groundwater flow in the operable unit. The work plan recommended quarterly monitoring throughout the duration of field and analytical activities. This monitoring approach was changed during the course of the LFI because short-term fluctuations caused by seasonal changes in the water table were not expected. As the reduced frequency of monitoring was consistent with other area monitoring strategies (e.g., RCRA) semiannual groundwater measurements, resources were better utilized by relying on RCRA water-level data. Water-level data from the unconfined aquifer are mainly from *Groundwater Maps of the Hanford Site, June 1995* (Serkowski et al. 1996) and are used to address the horizontal component of groundwater flow.

Groundwater flow direction and gradients in the lower unconfined aquifer, Ringold Unit A, and the Rattlesnake Ridge interbed were determined using data in Table 2-4. Groundwater flow and gradients are discussed in Section 3.3.2.

2.4 GROUNDWATER CHEMISTRY

Groundwater chemistry contributes to the conceptual model by providing the context in which contaminant characteristics can be determined or implied with respect to their mobility and fate. Contaminant fate and transport considerations support the evaluation of feasibility and effectiveness of the design alternatives for IRM plume remedial actions. In addition, these considerations support the evaluation of contaminant migration and long-term risks.

Groundwater chemistry data needs are divided between groundwater chemical conditions and aquifer chemical conditions, with a minor consideration required for well construction materials because of their potential impact on data quality. Data required to assess these conditions include common ion concentrations, pH, Eh, temperature, total dissolved solids, total organic carbon, alkalinity, specific conductance, and trace organic compounds. In addition, data from the aquifer media (e.g., mineralogy, cation exchange, and total organic carbon) are needed to assess sorption potential.

Activities completed to support acquisition of the data include sampling and analysis, the fitness determination described in Section 2.1.2, and a search of the existing literature for background values for contaminants and supporting information addressing contaminant mobility and transport. A discussion of groundwater chemistry is presented in Section 3.5. A description of vertical profiling activities related to groundwater chemistry is contained in the *Description of Work for the 200-UP-1 Groundwater Contaminant Vertical Profiling Activity (Profiling DOW)* (WHC 1993c) and the *Description of Work for Characterization of 200-UP-1 Monitoring Wells* (WHC 1994). Results of the vertical profiling activities are summarized in *200-UP-1 Vertical Profiling Activity Summary Report* (Ford 1995).

2.5 HYDROSTRATIGRAPHY

The work plan (DOE-RL 1994C) identifies several issues related to interpretation and identification of major hydrostratigraphic units in the operable unit. Specific data needs require better definition of hydrostratigraphic relationships, including description of lithologic units, unit thicknesses, and depths to the Plio-Pleistocene unit, Ringold Unit E, and other major lithologies.

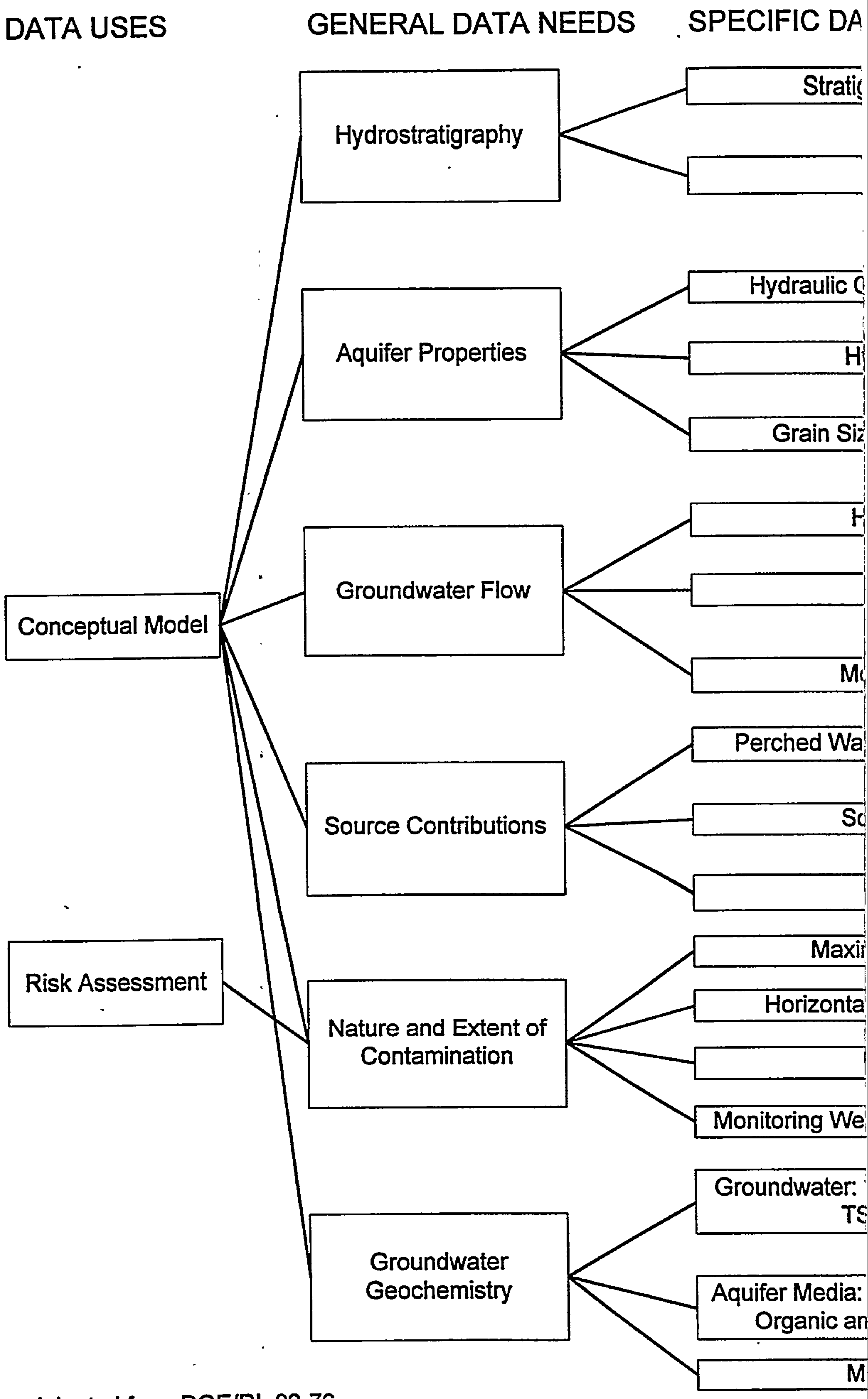
Hydrostratigraphy is evaluated by reviewing existing reports to incorporate current knowledge of the site. The reports used to refine stratigraphic relationships are identified in Section 2.1.3. Results of the hydrostratigraphic investigation are discussed in Sections 3.2 and 3.3.

2.6 SOURCE CONTRIBUTION

Three specific data needs are identified to assess source contribution. Monitoring well seals should be evaluated to assess potential preferential pathways, saturated conditions within the vadose zone (perched water) should be identified because of the high potential for downward migration of contaminants to groundwater, and contaminant concentrations in the vadose zone should be determined to assess the type and distribution of contaminants in the sediment column. A discussion of source contribution is given in Section 3.1.

Source contribution is the main focus of the 200-UP-2 Operable Unit LFI [see *Limited Field Investigation for the 200-UP-2 Operable Unit* (DOE-RL 1995e) and *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1996)]. The investigative approach for 200-UP-2 is based on the analogous unit concept and represents the worst-case scenario for different disposal units. Waste disposal units investigated include the 216-U-1/2 Cribs, 216-U-4 Reverse Well, 216-U-4a French Drain, 216-U-8 Crib, 216-U-Pond Disposal System, and 216-U-12 Crib.

Activities performed to support 200-UP-1 and 200-UP-2 efforts include drilling, test pit excavations, geophysical logging, cone penetrometer pushes, and sampling of sediments and groundwater. Existing reports identified in Section 2.1.3 and DOE-RL (1996) were also reviewed to incorporate current knowledge of the operable unit.



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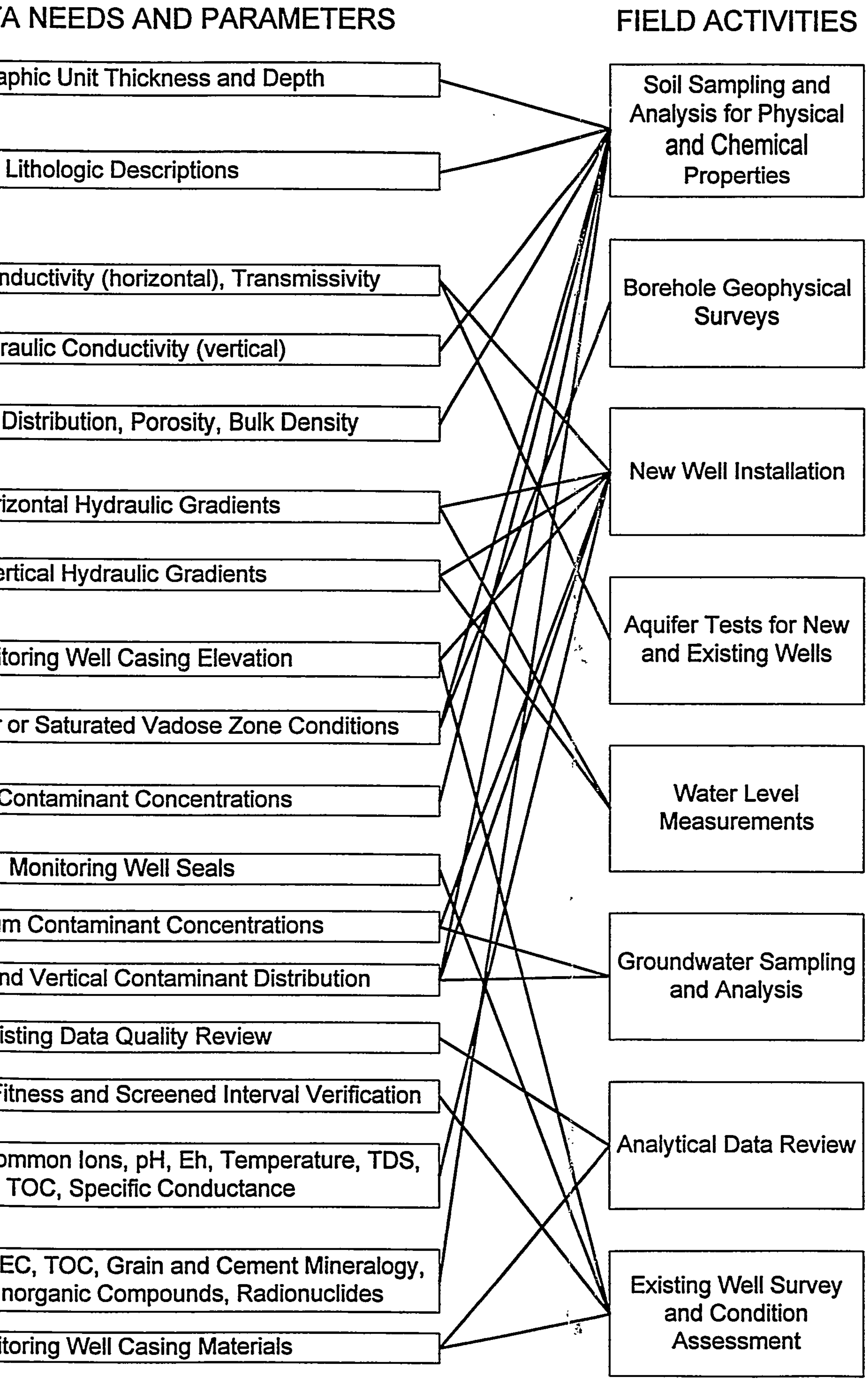


Figure 2-1. Schematic of LFI Data Needs and Investigation Activities.

Table 2-1. Well Evaluation Summary. (sheet 1 of 2)

Initial IRM and LFI Groundwater Monitoring Well Construction Design

Well	Location	Screened/Perforated Interval (ft BGS)	Seal Status	Well	Location	Screened/Perforated Interval (ft BGS)	Seal Status
299-W14-10	SE Laundry Bldg	195-230, cs	nas	299-W22-9	NE of S Plant	220-299, cs	nas
299-W18-15	U-Pond	170-243, cs	nas	299-W22-10	S1/S2 Crib	203-311, cs	pas
299-W18-20	Z-19 Ditch	220-249, cs	nas	299-W22-19	S-22 Crib	212-330, cs	nas
299-W19-2	U-8 Crib	235-295, cs	nas	299-W22-20	S-20 Crib	205-299, cs	nas
299-W19-3	U1/U2 Crib	230-280, cs	nas	299-W22-21	S-13 Crib	200-285, cs	as
299-W19-4	Burning pit	255-535, cs	nas	299-W23-2	S-Tank Farm	184-235, cs	pas
299-W19-8	U1/U2 Crib	ND	pas	299-W23-3	S-Tank Farm	176-228, cs	pas
299-W19-9	U1/U2 Crib	214-244, cs	pas	299-W23-4	S-21 Crib	180-300, cs	nas
299-W19-11	U1/U2 Crib	220-250, cs/s	pas	299-W23-5	S-Tank Farm	215-245, cs	pas
299-W19-12	U-Tank Farm	210-250, cs/s	pas	299-W23-7	S-Tank Farm	170-248, cs	pas
299-W19-13	U-16 Crib	209-249, s	pas	299-W23-9	S-25 Crib	164-230, cs	pas
299-W19-16	U1/U2 Crib	225-275, s	pas	299-W23-10	S-25 Crib	165-230, cs	pas
299-W19-18	U1/U2 Crib	230-355, s	pas	299-W23-11	S-25 Crib	165-230, cs	pas
299-W19-19	U-17 Crib	230-250, s	pas	299-W23-13*	S-Tank Farm	195-217, s	as
299-W19-20	U-17 Crib	231-251, s	pas	299-W23-14	S-25 Crib	193-215, s	as
299-W19-21*	U-14 Ditch	201-226, s	pas	299-W26-1	S-6 Crib	ND	nd
299-W19-23	U-17 Crib	233-253, s	as	299-W26-6	S-5 Crib	191-221, s	pas
299-W19-24	U-17 Crib	235-255, s	as	299-W26-7	S-10 Pond	184-205, s	as
299-W19-25	U-17 Crib	226-246, s	as	299-W26-8*	SE. of S-AA	195-215, s	as
299-W19-27*	U-14 Ditch	208-228, s	as	299-W26-9*	S-11 Pond	184-204, s	as
299-W19-28	S. of U-Plant	236-256, cs	as	299-W27-1	S-26 Crib	216-236, s	pas
299-W19-29	S. of U-Plant	235-255, sc	as	699-32-62	SE of U-AA	365-370, cs	nas
299-W19-31*	U-Tank Farm	201-222, s	as	699-35-78	SW. of U-Pond	330-389	nd
299-W19-32*	U-Tank Farm	201-222, s	as	699-36-61	East of U-AA	330-389, cs	nd
299-21-1	SE. U-AA	221-290, cs	nas	699-38-70	E of U-AA	255-374	nd
299-W22-1	S1/S2 Crib	190-280, cs	pas	699-36-70A	SE of U-12	216-236, cs	nd
299-W22-2	S1/S2 Cribs	195-285, cs	pas	699-40-62	NE of U-AA	335-374, cs	nd
299-W22-7	S-Plant Rail Rd	223-308,cs/s	nas	699-40-63	Location unknown	ND	nd

*Well will run dry in less than 3 years

s=stainless steel well screen

cs=carbon steel well construction with perforations

cs/s=carbon steel well construction with stainless steel screen.

ND=length of monitoring interval not documented

nd=information on annular seal not available

as=full annular seal

nas=no annular seal (deficient or suspect annular seal)

pas=partial annular seal (deficient or suspect annular seal)

Table 2-1. Well Evaluation Summary. (sheet 2 of 2)

Well	Well Condition	Well	Well Condition
299-W14-10	Sample ready	299-W22-9	Sample ready
299-W18-15	Cleaned	299-W22-10	Cleaned
299-W18-20	Cleaned and Remediated	299-W22-19	Sample ready
299-W19-2	Cleaned and Remediated	299-W22-20	Sample ready
299-W19-3	Sample ready	299-W22-21	Sample ready
299-W19-4	Cleaned	299-W23-2	Cleaned
299-W19-8	Sample ready	299-W23-3	Cleaned
299-W19-9	Sample ready	299-W23-4	Sample ready
299-W19-11	Sample ready	299-W23-5	Sample ready
299-W19-12	Cleaned	299-W23-7	Cleaned and remediated
299-W19-13	Sample ready	299-W23-9	Cleaned and remediated
299-W19-16	Sample ready	299-W23-10	Sample ready
299-W19-18	Cleaned and Remediated	299-W23-11	Sample ready
299-W19-19	Sample ready	299-W23-13	Sample ready
299-W19-20	Sample ready	299-W23-14	Sample ready
299-W19-21	Cleaned	299-W26-1	Sample ready
299-W19-23	Cleaned	299-W26-6	Sample ready
299-W19-24	Sample ready	299-W26-7	Sample ready
299-W19-25	Sample ready	299-W26-8	Cleaned
299-W19-27	Cleaned	299-W26-9	Sample ready
299-W19-28	Sample ready	299-W27-1	Sample ready
299-W19-29	Sample ready	699-32-62	Sample ready
299-W19-31	Sample ready	699-35-78	Sample ready
299-W19-32	Sample ready	699-36-61A	Sample ready
299-21-1	Cleaned and Remediated	699-36-70A	Sample ready
299-W22-1	Cleaned	699-38-70	Cleaned
299-W22-2	Cleaned	699-40-62	Sample ready
299-W22-7	Sample ready	699-40-63	Status and location unknown

Cleaned=Well surveyed with camera to verify condtion, and then scrubbed and bailed.
Remediated=Well monitoring interval shortened and or sand removed.
Status and location unknown=cannot locate well in field or data base.

Table 2-2. LFI Well List and Analyte Summary.

Well	Analytes	Round 1 (completed January 1995)	Round 2 (completed August 1995)	Round 3 (completed September 1995)	Notes
299-W14-10	DDT*, Bis*, Cd*	NA	Failed	Failed	Well does not recover after purging
299-W22-1	Sr*	NA	Sr	NA	
299-W22-2	Sr*	NA	Sr	NA	
299-W22-7	β, TCE, CCl_4	β, TCE, CCl_4	β, TCE, CCl_4	β, TCE, CCl_4	
299-W22-9	TCE, Cr, I	Failed	TCE, Cr, I	TCE, Cr, I	Sample with bladder pump
299-W22-10	Sr*, Pu*	NA	Sr, Pu	NA	
299-W22-19	β, Cr, CCl_4, TCE, DCA*, DCE*	β, Cr, CCl_4, TCE, DCA, DCE	β, Cr, CCl_4, TCE, DCA, DCE	β, Cr, CCl_4, TCE	c
299-W22-20	DCA*, DCE*, TCE, CCl_4, Cr, Alk*, TDS*, TSS*, TOC*, Common Ions*	DCA, DCE, TCE, CCl_4, Cr	TCE, CCl_4, Cr, Alk, TDS, TSS, TOC, Common Ions	TCE, CCl_4, Cr	
299-W22-21	Pu*, I, Sr*, Tc**, α, β, TCE, Cr	Failed	Pu, I, Sr, Tc, α, β, TCE, Cr	I, Tc, α, β, TCE, Cr	Pump problem
299-W23-2	β**, Tc**	NA	β, Tc	β, Tc	
299-W23-3	β**, Tc**	NA	β, Tc	β, Tc	
299-W23-4	U, α, β, CCl_4	U, α, β, CCl_4	U, α, β, CCl_4	U, α, β, CCl_4	
299-W23-7	β**, Tc**	NA	Failed	β, Tc	Pump problem
299-W23-9	N-nitrosodimethylamine*	NA	NA	NA	b
299-W23-10	N-nitrosodimethylamine*	NA	N-nitrosodimethylamine	NA	a
299-W23-11	As*, N-nitrosodimethylamine*	NA	NA	As	b
299-W26-6	Cr**	Cr	Cr	NA	
299-W26-7	Cr*	Cr	NA	NA	
299-W26-9	Cr*	Cr	NA	NA	
299-W27-1	Pu*, Cr**, $CHCl_3$*, DCA, DCE, TCE	Pu, Cr, $CHCl_3$, DCA, DCE, TCE	Cr, DCA, DCE, TCE	DCA, DCE, TCE	c
699-32-62	I**	NA	I	I	
699-36-61A	NO_3**, I**	NA	NO_3, I	NO_3, I	
699-36-70A	NO_3**, I**	NO_3, I	NO_3, I	NA	
699-40-62	NO_3**, I**	NA	NO_3, I	NO_3, I	

* = Only one analysis round required. ** = Only two analysis rounds required.

[a] Sampling for N-nitrosodimethylamine to confirm single detection of N-nitrosodimethylamine in well 299-W23-10.

[b] Sampling for N-nitrosodimethylamine not required; N-nitrosodimethylamine was not detected in well 299-W23-10 during round 2.

[c] Sampled for DCA and DCE if previous single detection of DCE and DCA in well 299-W22-20 is confirmed.

α = Gross alpha, β = Gross Beta, Alk = alkalinity, As = arsenic, Bis = bis(2-ethylhexyl)phthalate, Cd = cadmium, Cr = chromium, DCA = 1,2-dichloroethane, DCE = 1,1-dichloroethene, I = iodine-129, NA = not applicable, Pu = plutonium-238, Sr = strontium-90, TDS = total dissolved solids, TOC = total organic carbon, TSS = total suspended solids, U = uranium

Table 2-3. Wells Used for Assessment of 200-UP-1 Groundwater Contamination. (sheet 1 of 2)

Well Name	Drill date	Drill Depth BGS (ft)	Depth to Bottom BGS (ft)	Casing Type	Diameter (in.)	Perforated Interval BGS (ft)	Screen Interval BGS (ft)	Screen Type	Formation and Aquifer Typed Monitored	Sample Method	Comments
299-W14-10	7/31/81	330	325	CS	6	195-230	NA	NA	Ringold E/Unconfined	Submersible	
299-W18-15	4/30/80	248	243	CS	8	170 -243	NA	NA	Ringold E/Unconfined	Submersible	
299-W18-20	8/31/82	250	237	CS	8	220-249	NA	NA	Ringold E/Unconfined	ND	
299-W19-2	8/31/57	300	237	CS	8	235-299	NA	NA	Ringold E/Unconfined	Submersible	
299-W19-3	9/30/57	302	254	CS	8	230-280	NA	NA	Ringold E/Unconfined	Submersible	5 in. to 213 ft. grouted
299-W19-4	2/28/60	550	421	CS	8	255-535	NA	NA	Ringold E/Unconfined	Submersible	
299-W19-8	6/30/71	585	560	CS	6	ND	NA	NA	Ringold E/Unconfined	ND	
299-W19-9	8/31/44	302	257	CS	7	215-302	214-244	SS	Ringold E/Unconfined	Submersible	
299-W19-11	4/30/83	251	250	CS	6	NA	220-250	SS	Ringold E/Unconfined	Submersible	
299-W19-12	1/31/83	250	240	CS	6	NA	210-250	SS	Ringold E/Unconfined	Submersible	
299-W19-13	6/30/84	250	241	CS	6	NA	209-249	SS	Ringold E/Unconfined	Submersible	
299-W19-16	6/30/85	285	234	CS	6	NA	225-275	SS	Ringold E/Unconfined	Submersible	
299-W19-18	11/30/85	362	259	CS	6	NA	230-355	SS	Ringold E/Unconfined	Submersible	
299-W19-19	1/31/87	257	250	SS	5	NA	230-250	SS	Ringold E/Unconfined	Submersible	
299-W19-20	6/30/86	252	252	SS	6	NA	231-251	SS	Ringold E/Unconfined	Submersible	
299-W19-21	7/31/86	226	226	SS	6	NA	201-226	SS	Ringold E/Unconfined	Submersible	
299-W19-23	3/31/87	255	253	SS	5	NA	233-253	SS	Ringold E/Unconfined	Submersible	
299-W19-24	4/30/87	255	251	SS	5	NA	235-255	SS	Ringold E/Unconfined	Submersible	
299-W19-25	4/30/87	248	248	SS	5	NA	226-246	SS	Ringold E/Unconfined	Submersible	
299-W19-27	4/30/87	230	228	SS	5	NA	208-228	SS	Ringold E/Unconfined	Submersible	
299-W19-28	8/25/89	255	255	SS	4	NA	236-256	SS	Ringold E/Unconfined	Hydrostar	
299-W19-29	8/25/89	256	255	SS	4	NA	235-255	SS	Ringold E/Unconfined	Hydrostar	
299-W19-31	12/18/90	225	223	SS	4	NA	201-222	SS	Ringold E/Unconfined	Hydrostar	
299-W19-32	1/3/91	223	222	SS	4	NA	201-222	SS	Ringold E/Unconfined	Hydrostar	
299-21-1	9/30/57	352	253	CS	8	221-290	NA	NA	Ringold E/Unconfined	Submersible	
299-W22-1	6/30/56	306	285	CS	8	190-280	NA	NA	Ringold E/Unconfined	Submersible	
299-W22-2	5/31/56	307	307	CS	8	195-285	NA	NA	Ringold E/Unconfined	ND	
299-W22-7	4/15/56	311	242	CS	6	214-308	214-274	SS	Ringold E/Unconfined	ND	
299-W22-9	5/31/56	301	301	CS	8	220-299	NA	NA	Ringold E/Unconfined	ND	
299-W22-10	6/30/56	312	312	CS	8	203-311	NA	NA	Ringold E/Unconfined	ND	
299-W22-19	6/4/57	450	318	CS	8	212-330	NA	NA	Ringold E/Unconfined	ND	
299-W22-20	6/30/57	301	301	CS	8	205-299	NA	NA	Ringold E/Unconfined	Submersible	
299-W22-21	9/30/57	300	235	CS	8	200-285	NA	NA	Ringold E/Unconfined	Submersible	
299-W23-2	9/30/54	236	220	CS	8	184-235	NA	NA	Ringold E/Unconfined	None	
299-W23-3	2/28/56	232	232	CS	8	176-228	NA	NA	Ringold E/Unconfined	None	
299-W23-4	6/30/57	300	300	CS	8	180-300	NA	NA	Ringold E/Unconfined	Submersible	Submersible pump installed
299-W23-5	10/31/69	250	250	CS	6	215-245	NA	NA	Ringold E/Unconfined	Submersible	
299-W23-7	10/31/69	250	229	CS	4	170-248	NA	NA	Ringold E/Unconfined	ND	4 in. 0-165 Perf 0-209 Grouted
299-W23-9	8/31/72	235	235	CS	6	164-230	NA	NA	Ringold E/Unconfined	None	5-in. liner to 103 ft. grouted
299-W23-10	10/31/72	235	235	CS	6	165-230	NA	NA	Ringold E/Unconfined	ND	5-in. liner to 103 ft. grouted
299-W23-11	11/7/72	235	235	CS	6	165-230	NA	NA	Ringold E/Unconfined		
299-W23-13	12/4/90	218	217	SS	4	NA	195-217	SS	Ringold E/Unconfined	Hydrostar	
299-W23-14	4/16/91	224	215	SS	4	NA	193-215	SS	Ringold E/Unconfined	Hydrostar	
299-W26-1	1/30/54	87	54	ND	ND	NA	ND	ND	Ringold E/Unconfined	ND	
299-W26-6	3/16/83	227	221	SS	6	NA	191-221	SS	Ringold E/Unconfined	Submersible	
299-W26-7	4/15/91	207	205	SS	4	NA	184-205	SS	Ringold E/Unconfined	Hydrostar	
299-W26-8	5/22/90	216	216	SS	4	NA	195-215	SS	Ringold E/Unconfined	Hydrostar	
299-W26-9	5/4/93	206	205	SS	4	NA	184-204	SS	Ringold E/Unconfined	Hydrostar	
299-W27-1	6/30/84	257	251	SS	6	NA	216-236	SS	Ringold E/Unconfined	Submersible	
699-32-62	4/30/60	501	325	CS	8	365-370	NA	NA	Ringold E/Unconfined	Bailer	Cement plug at 340 ft
699-35-78	9/1/81	ND	ND	CS	8	330-389	NA	NA	Ringold E/Unconfined	ND	
699-36-61	ND	ND	ND	CS	ND	330-389	NA	NA	Ringold E/Unconfined	ND	
699-38-70	6/30/57	413	291	CS	8	255-374	NA	NA	Ringold E/Unconfined	Submersible	Cement plug at 295 ft
699-36-70A	12/10/94	440	287.74	CS	4	216-236	NA	NA	Ringold E/Unconfined	Hydrostar	
699-40-62	1/31/49	384	369	CS	8	335-374	NA	NA	Ringold E/Unconfined	Sunmersible	
699-40-63	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
299-W18-9	12/13\68	220	217	CS	6	180-218	182-217	SS	Ringold E/Unconfined	ND	
299-W18-19	6/30/82	250	202	CS	6	185-250	175-205	SS	Ringold E/Unconfined	Submersible	8 in. to 178 ft. grouted
299-W18-21	7/29/87	227	226	SS	4	NA	196-226	SS	Ringold E/Unconfined	Hydrostar	
299-W18-22	9/25/87	455	448	SS	4	NA	417-448	SS	Ringold E/Unconfined	Hydrostar	
299-W18-23	7/1/87	255	251	SS	4	NA	220-251	SS	Ringold E/Unconfined	Hydrostar	
299-W18-25	12/11/90	215	215	SS	4	NA	194-215	SS	Ringold E/Unconfined	Hydrostar	
299-W18-26	12/15/89	249.9	243.3	SS	4	NA	222-243	SS	Ringold E/Unconfined	Submersible	
299-W18-27	5/7/91	239	238	SS	4	NA	217-238	SS	Ringold E/Unconfined	Hydrostar	

Table 2-3. Wells Used for Assessment of 200-UP-1 Groundwater Contamination. (sheet 2 of 2)

Well Name	Drill date	Drill Depth BGS (ft)	Depth to Bottom BGS (ft)	Casing Type	Diameter (in.)	Perforated Interval BGS (ft)	Screen Interval BGS (ft)	Screen Type	Formation and Aquifer Typed Monitored	Sample Method	Comments
299-W18-27	5/7/91	239	238	SS	4	NA	217-238	SS	Ringold E/Unconfined	Hydrostar	
299-W18-28	5/9/91	230	229	SS	4	NA	208-229	SS	Ringold E/Unconfined	Hydrostar	
299-W18-29	6/6/91	150	135	SS	4	NA	119-135	SS	Ringold E/Unconfined	Hydrostar	
299-W18-30	11/14/91	236	234	SS	4	NA	198	SS	Ringold E/Unconfined	Hydrostar	
299-W18-31	12/11/91	228	222	SS	4	NA	187-222	SS	Ringold E/Unconfined	Hydrostar	
299-W18-32	7/29/92	225	222	SS	4	NA	202-222	SS	Ringold E/Unconfined	Hydrostar	
299-W18-33	6/7/93	232	229	SS	4	NA	198-228	SS	Ringold E/Unconfined	Hydrostar	
299-W19-1	5/31/57	301	206	CS	8	178-299	NA	NA	Ringold E/Unconfined	ND	
299-W19-14	6/30/84	250	245	CS	6	ND	210-250	SS	Ringold E/Unconfined	ND	
299-W19-15	6/30/85	285	235	CS	6	NA	225-275	SS	Ringold E/Unconfined	Submersible	
299-W19-17	12/31/85	358	248	CS	6	NA	228-353	SS	Ringold E/Unconfined	Submersible	
299-W19-30	4/25/90	256	253	SS	4	NA	233-253	SS	Ringold E/Unconfined	Hydrostar	
299-W19-26	4/30/87	250	248	SS	5	NA	228-248	SS	Ringold E/Unconfined	Submersible	
299-W19-	5/18/94	345	340	SS	6	NA	324	SS	Ringold E/Unconfined	Hydrostar	
299-W19-	11/4/94	557	421	SS	6	NA	324-421	SS	Ringold E/lower	Hydrostar	
299-W19-35	4/18/94	274	270	SS	4	NA	240-270	SS	Ringold E/Unconfined	Hydrostar	
299-W19-38	8/10/95	259	239	SS	4	NA	239-259	SS	Ringold E/Unconfined	Hydrostar	
299-W19-91	3/31/87	150	120	SS	8	NA	110-120	SS	Hanford Sands/Perched	ND	
299-W19-92	3/31/87	150	122	SS	8	NA	113-123	SS	Hanford Sands/Perched	ND	
299-W19-93	4/2/87	120	105	SS	8	NA	103-115	SS	Hanford Sands/Perched	ND	
299-W22-22	7/31/60	301	301	CS	8	225-300	NA	NA	Ringold E/Unconfined	Submersible	
299-W22-23	8/31/60	307	236	CS	8	200-300	NA	NA	Ringold E/Unconfined	ND	
299-W22-26	12/31/63	300	282	CS	8	200-297	NA	NA	Ringold E/Unconfined	Submersible	
299-W22-39	2/20/91	223	221	SS	4	NA	200-221	SS	Ringold E/Unconfined	Hydrostar	Hydrostar intake = 210.2 ft BGS
299-W22-40	5/15/90	245	245	SS	4	NA	224-245	SS	Ringold E/Unconfined	Hydrostar	
299-W22-41	5/15/90	245	245	SS	4	NA	224-245	SS	Ringold E/Unconfined	Hydrostar	
299-W22-42	5/15/90	243	243	SS	4	NA	223-243	SS	Ringold E/Unconfined	Hydrostar	
299-W22-43	5/15/90	244	244	SS	4	NA	224-244	SS	Ringold E/Unconfined	Hydrostar	
299-W22-44	10/11/91	246	242	SS	4	NA	205-242	SS	Ringold E/Unconfined	Hydrostar	
299-W22-45	9/4/92	240	234	SS	4	NA	198-234	SS	Ringold E/Unconfined	Hydrostar	
299-W22-46	11/12/91	241	229	SS	4	NA	193-229	SS	Ringold E/Unconfined	Hydrostar	
299-W23-15	12/3/91	225	222	SS	4	NA	186-222	SS	Ringold E/Unconfined	Hydrostar	
299-W23-16	4/19/93	236	234	SS	4	NA	202-234	SS	Ringold E/Unconfined	Hydrostar	
299-W23-17	4/8/93	233	224	SS	4	NA	194-225	SS	Ringold E/Unconfined	Hydrostar	
299-W26-10	4/4/91	223	221	SS	4	NA	201-221	SS	Ringold E/Unconfined	Hydrostar	
299-W26-12	3/29/91	230	228	SS	4	NA	207-228	SS	Ringold E/Unconfined	Hydrostar	
299-W26-3	6/30/54	190	189	CS	8	NA	NA	NA	Ringold E/Unconfined	ND	
299-W27-2	12/18/92	435	416.6	SS	4	NA	406-416	SS	Ringold E/Unconfined	Hydrostar	
699-29-78	11/30/62	600	600	CS	6	599-600	NA	NA	Ringold E/Unconfined	Submersible	
699-32-70B	8/31/57	350	221	CS	8	207-330	NA	NA	Ringold E/Unconfined	Submersible	
699-32-72A	7/31/57	580	415	CS	8	210-485	NA	NA	Ringold E/Unconfined	Submersible	Cement plug at 415 ft
699-32-72B	5/18/94	255	245	SS	4	NA	214-245	SS	Ringold E/Unconfined	Hydrostar	
699-32-77	5/31/51	291	220	CS	8	175-290	NA	NA	Ringold E/Unconfined	Submersible	Cement plug at 222 ft
699-34-61	12/28/93	345	324	SS	4	NA	303-323	SS	Ringold E/Unconfined	Hydrostar	
699-35-70	9/30/48	325	260	CS	6	235-320	233-253	PVC	Upper	Submersible	
699-35-66A	6/30/57	450	322	CS	8	260-415	NA	NA	Ringold E/Unconfined	Submersible	Cement plug at 322 ft
699-37-82A	10/31/60	440	175	CS	8	155-410	NA	NA	Ringold E/Unconfined	ND	Cement plug at 175 ft, grouted
699-38-61	10/29/93	358	354	SS	4	NA	334-354	SS	Ringold E/Unconfined	Hydrostar	
699-38-65	12/31/59	536	395	Other	8	220-520	NA	NA	Ringold E/Unconfined	Submersible	Plug at 440 ft
699-38-68A	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	

BGS = below ground surface
CS = carbon steel
NA = not applicable
ND = no data available
PVC = polyvinylchloride
SS = stainless steel

Table 2-4. Water-Table Elevations for Selected Wells in the 200 West Area.

Well Name	Water-Table Elevation in meters (ft) above mean sea level (MSL)	Elevation of Screen Interval in meters (ft) above/below MSL	Unit
299-W19-6	139.2 (456.75)	83.8 to 93.3 (275 to 306)	Ringold Formation lower E
299-W19-29	139.13 (456.46)	135.12 to 141.7 (443.2 to 464.8)	Ringold Formation upper E
299-W19-34A	139.17 (456.59	108.9 to 114.7 (357.2 to 376.2)	Ringold Formation middle E
299-W19-34B	138.11(453.12)	85 to 88.0 (279.1 to 288.8)	Ringold Formation Unit A
299-W22-24AQ	137.6 (451.45)	59.4 to 66.14 (195 to 217)	Ringold Formation lower mud/E
299-W27-2	138.44 (454.21)	79.2 to 82.6 (260 to 271)	Ringold Formation lower E
699-29-70AP	133.32 (437.39)	-32.3 to -29.3 (-106 to -96)	Rattlesnake Ridge interbed
699-32-72AP	135.8 (445.56)	60.6 to 61.9 (198 to 203)	Ringold Formation Unit A
699-43-91AP	133.9 (439.40)	-48.16 to -43 (-158 to -141)	Rattlesnake Ridge interbed
699-43-91AQ	134 (439.62)	-0.9 to 2.13 (-3 to 7)	Ringold Formation Unit A
699-47-80AP	133.87 (439.21)	3.7 to 10.36 (12 to 34)	Rattlesnake Ridge interbed
699-47-80AQ	137 (449.43)	61 to 64 (200 to 210)	Ringold Formation Unit A

3.0 INVESTIGATION RESULTS

3.1 SOURCE CONTRIBUTION

As stated in Section 2.6, source contribution is the focus of the 200-UP-2 Operable Unit investigation. Results of the investigation suggest that under saturated or near-saturated conditions, effluent and mobile contaminants such as technetium-99 reach groundwater in less than 2 years (DOE-RL 1995e). Direct observations of changes in the elevation of the perched water table/water table at the 216-U-14 Ditch support these conclusions (Singleton and Lindsey 1994) and are intended here to represent the worst-case transport scenario during waste unit operations. An analysis was not completed to determine the impact of less mobile contaminants on the groundwater in the 200-UP-2 LFI report. However, sample data suggest that most of the less mobile contaminants remain near points of discharge (i.e., bottom of crib/ditches). The maximum concentrations of 200-UP-2 Operable Unit vadose contaminants are documented in the LFI for the 200-UP-2 Operable Unit (DOE-RL 1995e).

Effluent discharges to the sediment column have been phased out over the last decade. In June 1995 effluent discharges to the sediment column in the 200 West Area were terminated (WHC 1995). The overall effect of stopping discharge results in a reduction of vadose moisture, which is the primary mechanism of transport to groundwater. Recent observation in the 200 West Area indicates that it may take several years for vadose zone sediments to return to approximate natural moisture conditions following the end of water disposal at a facility (DOE-RL 1995e).

Residual contamination in the vadose zone (i.e., contamination remaining after remedial measures are completed) was evaluated to assess the potential for future impacts to groundwater. In general, the results of this assessment suggest that a very low concentration of contaminants would migrate at very slow rates toward the groundwater. Additionally, groundwater would not be impacted in the next 1,000 years (DOE-RL 1996). Concentrations used to assess the impact of residual contamination on the groundwater are documented in the *Focused Feasibility Study for the 200-UP-2 Operable Unit* (DOE-RL 1996).

3.1.1 Perched Water

The occurrence of perched water in the 200-UP-1 Operable Unit has been documented only at the U Pond Disposal System 216-U-14 Ditch. The ditch received effluent from at least 10 facilities (e.g., U Plant, 284-Powerhouse, 242-S Evaporator) in the 200 West Area. Operation of the ditch began in 1944. The ditch was stabilized with soil and river cobbles in 1995 and no longer receives effluent. All discharges to the sediment column in the 200 West Area were discontinued in June 1995.

Perching horizons at the 216-U-14 Ditch are associated with discontinuous fine-grained layers within the Hanford formation and the laterally extensive Plio-Pleistocene unit (caliche layer). The composite saturated thickness of the perched zone is documented to be greater than 18.3 m (60 ft) depending on the amount of effluent discharged. The thickness of the perched water zone decreases when the volume of effluent discharged to the ditch is reduced. This decrease in the thickness shortly after the reduction in discharge may be indicative of preferential vertical pathways. Natural preferential pathways common to the Hanford formation and Plio-Pleistocene unit such as clastic dikes likely limit the lateral spread of water on any given perching unit. Recent measurements of depth to water in perched water monitoring wells indicate that the perching horizon has dissipated. Arsenic, gross alpha and beta, strontium-90, and uranium-238 have been detected in perched water at the 216-U-14 Ditch at elevated levels. A detailed discussion of the perching water table at the 216-U-14 Ditch horizons is provided in Singleton and Lindsey (1994) and DOE-RL (1995e).

3.1.2 Evaluation of Groundwater Monitoring Well Seals

Unsealed wells may contribute to groundwater contamination by providing preferential contaminant pathways to the aquifer. The potential of transporting contaminants to groundwater is greatest in source areas where effluent is discharged to the sediment column and unsealed wells are present. Unsealed wells located within 30 m (100 ft) of a disposal unit have the greatest potential to impact groundwater because transport pathways are predominantly vertically downward beneath ponds, cribs, etc., and lateral spreading is generally limited by facies associations. As a general rule, the potential for impact to groundwater due to unsealed well seals decreases as the distance of the noncompliant well increases from the liquid waste disposal facility. In this report 30 m (100 ft) is used as the outer limit selected to identify these noncompliant wells with the greatest potential to impact groundwater during the time frame of effluent discharge. It should be noted, however, that effluent is no longer discharged to the sediment column in the 200 West Area/200-UP-1 Operable Unit. Therefore, the potential for impact is presently less than it ever has been over the operational history of any disposal unit.

Fifty-five groundwater monitoring wells were evaluated to identify design deficiencies that may contribute to groundwater contamination. This qualitative evaluation of well seals indicates that 41 groundwater monitoring wells have deficient or suspect well seals. Nineteen of the forty-one wells have no well seal. Wells with deficient or suspect well seals are identified in Table 2-1. Wells with the greatest potential for impacting groundwater during the time frame of effluent discharge are listed below.

299-W18-15
299-W18-20
299-W19-2
299-W19-3
299-W19-8
299-W19-9
299-W19-11
299-W19-13
299-W19-16
299-W19-18
299-W22-1
299-W22-2
299-W22-7
299-22-19
299-W23-9
299-W23-10
299-W23-11
299-W26-1
299-W26-6

A limited amount of data are available to provide evidence of transport in the annulus of wells in the 200-UP-1 Operable Unit. Results of the 200-UP-1 Operable Unit vertical profiling investigation suggest there is evidence that supports the transport of contaminants in the annulus of wells that lack seals. Vertical profiling results are presented in Ford (1995) and Section 3.4.3.

3.1.3 Geodetic Survey

A comparison of NAVD88 and NGVD29 survey data indicates that there is a vertical discrepancy of a least 2.3 m (7.5 ft) between the two methodologies. Differences in horizontal position vary by as much as 149.7 m (491 ft), but are generally less than 1 m (3.28 ft). Table 3-1 lists geodetic survey data that compare NAVD88 and NGVD29 measurements in wells where a fitness determination was performed. Groundwater maps presented in this report are based on NGVD29. Survey results are presented in Phase III, IV, and V Results for the Well Surveying Program at the U.S. Department of Energy Hanford Site, Vol. II, "Well Location Report" (DOE-RL 1993c, 1994b, 1995f).

3.2 GEOLOGY

The geology of the 200-UP-1 Operable Unit is described in the *Borehole Summary Report for 200-UP-1 Operable Unit, 200 West Area* (Kelty et al. 1995a) and *Borehole Summary Report for 200-UP-2 Operable Unit, 200 West Area* (Kelty et al. 1995b). The reports describe the depths, thicknesses, and lateral extent of stratigraphic units above the Columbia River Basalt within the operable units. Detailed information regarding the Elephant Mountain Member and Rattlesnake Ridge interbed is not included in these reports. As noted in the work plan, the Rattlesnake Ridge interbed will be evaluated after completion of the existing IRM. Geologic units described for the 200-UP-1 LFI from youngest to oldest are as follows:

- Holocene deposits [0 to 3.0 m (0 to 10 ft) thick]
- Hanford formation, Unit 1 [0 to 32.6 m (0 to 107 ft) thick]
- Hanford formation, Unit 2 [8.2 to 55.8 m (27 to 183 ft) thick]
- Plio-Pleistocene unit [0.61 to 14.6 m (2 to 48 ft) thick]
- Upper Ringold Formation [0 to 14.3 m (0 to 47 ft) thick]
- Ringold Formation, Unit E [49.7 to 89.6 m (163 to 294 ft) thick]
- Ringold Formation, lower mud unit [7.9 to 21.9 m (26 to 72 ft) thick]
- Ringold Formation, Unit A [13.7 to 37.2 m (45 to 122 ft) thick]
- Elephant Mountain Member [25.3 to 44.2 m (83 to 145 ft) above mean sea level].

A generalized stratigraphic column is shown in Figure 3-1.

3.3 HYDROSTRATIGRAPHY

3.3.1 Vadose Zone

The available June 1995 groundwater data indicate that the vadose zone is 59 to 75 m (193 to 247 ft) thick in the 200-UP-1 Operable Unit. This zone comprises surficial eolian deposits, the Hanford formation, a Plio-Pleistocene soil unit, and part of the Ringold Formation. Water infiltrating from the ground surface is subject to the flow characteristics of these units before reaching groundwater. Surficial eolian deposits may or may not be present at a particular locale and generally do not impact the movement of contaminated water because disposal of this water occurs beneath them. Eolian deposits will not be described below.

3.3.1.1 Hanford Formation. The Hanford formation is composed of two units: an upper coarse-grained unit (Unit 1) and an underlying fine-grained unit (Unit 2). Unit 1 is a highly permeable gravel facies, and water movement is generally unimpeded vertically. Saturated hydraulic conductivities range between 1.10 x 10^{-2} cm/s (31 ft/day) and 5.5 x 10^{-2} cm/s (156 ft/day) (Kelty 1995a, 1995b; Singleton and Lindsey 1994).

Unit 2 consists mainly of interstratified sands and silts. Saturated hydraulic conductivities in this zone typically range between 1 x 10^{-7} and 6.9 x 10^{-5} cm/s (2.83 x 10^{-4} and 0.2 ft/day) (Kelty 1995a, 1995b; Singleton and Lindsey 1994). Perched water was documented in this unit. The previous development of perched water indicates this unit can significantly impede the vertical movement of water. The lateral extent of perching was limited and controlled by abundant lateral discontinuities in the form of lenticular beds and clastic dikes. Perching does not presently occur in this zone. Perching conditions in the 200-UP-1 Operable Unit are discussed in Section 3.1.1.

3.3.1.2 Plio-Pleistocene Unit. Underlying the Hanford formation is a silt-rich calcium carbonate-enriched horizon referred to as the Plio-Pleistocene unit. This unit has been demonstrated to play a controlling role on the vertical movement of both water and contamination. The unit is up to 14.6 m (48 ft) thick and has extensive horizons of caliche. Where present, these caliche-rich zones may be discontinuous and highly fractured. Clastic dikes are present within the Plio-Pleistocene unit and may limit the lateral extent of perched water in this unit. All perched water monitoring wells in this zone are presently dry. Saturated hydraulic conductivities in this unit are between 5.5 x 10^{-6} and 2.58 x 10^{-3} cm/s (2 x 10^{-2} and 7.3 ft/day) (Kelty 1995a, 1995b; Singleton and Lindsey 1994). Perching conditions in the 200-UP-1 Operable Unit are discussed in Section 3.1.1.

3.3.1.3 Ringold Formation. The upper Ringold Formation (member of Taylor Flat) underlies the Plio-Pleistocene unit on the north-central edge of the operable unit. This erosional remnant consists of abundant well-sorted fluvial sand and smaller amounts of silty sand and gravelly sand. The available data indicate that laboratory-measured saturated hydraulic conductivities 1range from 1.65 x 10^{-4} to 1.1 x 10^{-3} cm/s (0.47 to 2.83 ft/day) (Connelly et al. 1992).

3.3.2 Saturated Zone

3.3.2.1 Ringold Formation Unit E. Unit E of the Ringold Formation comprises the lower part of the vadose zone over most of the operable unit and serves as the primary affected aquifer in the vicinity of 200-UP-1. Unit E ranges from 50 to 90 m (163 to 294 ft) in thickness over the 200-UP-1 Operable Unit. The saturated thickness of Unit E is estimated to be at least 61 m (200 ft) thick (Swanson 1996). The elevation of the water table ranges between 133 and 144 m (436 and 472 ft) above sea level. The depth of the water table ranges from 59 to 79 m (193 to 247 ft) below ground surface.

The hydraulic character of the unit is variable as it consists of interbedded sand and gravel facies and overbank sands and silts. It is apparent from drilling at the IRM site and within the adjacent 200-ZP-1 Operable Unit that zones of higher hydraulic conductivity are present but separated by zones of highly impermeable (clay/silt rich) materials (Swanson 1996). A long-duration aquifer test conducted at the IRM site indicates that hydraulic conductivity in that area is from 15.2 to 18 m/day (50 to 60 ft/day). Slug tests suggest that hydraulic conductivities typically range from 0.61 to 16.8 m/day (2 to 55 ft/day) (Singleton and Lindsey 1994, Kelty et al. 1995a). Hydraulic conductivities exceed 150 ft/day in three wells screened across Ringold Unit E (BHI 1994). Swanson (1996) and BHI (1994) indicate that transmissivities range between 49.7 to 222.7 m^2/day (535 to 2,397 ft^2/day). Aquifer testing results are summarized in Table 3-2.

Groundwater flow has two components in the 200-UP-1 Operable Unit. In the southern half of the operable unit flow is to the east; flow direction is to the northeast in the northern half (Figure 3-2). The average hydraulic gradient in the upper unconfined aquifer (generally defined as the upper 30 m [100 ft] of the unconfined aquifer) is 1.51×10^{-3}. The hydraulic character of the unit is changing as the remnant mound from U Pond gradually declines. During the last 6 months of 1995, water levels were dropping at a rate of about 1.5 m/year (5.0 ft/year) in the area defined by the 140-m contour line (Figure 3-2). Similarly, the rate of decline in the confined aquifer (Ringold Unit A) typically results in less than 0.3 m/year (1 ft^2/year) decline in the piezometric surface over the last 6 years. The declining water table is the result of ceasing effluent discharge to the sediment column in the 200 West Area. This decline in the water table will result in a lower hydraulic gradient and subsequently a lower groundwater flow velocity from the 200 West Area. Estimates of hydraulic conductivity associated with wells may change as portions of the aquifer are dewatered. As the water table in the unconfined aquifer declines, the hydraulic head difference between Unit E and the underlying confined units may become less pronounced, and a vertically upward hydraulic potential is likely to develop. Data used to determine vertical gradients are listed in Table 2-4.

The horizontal gradient in the deep unconfined aquifer (generally defined as the area 30 m [100 ft] above the Ringold Formation lower mud unit) is 2×10^{-3}; flow direction is to the southeast. A downward vertical gradient exists between the upper unconfined aquifer and deep unconfined aquifer.

3.3.2.2 Ringold Formation Lower Mud Unit. The Ringold Formation lower mud unit serves as a widespread aquitard, restricting the movement of both water and contaminants. Vertical hydraulic conductivity of the lower mud unit is estimated to be about 5.32 x 10^{-5} cm/sec (0.15 ft/day). The unit is reported to range from 7.9 to 21.9 m (26 to 72 ft) thick in the 200-UP-1 Operable Unit. The hydraulic conductivity contrast between the lower mud unit and the overlying Unit E is such that horizontal movement within Unit E is the predominant direction.

3.3.2.3 Ringold Formation Unit A. Unit A of the Ringold Formation is a gravel-dominated sequence ranging from 13.7 to 37.2 m (45 to 122 ft) thick. Hydrologic conductivities in Unit A range from 0.8 to 6 m/day (2.5 to 19 ft/day) (Kelty et al. 1995a). The unit acts as a semiconfined to confined aquifer, as water-level decreases are noted once the unit is penetrated by a well. This rapid adjustment in water level is indicative of the tightness of the lower mud unit. Table 2-4 shows the head distribution associated with Unit A. The direction and magnitude of potential flow are location dependent. Near the groundwater mound in the 200 West Area, flow direction is downward and the potential difference is about 1.1 m (3.6 ft). Away from the mounded area, flow direction is upward and the magnitude is on the order of tenths of feet. As the overlying mound continues to dissipate, the direction of flow will likely revert to vertically upward. The horizontal gradient in Unit A is 1 x 10^{-5}; flow direction is to the southwest. The vertical gradient between Unit A and the Rattlesnake Ridge interbed is downward.

3.3.2.4 Elephant Mountain Member. The Elephant Mountain Member is bedrock beneath the site. The basalt has a low hydraulic conductivity of 0.009 m/day (0.03 ft/day) (Singleton and Lindsey 1994).

A hydrostratigraphic section of major units investigated is shown in Figure 3-3.

3.4 NATURE AND EXTENT OF CONTAMINATION

The 200-UP-1 work plan (DOE-RL 1994c) identifies 26 high-priority groundwater contaminants based on the review of groundwater data from 1988 through 1990. These contaminants are as follows:

- Fifteen organic compounds: 1,2-dichloroethane, 1,1-dichloroethene, carbon tetrachloride, chloroform, trichloroethene, bis(2-ethylhexyl)phthalate, n-nitrosodimethylamine, and the pesticides aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC (Lindane), and heptachlor

- Six radionuclides: potassium-40, strontium-90, technetium-99, iodine-129, plutonium-238, and uranium

- Five inorganic constituents: arsenic, cadmium, chromium, fluoride, and selenium.

To assess the nature and extent of contamination, data for the 26 high-priority groundwater contaminants from 105 wells for the years 1990 through 1996 have been evaluated. The wells are listed in Table 2-3 and shown in Figure 3-4. This set of wells was used for the risk assessment and includes data from 45 of the 49 wells listed in Table 4-11 of the 200-UP-1 work plan and all groundwater data obtained during the 1995 200-UP-1 LFI sampling.

3.4.1 Evaluation of One-Time Detections

The following 11 organic high-priority groundwater contaminants were noted in Section 3.1.2.2.1 of the 200-UP-1 work plan (DOE-RL 1994c) as one-time detections based on the available data: 1,1-dichloroethene, bis(2-ethylhexyl)phthalate, n-nitrosodimethylamine, aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC (Lindane), and heptachlor. The work plan recommended further investigation of these 11 contaminants in order to determine if they are one-time detections. One-time detections will be removed from the list of high-priority groundwater contaminants.

Table 3-2 presents summary statistics for the 26 high-priority groundwater contaminants from the 105 wells for 1990 through 1995, and for samples collected in 1994 and 1995. Included in the table for each analyte are the number of wells sampled; analyses performed; detections; wells with detections; and the minimum, maximum, and average concentrations.

The organic compounds bis(2-ethylhexyl)phthalate and n-nitrosodimethylamine and the pesticides aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC (Lindane), and heptachlor occur as one-time detections for 1990 through 1995. This is illustrated in Table 3-2 by comparing the number of detections and the number of wells where detections occurred. Of these 10 compounds, only DDD was found in 1994 and 1995 (Table 3-2). There were five detections of 1,1-dichloroethene in 1994 and 1995.

The 16 high-priority groundwater contaminants not eliminated as one-time detections are evaluated in following sections.

3.4.2 Spatial Distribution of High-Priority Groundwater Contaminants

The 10 organic compounds bis(2-ethylhexyl)phthalate, n-nitrosodimethylamine, and the pesticides aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC (Lindane), and heptachlor have been eliminated as high-priority groundwater contaminants based on one-time detection criteria. The following two criteria are used to evaluate the remaining 16 high-priority groundwater contaminants.

- The constituent must be present in at least three adjacent wells to constitute a plume; detections in single wells do not constitute plumes.

- The constituent must be present in concentrations that exceed background or a drinking water standard.

Background concentrations are available for the inorganic constituents and most of the radionuclide constituents, but background concentrations are not available for organic constituents. The background concentrations for inorganic constituents and uranium are as follows: arsenic, 10 µg/L; cadmium, less than 10 µg/L; chromium, less than 30 µg/L; selenium, less than 5 µg/L; fluoride, 775 µg/L; and uranium, 3.43 pCi/L (DOE-RL 1992a). These background concentrations are the 95% confidence limit of the 95th percentile of the sitewide background data set, normal distribution, also known as the 95% upper threshold limit (DOE-RL 1992a). The background concentrations for potassium-40, strontium-90, iodine-129, and plutonium-238 are arithmetic means calculated from samples collected from four monitoring wells upgradient of the 200-UP-1 Operable Unit. These wells are 699-19-98, 699-43-88, 699-55-76, and 699-55-89. The background concentrations are as follows: potassium-40, 2.47 pCi/L; strontium-90, 3.77×10^{-3} pCi/L; iodine-129, 3.12×10^{-5} pCi/L; and plutonium-238, 6.43×10^{-5} pCi/L. A background concentration for technetium-99 is not available. The background for organic compounds is assumed to be zero.

3.4.2.1 High-Priority Organic Groundwater Contaminants.

3.4.2.1.1 1,1-Dichloroethene. The volatile organic compound 1,1-dichloroethene has been detected in 7 of 144 analyses of unfiltered samples, with detections in 1 of 58 wells sampled during the period 1990 through 1995 (Table 3-2). 1,1-dichloroethene has been detected in 5 of 96 unfiltered samples, with detections in 1 of 30 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average 1,1-dichloroethene concentrations for 1990 through 1995 are 1.7, 5.7, and 2.8 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 and 1995 are 2.0, 3.2, and 2.44 µg/L, respectively. The MCL for 1,1-dichloroethene is 7.00 µg/L.

The volatile organic compound 1,1-dichloroethene is present only in well 299-W22-20; thus, no plume exists for this constituent.

3.4.2.1.2 1,2-Dichloroethane. The volatile organic compound 1,2-dichloroethane has been detected in 13 of 685 analyses of unfiltered samples, with detections in 3 of 102 wells sampled during 1990 through 1995 (Table 3-2). 1,2-dichloroethane has been detected in 7 of 282 unfiltered samples, with detections in 3 of 87 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average 1,1-dichloroethene concentrations for 1990 through 1995 are 0.1, 5.5, and 4.3 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 through 1995 are 0.1, 5.5, and 4.2 µg/L, respectively. The MCL for 1,2-dichloroethene is 5.00 µg/L.

There are no 1,2-dichloroethane plumes, because the three wells in which detections have occurred, i.e., 299-W19-9, 299-W22-9, and 299-W22-20, are not adjacent. Eleven detections have occurred in well 299-W22-20, and one-time detections in wells 299-W19-9 and 299-W22-9.

3.4.2.1.3 Carbon Tetrachloride. Carbon tetrachloride has been detected in 518 of 686 analyses of unfiltered samples, with detections in 90 of 102 wells sampled during the period 1990 through 1995 (Table 3-2). Carbon tetrachloride has been detected in 220 of 282 unfiltered samples, with detections in 76 of 87 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average carbon tetrachloride concentrations for 1990 through 1995 are 5.30×10^{-2}, 1,800, and 117 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 through 1995 are 5.30×10^{-2}, 1,800, and 140 µg/L, respectively. The MCL for carbon tetrachloride is 5.00 µg/L.

The 200-UP-1 Operable Unit carbon tetrachloride plume is generally part of the much larger 200 Area West plume, as shown in Figure 3-5. The 200-UP-1 plume is largely attributed to disposal practices that occurred in the 200-ZP-1 Operable Unit, although the maximum carbon tetrachloride concentration in the 200-UP-1 Operable Unit occurs in well 299-W18-21. This well is situated at the northwest boundary between the 200-UP-1 and 200-ZP-1 Operable Units and is near the 216-U-11 Ditch and 216-U-10 Pond. Other areas with high carbon tetrachloride concentrations are the 216-U-1/U-2 Cribs, as shown by well 299-W19-16, and the area east of U Plant, as indicated by wells 299-W19-29 and 299-W19-34A. Two widely separated wells in the southern portion of the operable unit show high carbon tetrachloride concentrations, i.e., 299-W22-9 and 299-W23-14. Well 299-W22-9 is situated east of S Plant, and well 299-W23-14 monitors the 241-S/SX Tank Farm.

Trend plots for wells 299-W18-21, 299-W19-16, 299-W19-34A, 299-W19-29, 299-W22-9, and 299-W23-14 are shown in Figure 3-6. Concentrations of carbon tetrachloride are rising in well 299-W18-21, at the 200-UP-1/200-ZP-1 boundary; in well 299-W19-16, at the 216-U-1/U-2 Cribs; and in well 299-W19-29, east of U Plant. However, concentrations are relatively stable in well 299-W19-34A. Concentrations of carbon tetrachloride in the two southern wells (i.e., 299-W22-9 and 299-W23-14) are declining or relatively stable.

3.4.2.1.4 Chloroform. Chloroform has been detected in 456 of 690 analyses of unfiltered samples, with detections in 87 of 105 wells sampled during 1990 through 1995 (Table 3-2). Chloroform has been detected in 198 of 282 unfiltered samples, with detections in 70 of 87 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average chloroform concentrations for 1990 through 1995 are 5.0×10^{-2}, 183, and 6.03 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 and 1995 are 5.00×10^{-2}, 29, and 4.39 µg/L, respectively. There is no MCL for chloroform. The Washington State *Model Toxics Control Act* (MTCA) Method B and Method C groundwater standards for chloroform are 7.17 and 71.7 µg/L, respectively.

The 200-UP-1 Operable Unit chloroform plume is part of the much larger 200 West Area plume and can be considered the southern edge of the 200-ZP-1 Operable Unit chloroform plume, as shown in Figure 3-7. Of the chloroform analyses performed from 1994 through 1995, 10 analyses exceeded 10 µg/L. These occur in six wells located in the northern part of the 200-UP-1 Operable Unit. The maximum, 29 µg/L, occurs in well 299-W19-18 located near the 216-U-1/U-2 Cribs, although this result appears to be an outlier when concentration trends for the well are examined. Wells 299-W18-29 and 299-W18-31, located near the 216-Z-11-2 Ditch, have chloroform concentrations of 20 and 18 µg/L, respectively. Well 299-W19-34A, located east of U Plant, has a concentration of 14 µg/L. Wells 299-W18-15 and 299-W18-21, located near the 216-U-10 Pond and 216-U-11 Ditch, have chloroform concentrations of 14 and 13 µg/L, respectively.

An additional 15 chloroform results from 1994 and 1995 exceed 7.17 µg/L. These results are from the six wells mentioned above; from well 299-W19-34B, located in the northern plume; and from two adjacent wells in the southern part of the operable unit. The two adjacent wells (i.e., 299-W22-20 and 299-W27-1) are situated near the 216-S-26 Crib. Most wells in the central part of the operable unit have chloroform concentrations less than 7.17 µg/L.

Trend plots for five of the high-concentration northern wells and the two southern wells are shown in Figure 3-8. In the northwestern part of the operable unit, concentrations of chloroform are rising in wells 299-W18-15, 299-W18-21, and 299-W18-29, with the exception of one apparently anomalous low result in well 299-W18-21 and an erratic result in well 299-W18-29. Concentration trends were stable in well 299-W19-18 near the 216-U-1/U-2 Cribs, except for an apparent anomalous result in mid-1994, and have been declining east of U Plant in well 299-W19-34A. Concentrations of chloroform in the two southern wells (i.e., 299-W22-20 and 299-W27-1) are declining.

3.4.2.1.5 Trichloroethene. Trichloroethene has been detected in 227 of 686 analyses of unfiltered samples, with detections in 50 of 102 wells sampled during 1990 through 1995 (Table 3-2). Trichloroethene has been detected in 118 of 282 unfiltered samples, with detections in 42 of 87 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average trichloroethene concentrations for 1990 through 1995 are 5.00×10^{-2}, 50, and 39.7 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 and 1995 are 5.00×10^{-2}, 33, and 3.47 µg/L, respectively. The MCL for trichloroethene is 5.00 µg/L.

The 200-UP-1 Operable Unit trichloroethene plume is defined by six wells associated with the uranium and technetium-99 IRM effort. During 1994 and 1995, 35 detections of trichloroethene in concentrations greater than the MCL of 5.00 µg/L occurred in the following seven wells: 299-W19-19, 299-W19-20, 299-W19-29, 299-W19-34A, 299-W19-35, 299-W22-20, and 699-38-70. Six of the wells are in the area of the 200-UP-1 IRM effort; well 299-W22-20 is located in the southern part of the operable unit. The minimum, maximum, and average 1994 through 1995 trichloroethene concentrations for the six wells are 5.9, 13, and 8.25 µg/L. Although well 299-W22-20 has the highest trichloroethene concentration of all 200-UP-1 wells, 33 µg/L, it does not constitute a plume because trichloroethene has not been detected in adjacent wells.

Figure 3-9 presents the trichloroethene concentration trends for six of the seven wells. Concentrations have been relatively stable for the five northern wells, i.e., those associated with the 200-UP-1 IRM. The concentration in the southern well, 299-22-20, appears to be decreasing.

3.4.2.2 High-Priority Radionuclide Groundwater Contaminants.

3.4.2.2.1 Potassium-40. Potassium-40 has been detected in 74 of 79 analyses of unfiltered samples, with detections in 43 of 45 wells sampled during 1990 through 1995 (Table 3-2). Potassium-40 has been detected in 32 of 37 unfiltered samples, with detections in 21 of 23 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average concentrations for 1994 through 1995 are 15, 142, and 46.3 pCi/L, respectively. The minimum, maximum, and average potassium-40 concentrations for 1990 through 1995 are 6.13, 373, and 83.8 pCi/L, respectively. The background concentration of for potassium-40 at Hanford is 2.47 pCi/L, which is less than the minimum concentration in the 200-UP-1 samples. The MCL for potassium-40 is 295 pCi/L.

There are no potassium-40 plumes that exceed the MCL in the 200-UP-1 Operable Unit, based on 1994 and 1995 results. There are no well-defined potassium-40 plumes relative to the 200-UP-1 background. This is mainly a consequence of the limited number and areal distribution of wells sampled (Table 3-2). There are two areas where higher concentrations occur and other scattered, widely separated wells with anomalously high concentrations. The 241-U and 241-S/SX Tank Farms are the two areas where many wells have high potassium-40 concentrations, relative to background. Trend plots for wells near the 241-S/SX Tank Farms show that concentrations have rapidly declined from the high values reported in late 1991 (Figure 3-10).

3.4.2.2.2 Strontium-90. Strontium-90 has been detected in 48 of 267 analyses of unfiltered samples, with detections in 32 of 78 wells sampled in 1990 through 1995. Strontium-90 has been detected in 33 of 120 analyses of unfiltered samples, with detections in 27 of 55 wells sampled during 1994 and 1995 (Table 3-2). All of the samples exceed the 200-UP-1 Operable Unit background of 3.77×10^{-3} pCi/L. The minimum, maximum, and average strontium-90 concentrations for 1994 and 1995 are 8.13×10^{-3}, 71.3, and 4.93 pCi/L, respectively. The minimum, maximum, and average strontium-90 concentrations for 1990 through 1995 are 8.13×10^{-3}, 7,820, and 168 pCi/L, respectively. The maximum concentration is from well 299-W19-91, which monitors perched water. This result is probably an outlier, because the two subsequent results were nondetect and 14.4 pCi/L. The MCL for strontium-90 is 8 pCi/L.

There are no strontium-90 plumes that exceed the MCL in the 200-UP-1 Operable Unit, based on 1994 and 1995 results. Three nonadjacent wells sampled in 1994 and 1995 have strontium-90 concentrations that exceed the MCL of 8 pCi/L, i.e., 299-W19-24 with 14.4 pCi/L, 299-W22-1 with 71.3 pCi/L, and 299-W22-10 with 26.8 pCi/L. These wells are shown in Figure 3-4. A trend plot for well 299-W22-10 and concentrations for wells 299-W19-24 and 299-W22-1, which have one analysis each, are shown in Figure 3-11.

3.4.2.2.3 Technetium-99. Technetium-99 has been detected in 503 of 568 analyses of unfiltered samples, with detections in 90 of 99 wells sampled in 1990 through 1995. Technetium-99 has been detected in 265 of 288 analyses of unfiltered samples, with detections in 73 of 78 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average technetium-99 concentrations for 1990 through 1995 are 3.32×10^{-2}, 28,500, and 1,560 pCi/L, respectively. The minimum, maximum, and average uranium concentrations for 1994 through 1995 are 5.86×10^{-2}, 21,400, and 1,590 pCi/L, respectively. A background concentration for technetium-99 is not available. The MCL for technetium-99 is 900 pCi/L. There are 90 results greater than 900 pCi/L for 1990 through 1995 and 46 results greater than 900 pCi/L for 1994 and 1995.

The 200-UP-1 technetium-99 plume is associated with the uranium and technetium-99 IRM effort (Figure 1-3). There are no other plumes that exceed 900 pCi/L in the 200-UP-1 Operable Unit; only two adjacent wells sampled in 1994 and 1995 exceeded 900 pCi/L, but other nearby wells have not exceeded 900 pCi/L. These wells (299-W23-15 and 299-W23-2) are near the 241-S/SX Tank Farm and 216-S-25 Ditch. Based on the distribution and sharp concentration peak, the most likely source of the technetium-99 is the 241-S/SX Tank Farm. Figure 3-12 shows the technetium-99 concentration trends in wells monitoring the 241-S/SX Tank Farm. The more recent data indicate that the concentrations are now below the 900-pCi/L standard.

3.4.2.2.4 Iodine-129. Iodine-129 has been detected in 208 of 365 analyses of unfiltered samples, with detections in 69 of 86 wells in 1990 through 1995. Iodine-129 has been detected in 106 of 188 analyses of unfiltered samples, with detections in 53 of 73 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average iodine-129 concentrations for 1990 through 1995 are 4.12×10^{-3}, 86.1, and 5.72 pCi/L, respectively. The minimum, maximum, and average iodine-129 concentrations for 1994 and 1995 are 4.12×10^{-3}, 86.1, and 7.84 pCi/L, respectively. All of the detections exceed the 200-UP-1 Operable Unit background of 3.12×10^{-5} pCi/L. The MCL for iodine-129 is 0.48 pCi/L.

The 200-UP-1 Operable Unit iodine-129 plume, as derived from the maximum 1994 and 1995 concentrations, is shown in Figure 3-13. There are 114 samples collected from 33 wells in 1994 and 1995 that exceed the MCL of 0.48 pCi/L for iodine-129. The 1994 and 1995 iodine-129 concentrations in four wells, i.e., 299-W22-9, 299-W22-23, 699-35-70, and 699-36-70A, exceed the proposed MCL of 21 pCi/L. The plume maximum occurs in well 299-W22-9. No waste disposal sites are near this well; therefore, the source area(s) is inferred to have been located upgradient. One possible source of the iodine-129 is the 216-U-12 Crib, which received stack drainage, vault waste, and process condensate (DOE-RL 1993). Well 299-W22-23 monitors this crib and had an iodine-129 concentration of 22.2 pCi/L when sampled in March 1994. Other possible source areas include the 216-S-13, 216-S-20, and 216-S-22 Cribs; the 216-U-1/U-2 Cribs; and the 216-U-4 Reverse Well (DOE-RL 1994).

Figure 3-14 presents trend plots for many of the 200-UP-1 wells showing high concentrations of iodine-129. Concentrations in most of the wells have been relatively stable over multiple sampling events. Wells 299-W22-23 and 699-36-70A show the most variability, whereas wells 299-W22-42 and 699-38-65 generally show increasing concentrations.

3.4.2.2.5 Plutonium-238. Plutonium-238 has been detected in 28 of 192 analyses of unfiltered samples, with detections in 20 of 65 wells sampled in 1990 through 1995. Plutonium-238 has been detected in 3 of 38 analyses of unfiltered samples, with detections in 3 of 20 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average plutonium-238 concentrations for 1994 through 1995 are 2.24×10^{-3}, 4.15×10^{-3}, and 2.98×10^{-3} pCi/L. The minimum concentration for 1994 and 1995 is greater than the 200-UP-1 Operable Unit background, i.e., 6.43×10^{-5} pCi/L. The MCL for plutonium-238 is 15 pCi/L.

There is no plutonium-238 plume in the 200-UP-1 Operable Unit. Plutonium-238 occurred predominantly as one-time detections for 1990 through 1995; i.e., 15 wells have one-time detections, 4 wells have two detections, and 1 well has three detections. Three nonadjacent wells, i.e., 299-W22-2, 299-W23-10, and 299-W23-3, had one-time detections in 1994 and 1995. The multiple detections occurred in the 1990 through 1993 samples collected in four other wells. Trend plots for these four wells (i.e., 299-W18-21, 299-W18-29, 299-W18-30, and 299-W23-13) are shown in Figure 3-15. The only well with three consecutive detections is 299-W18-21. This well is located near the 216-U-11 Ditch and 216-U-10 Pond.

3.4.2.2.6 Uranium. Uranium has been detected in 725 of 726 analyses of nonfiltered samples collected from each of the 96 wells sampled from 1990 through 1995. Uranium has been detected in 274 of 275 analyses of unfiltered samples collected from all 80 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average uranium concentrations for 1990 through 1995 are 8.00×10^{-3}, $1.64 \times 10^{+4}$, and 219 µg/L, respectively. The minimum, maximum, and average uranium concentrations for 1994 through 1995 are 2.50×10^{-2}, $1.64 \times 10^{+4}$, and 375 µg/L, respectively. The minimum concentration is less than the Hanford Site background, i.e., 4.91 µg/L. Of the 724 results from 1990 through 1995, 370 exceed background. Of the 274 results from 1994 and 1995, 157 exceed background. Of the 1994 and 1995 results, 91 exceed the 44 µg/L MCL, and 108 results exceed the proposed MCL of 20 µg/L.

The 200-UP-1 uranium plume is associated with the uranium and technetium-99 IRM effort (Figure 1-2). Figure 1-2 shows that the plume coincides with wells monitoring the 216-U-17 Crib and with the 216-U-1/U-2 and 216-U-16 Cribs. Well 299-W19-2, near the 216-U-8 Crib, and wells located west of the 216-U-1/U-2 Cribs, i.e., 299-W18-30, 299-W19-1, 299-W19-12, 299-W19-21, 299-W19-27, and 299-W19-32, have concentrations greater than background, but less than the current and proposed MCLs.

There are no other plumes that have concentrations that exceed the 44 µg/L MCL. Well 299-W22-21 has a 1995 average concentration of 64.3 µg/L, a maximum concentration for 1994 through 1995 of 118 µg/L, and is associated with the 216-S-13 Crib. This isolated well does not constitute a plume, although concentrations exceed the MCL. Many other wells shown in the southern part of the operable unit, e.g., 299-W23-4, 299-W23-9, 299-W23-10, and 299-W23-13 that are associated with the 216-S-25 Crib and 241-S/SX Tank Farm have 1995 average uranium concentrations greater than the Hanford Site background of 4.91 µg/L, but less than the MCLs. Trend plots for selected 200-UP-1 uranium and technetium-99 IRM plume wells and southern wells are discussed below.

The uranium trend plots for nine 216-U-17 wells generally show that concentrations are increasing at most wells, although departures from this pattern are shown by wells 299-W19-25, 299-W19-26, and 299-W19-29 (Figure 3-16). Trend plots for the 216-U-1/U-2 wells show decreasing concentrations from 1990 through mid-1993 followed by stable to increasing concentrations (Figure 3-16). Concentrations of uranium in the wells west of the 216-U-1/U-2 Cribs generally have decreased from 1990 to 1996 (Figure 3-16). Concentrations of uranium in the four southern wells associated with the 241-S/SX Tank Farm do not show consistent trends (Figure 3-16).

3.4.2.3 High-Priority Inorganic Groundwater Contaminants.

3.4.2.3.1 Arsenic. Arsenic has been detected in 136 of 242 analyses of filtered samples, with detections in 48 of 54 wells sampled from 1990 through 1995. Arsenic has been detected in 30 of 35 analyses of filtered samples, with detections in 17 of 19 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average filtered arsenic concentrations for 1990 through 1995 are 1.0, 25, and 7.4 µg/L, respectively. The minimum, maximum, and average filtered arsenic concentrations for 1994 through 1995 are 1.3, 18, and 6.1µg/L, respectively. Arsenic has been detected in 146 of 281 analyses of unfiltered samples, with detections in 55 of 73 wells sampled from 1990 through 1995, and in 34 of 39 analyses of unfiltered samples, with detections in 22 of 24 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average unfiltered arsenic concentrations for 1990 through 1995 are 1.2, 27, and 7.1µg/L, respectively. The minimum, maximum, and average unfiltered arsenic concentrations for 1994 through 1995 are 1.2, 17, and 5.1µg/L, respectively. The MCL for arsenic is 50 µg/L.

There are no arsenic plumes in the 200-UP-1 Operable Unit. None of the detections exceed the MCL, and the detections above background occur in wells that are not adjacent.

Eight of the 1994 and 1995 filtered samples, collected at three wells, exceed the Hanford Site background arsenic concentration of 10 µg/L (DOE-RL 1992a). These wells are 299-W19-21, with five detections greater than background, 299-W19-27 with two, and 299-W18-29 with one detection greater than background. The minimum, maximum, and average arsenic concentrations for these eight samples are 12, 18, and 14.3 µg/L, respectively. Seven of the 1994 and 1995 unfiltered samples, collected at three wells, exceed the Hanford Site background arsenic concentration of 10 µg/L (DOE-RL 1992a). These wells are 299-W19-21, with four detections greater than background, 299-W19-27 with two, and 299-W23-11 with one detection greater than background. The minimum, maximum, and average arsenic concentrations for these seven samples are 10, 17, and 13 µg/L, respectively.

3.4.2.3.2 Cadmium. Cadmium has been detected in 7 of 557 analyses of filtered samples, with detections in 7 of 83 wells sampled in 1990 through 1995. Cadmium has been detected in 7 of 204 analyses of filtered samples, with detections in 7 of 75 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average filtered cadmium concentrations for 1990 through 1995 are 1.1, 7.2, and 3.1 µg/L, respectively. The minimum, maximum, and average filtered cadmium concentrations for 1994 through 1995 are 1.1, 7.2, and 3.1 µg/L, respectively. Cadmium has been detected in 9 of 452 analyses of unfiltered samples, with detections in 8 of 86 wells sampled in 1990 through 1995 and in 6 of 130 analyses of unfiltered samples, with detections in 5 of 63 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average unfiltered cadmium concentrations for 1990 through 1995 are 2.0, 660, and 98.5 µg/L, respectively. The minimum, maximum, and average unfiltered cadmium concentrations for 1994 through 1995 are 2.0, 660, 126 µg/L, respectively. The MCL for cadmium is 5.00 µg/L.

There are no cadmium plumes based on 1994 and 1995 filtered and unfiltered samples. There are no detections in three adjacent wells. Only one of the filtered samples exceed the MCL and none exceed the background Hanford Site background concentration, which is less than 10 µg/L (DOE-RL 1992a). The maximum cadmium concentration reported, 660 µg/L, was an unfiltered sample collected from well 699-66-70A during the first sampling event at the well. This result is an outlier because cadmium was not detected in the associated filtered sample or in any of the filtered or unfiltered samples collected during the following six sampling events. The next largest unfiltered cadmium concentration, 55 µg/L, is also suspect because it had a turbidity of 49 nephelometric turbidity units (NTU). The *EPA RCRA Technical Enforcement Guidance Document* (NWWA 1986) recommends that groundwater samples with turbidity greater than 5 NTU should not be used for metals analyses. Of the remaining four unfiltered detections, two are from well 299-W19-91, which monitors perched water, and two have concentrations less than the 5.00 µg/L cadmium MCL.

3.4.2.3.3 Chromium. Chromium has been detected in 177 of 577 analyses of filtered samples, with detections in 62 of 83 wells sampled in 1990 through 1995. Chromium has been detected in 118 of 204 analyses of filtered samples, with detections in 59 of 75 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average filtered chromium concentrations for 1990 through 1995 are 3.6, 2,500, and 47.8 µg/L, respectively. The minimum, maximum, and average filtered chromium concentrations for 1994 through 1995 are 3.6, 2,500, and 4.28 µg/L, respectively. Chromium has been detected in 375 of 468 analyses of unfiltered samples, with detections in 74 of 88 wells sampled in 1990 through 1995, and in 125 of 146 analyses of unfiltered samples with detections in 63 of 69 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average unfiltered chromium concentrations for 1990 through 1995 are 3.4, 2,400, and 142 µg/L, respectively. The minimum, maximum, and average unfiltered chromium concentrations for 1994 through 1995 are 3.4, 2,00, and 158 µg/L, respectively. The MCL for chromium is 100 µg/L.

There are no chromium plumes that exceed the MCL in the 200-UP-1 Operable Unit based on filtered and unfiltered data from 1994 and 1995 samples.

Thirteen of the 1994 and 1995 filtered samples exceeded 30 µg/L and seven exceeded the MCL. The Hanford Site background chromium concentration is less than 30 µg/L (DOE-RL 1992a). These samples were from eight wells: 299-W19-28, 299-W19-32, 299-W22-20, 299-W22-23, 299-W22-42, 299-W26-7, 699-32-62, and 699-34-61, of which only 299-W22-23 and 299-W22-42 are adjacent. The maximum chromium concentration reported, 2,500 µg/L, was a filtered sample collected from well 299-W22-23 on September 22, 1994. This result is an outlier and suspect because chromium was not detected in the previous five analyses or in the following analysis. In this well a similar pattern of one high-concentration detection in the sample from September 22, 1994 preceded by multiple nondetections and followed by a nondetection is also shown by cobalt, copper, nickel, and vanadium. The results for these constituents are also suspect. When the suspect chromium result from well 299-W22-23 is excluded, the minimum, maximum, and average chromium concentrations for the remaining 12 samples are 31, 250, and 116.9 µg/L, respectively, with 6 of the 12 filtered samples exceeding the 100 µg/L MCL. None of these seven wells are adjacent; consequently, plumes that exceed the MCL or background are not present.

There are 74 unfiltered chromium results that exceed 30 µg/L. However, only 26 of the 74 results are considered reliable, in that the turbidity of the sample was less than 5 NTU or the aluminum concentration associated with the sample was less than twice the Hanford Site background of 200 µg/L. Table 3-3 lists the 74 unfiltered samples from 1994 and 1995 that equal or exceed 30 µg/L, the corresponding aluminum concentrations and turbidity values, and reasons for exclusion of suspect chromium analyses. When the suspect chromium data (i.e., 48 results) are excluded, the minimum, maximum, and average chromium concentrations for the remaining 26 samples are 33, 340, and 102.2 µg/L, respectively, with 8 of the 26 unfiltered samples exceeding the 100 µg/L MCL. These 26 samples are from 17 wells. The 8 samples that exceed the MCL are from eight wells. There are no sets of three adjacent wells in the group of eight; therefore, no plumes are present that exceed the MCL.

The *EPA RCRA Technical Enforcement Guidance Document* (NWWA 1986) recommends that groundwater samples with turbidity greater than 5 NTUs not be used for metals analysis. Turbidity of the sample is important because the SW-846 inductively coupled plasma analytical method for chromium analysis involves acid digestion of the sample. This digestion can extract chromium and other metals from sediment present in a turbid groundwater sample. Unfortunately, turbidity was not measured for all the groundwater samples, so an aluminum concentration twice the Hanford background of 200 µg/L (DOE-RL 1992a) is also used to indicate samples with high turbidity. Aluminum concentrations in the groundwater samples should be low since aluminum tends to be partitioned in kaolinitic species, e.g., in clay minerals (DOE-RL 1992a). In four samples neither turbidity nor aluminum concentrations were determined; these results are excluded because the quality of the sample is indeterminate.

Figure 3-17 presents trend plots of chromium concentrations for 1990 through 1995 for the seven wells that have filtered chromium concentrations greater than 30 µg/L, excluding data from well 299-W22-23. The trend plots show the larger and more variable chromium concentrations in unfiltered samples relative to filtered samples. One-time detections above background occur in filtered samples from wells 299-W19-28 and 299-W22-42. The filtered sample result from well 299-W22-42, 31 µg/L, has a "B" qualifier, and the actual concentrations may be less than that reported. Consistent chromium concentrations greater than background for filtered samples occur at wells 299-W22-20, 299-W26-7, and 699-34-61 for the last three sampling events. The detections at wells 299-W22-20, 299-W26-7, and 699-34-61 do not constitute chromium plumes because adjacent wells do not have filtered chromium concentrations greater than background.

3.4.2.3.4 Selenium. Selenium has been detected in 38 of 241 analyses of filtered samples, with detections in 22 of 53 wells sampled in 1990 through 1995. Selenium has been detected in 19 of 32 analyses of filtered samples, with detections in 10 of 16 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average filtered selenium concentrations for 1990 through 1995 are 1.30, 12.8, and 3.66 µg/L, respectively. The minimum, maximum, and average filtered selenium concentrations for 1994 through 1995 are 1.30, 12.8, and 3.96 µg/L, respectively. Selenium has been detected in 43 of 291 analyses of unfiltered samples, with detections in 26 of 73 wells sampled in 1990 through 1995, and in 17 of 36 analyses of unfiltered samples, with detections in 10 of 20 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average unfiltered selenium concentrations for 1990 through 1995 are 1.0, 35, and 5.21 µg/L, respectively. The minimum, maximum, and average unfiltered selenium concentrations for 1994 through 1995 are 1.80, 8.60, and 4.09 µg/L, respectively. The MCL for selenium is 50 µg/L.

There are no selenium plumes that exceed the MCL or the Hanford Site background in the 200-UP-1 Operable Unit based on filtered and unfiltered data from 1994 and 1995 samples. None of the 1194 and 1995 selenium results exceed the MCL. The Hanford Site background selenium concentration is less than 5 µg/L (DOE-RL 1992a). Five filtered samples and three unfiltered samples from 1994 and 1995 exceeded 5 µg/L. These are one-time detections and do not constitute plumes relative to background because there are no groups of three adjacent wells that exceed 5 µg/L. Only two of the five filtered samples are from adjacent wells; i.e., from 299-W21-1 and 699-36-70A. Wells with filtered selenium concentrations exceeding 5 µg/L are 299-W19-19, 299-W19-35, 299-W21-1, 299-W27-1, and 699-36-70A. Wells with unfiltered selenium concentrations exceeding 5 µg/L are 299-W19-19, 299-W27-1, and 699-38-68A.

3.4.2.3.5 Fluoride. Fluoride has been detected in 794 of 839 analyses of unfiltered samples, with detections in 102 of 104 sampled wells during 1990 through 1995. Fluoride has been detected in 308 of 311 unfiltered samples, with detections in all 95 wells sampled during 1994 and 1995 (Table 3-2). The minimum, maximum, and average concentrations for 1990 through 1995 are 100, 4,000, and 665 µg/L, respectively. The minimum, maximum, and average concentrations for 1994 through 1995 are 100, 2,400, and 724 µg/L, respectively. The MCL for fluoride is 4,000 µg/L.

There are no fluoride plumes that exceed the MCL in the 200-UP-1 Operable Unit based on unfiltered data from 1994 and 1995 samples, because no samples exceeded the 4,000 µg/L MCL. Four fluoride plumes exceed the Hanford Site fluoride background of 775 µg/L. The four plumes are defined by 51 wells sampled in 1994 and 1995 and are shown in Figure 3-18.

Figure 3-18 presents the 1995 average fluoride concentrations in 200-UP-1 monitoring wells. The largest average fluoride concentrations range from 1,200 to 2,150 µg/L and occur in the plume located approximately 250 m southeast of U Plant. This plume is defined by six wells associated with the 200-UP-1 uranium and technetium-99 IRM effort. Average fluoride concentrations of 800 to 1,000 µg/L occur at six wells near the 216-U-1/U-2 and 216-U-16 Cribs and define a plume located less than 100 m southwest of U Plant. Average fluoride concentrations of 850 to 1,150 µg/L occur at four wells that constitute a plume near the 216-U-12 Crib, approximately 500 m south of U Plant. Average fluoride concentrations of 800 µg/L occur in three wells that constitute a plume near the 241-S/SX Tank Farm, located approximately 1,000 m southwest of U Plant.

Wells showing the highest fluoride concentrations for 1994 through 1995 are associated with the uranium and technetium-99 IRM effort; this may be indicative of a common source of these constituents. Fluoride concentration trends for wells at or near the IRM site, e.g., 299-W19-19, 299-W19-23, 299-W19-24, 299-W19-25, and 299-W19-26, are shown in Figure 3-19. Concentrations of fluoride are below the MCL of 4,000 µg/L and are remaining constant or dropping.

3.4.2.4 Summary of High-Priority Groundwater Contaminant Plumes. Table 3-4 summarizes the 1994 and 1995 data for the 26 high-priority groundwater contaminants such as the maximum concentrations, background, federal and state groundwater standards, and presents an assessment of the existence of contaminant plumes. Federal and state groundwater standards that are exceeded by the maximum concentrations are shaded in the table. Plumes formed by high-priority groundwater contaminants that exceed the MCL or background are also shaded in the table.

The following high-priority groundwater contaminants have maximum concentrations that exceed MCLs: 1,2-dichloroethane, carbon tetrachloride, trichloroethene, strontium-90, technetium-99, iodine-129, uranium, cadmium, and chromium. The following high-priority groundwater contaminants have maximum concentrations that exceed the Washington MTCA Method B cleanup standards: 1,1-dichloroethene, 1,2-dichloroethane, carbon tetrachloride, chloroform, trichloroethene, uranium, arsenic, chromium, and fluoride. The following high-priority groundwater contaminants have maximum concentrations that exceed the Washington MTCA Method C cleanup standards: 1,1-dichloroethene, carbon tetrachloride, arsenic, chromium, and fluoride.

Plumes that exceed the MCL exist for the following high-priority groundwater contaminants: carbon tetrachloride, trichloroethene, iodine-129, technetium-99, and uranium. The trichloroethene, technetium-99, and uranium plumes are associated with the 200-UP-1 uranium and technetium-99 IRM effort. An MCL does not exist for chloroform. Chloroform constitutes a plume that exceeds the MTCA Method B groundwater cleanup standard. Fluoride and potassium-40 constitute plumes that exceed background, but not MCLs.

3.4.3 Vertical Profiling Results

Five groundwater monitoring wells (299-W19-18, 299-W19-29, 299-W19-34A, 299-W19-34B, and 699-38-70) were sampled to assess the vertical distribution of contaminants in the 200-UP-1 Operable Unit. Results and figures presented in this section are from Ford (1995). The locations of wells used in this vertical profiling investigation are shown relative to the technetium/uranium and carbon tetrachloride plumes along section A-A' in Figures 3-20 and 3-21, respectively.

The available data suggest that the technetium-99 and uranium plumes extend to a depth of approximately 15.2 and 30.5 m (50 and 100 ft) below the water table, respectively. Decreases in the level of contamination were generally observed within the plumes with depth. Where the trends are reversed, the reversal appears to be associated with unsealed groundwater wells. Evidence for these reversals is apparent in well 299-W19-18 (Figures 3-22 and 3-23). Carbon tetrachloride is distributed similarly to technetium-99 and uranium in the upper unconfined aquifer. The vertical extent of the carbon tetrachloride plume is estimated to be about 30.5 m (100 ft) below the water table. Evidence for increasing concentrations with depth was observed in wells 299-W19-4 and 299-19-18 (Figure 3-24), which have no documented annular seals. Carbon tetrachloride was also detected at elevated levels (15.4 ppb) above and below the Ringold lower mud unit.

Three chemical/physical conditions are proposed in Ford (1995) that may explain the contaminant profiles observed: dissolved oxygen/redox conditions, hydrostratigraphic control, and preferential contaminant pathways.

The transition with depth from oxygenated to reducing (redox) conditions in an aquifer provides a potential control on the mobility of redox-sensitive contaminants. Dissolved oxygen and redox measurements at well 299-W19-34 (Figures 3-25 and 3-26) indicate that a transition zone in the dissolved oxygen and redox conditions in the unconfined aquifer occurs between 30.5 to 39.6 m (100 to 130 ft) below the water table. The control that redox conditions exert on the distribution of contaminants may be evident in the vertical distribution of uranium and technetium-99. Both uranium and technetium-99 are subject to chemical reduction and immobilization in an oxygen-depleted environment.

Hydrostratigraphic control may restrict contaminant movement to the upper oxygenated portion of the unconfined aquifer in which contaminants are mobile. During the drilling of well 299-W19-34, numerous fine-grained, low-conductivity units were encountered. These units also restrict the vertical movement of contaminants and promote lateral spreading of effluent. This impediment to vertical movement may explain the relatively shallow distribution of uranium and technetium-99 and the highest levels of carbon tetrachloride contamination in the unconfined aquifer. Deeper contamination should occur if there is a preferential hydraulic pathway that crosscuts low-conductivity stratigraphic units. Such pathways may exist around unsealed wells, such as well 299-W19-18.

The deep distribution of uranium, technetium, and carbon tetrachloride suggests there is a mechanism that circumvents hydrostratigraphic control in the upper unconfined aquifer. Unsealed wells appear to provide a likely preferential contaminant pathway. The potential for movement of contaminants along unsealed wells has been proposed in other studies (Johnson et al. 1993, Rohay et al. 1994). No testing was specifically performed to assess the transport of contaminants in the annulus of unsealed wells in the 200-UP-1 Operable Unit. Indirect evidence of transport in the annulus of wells in the 200-UP-1 Operable Unit is mainly provided by the contaminant profiles of a few sealed and unsealed wells (Figures 3-22 through 3-24). These data strongly suggest that adverse contaminant impacts on the aquifer are significantly greater in the presence of unsealed wells.

3.4.4 Evidence for Continued Impact on Groundwater Quality

Groundwater may be impacted years after effluent discharge has ceased at liquid waste disposal facilities. Evidence for continued contaminant impacts is being investigated at the 216-U-12 Crib as part of the RCRA interim-status groundwater quality assessment program. This crib was in operation from 1960 to 1972 and 1981 to 1988 and received nitric acid and low-level radioactive waste containing plutonium, strontium, ruthenium, and uranium in 1.33×10^8 L (3.5×10^7 gal) of wastewater. Based on a comparison of up and down-gradient groundwater data, preliminary findings of this investigation suggest that four contaminants (nitrate, iodine, technetium, and tritium) are currently impacting the aquifer 8 years after discharge ceased. All four contaminants have low distribution coefficients that suggest that their movement through the subsurface is within a saturated or near-saturated area beneath the crib. Significant contaminant impact is noted only for nitrate relative to its MCL. The concentration of nitrate in groundwater has increased from 300,000 ppb to 500,000 ppb between 1991 and 1995. The remaining contaminants are above background but less than their respective MCLs and are not necessarily indicators of significant impact. The concentration of these contaminants in at least one downgradient well has shown slight increases over time. Results of the RCRA investigation suggest that the vadose zone contains remnant amounts of effluent and several highly mobile contaminants that are sources of groundwater contamination (see Annual Reports for RCRA Groundwater Monitoring Projects at the Hanford Site Facilities [DOE-RL 1994a, 1995a]).

3.4.5 Geophysical Logging Results

Operable unit boreholes logged with the radionuclide logging system can be divided into two general groups based on their location in or adjacent to source waste management units (e.g., pond, ditches, cribs). Four boreholes (i.e., 299-W19-94, 299-W19-96, 299-W19-98, and 299-W19-231) drilled through inactive waste managements units were logged with the radionuclide logging system. Seventeen boreholes were logged in the operable unit that are located adjacent to or in the vicinity of waste management units.

Geophysical log profiles from boreholes drilled through and adjacent to waste management units indicate that higher levels of contamination were detected beneath source waste management units. Greater levels of contamination were detected at points of discharge and near the bottom of these facilities. Less contamination was generally detected with depth; however, elevated levels were also detected associated with the Hanford formation and the Plio-Pleistocene unit. Considerably less or no contamination was detected in wells located adjacent to waste management units. For example, no manmade radionuclides were detected in adjacent wells (i.e., 299-W19-34A, 299-W19-34B, 299-W19-35, and 699-38-68A) drilled to support the 200-UP-1 IRM/LFI.

Results of the geophysical investigation suggest that the primary contaminant pathway is vertically downward beneath waste management units. Detection of little or no contamination adjacent to waste management units is an indicator that contaminants may spread laterally along fine-grained horizons within the Hanford formation and on top of the Plio-Pleistocene unit. The lateral extent of spreading appears to be limited. Logging results, including the distribution of radionuclides, are presented in the reports referenced in Section 2.1.3 and DOE-RL (1995e).

3.5 GROUNDWATER CHEMISTRY

As stated in Section 2.4, groundwater chemistry background data contribute to the development of both the conceptual model and the risk assessment. This section identifies existing data from earlier investigations and the contributions of the more recent 200-UP-1 LFI results to establish the local groundwater chemistry background. Data from local source operable unit site investigation activities were incorporated into the groundwater chemistry background.

3.5.1 Local Groundwater Chemistry

The groundwater background is composed of the analytes that exist naturally in the groundwater at the Hanford Site. The local groundwater of the 200-UP-1 Operable Unit is considered to be a composite of the contribution from the waste disposal activities in the operable unit combined with the background groundwater as it flowed through the operable unit boundaries. Earlier sections of this report presented the results of groundwater monitoring and screening activities that defined the groundwater contaminants of concern. The other constituents of the groundwater, while themselves being determined not hazardous after this screening procedure, can affect the solubility and transport of the contaminants.

Concentrations of the common constituents found in the Hanford groundwater are described in the *Hanford Site Groundwater Background* (DOE-RL 1992a). Tables 3-5 and 3-6 list the background concentrations of these constituents and the low, average, and high values of these constituents as determined during the 200-UP-1 LFI groundwater monitoring. Comparison of the average LFI concentrations to the background shows a factor of ten increase for concentrations of both alkalinity and nitrate and a large increase for phosphate. Reagents containing nitrate and phosphate were commonly used in the 200 West Area processing plants.

3.5.2 Aquifer Media

Limited aquifer media (matrix) samples were collected and characterized during the local source operable unit characterization activities and the well construction to support the 200-UP-1 IRM groundwater pump-and-treat operation. This information is presented in the various borehole summary reports prepared during the LFI. Additional information on the chemical composition and grain size distribution of the 200-UP-1 aquifer material can be found in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes* (DOE-RL 1995b).

3.5.3 Monitoring Well Influences

As shown in Table 3-4, groundwater concentrations of iron and the alloying elements (chromium, manganese, and nickel) are at levels above the Hanford background and may indicate a sampling bias. There is the potential that sampling bias could be introduced through the interaction of the groundwater with the perforated carbon steel casings used for the majority of the pre-1980 wells, or with the stainless steel well screens of the more recently constructed groundwater monitoring wells. If there were sampling bias, the reported concentrations for these elements would not be representative of actual groundwater conditions.

Knowledge of the operational processes involved at the plants and facilities located near contaminant highs, the identity and quantity of chemicals used in the process, and the amount of effluent disposed to the soil column at nearby disposal sites can help determine if monitoring wells influence the quality of a groundwater sample. In addition, the use of analytical data from filtered groundwater samples should remove any bias introduced by the inclusion of particulate and colloids in the groundwater sample. Evaluation of the available analytical data for filtered samples of 200-UP-1 groundwater indicates that the groundwater monitoring wells do not have a noticeable effect on the groundwater quality.

3.5.4 Summary

Characterization of the 200-UP-1 groundwater has produced no changes from the initial conceptual model introduced in the 200 West Area Groundwater AAMSR (DOE-RL 1993a). Groundwater is slightly basic due to calcium carbonate buffering of the system. Redox potential changes from oxidizing to reducing with depth below the water table; this may act as a solubility control and limit vertical migration of redox-sensitive contaminants (e.g., uranium and technetium-99). The fine size fraction in the aquifer matrix shows some tendency to sorb cations.

Figure 3-1. Generalized Stratigraphic Column.

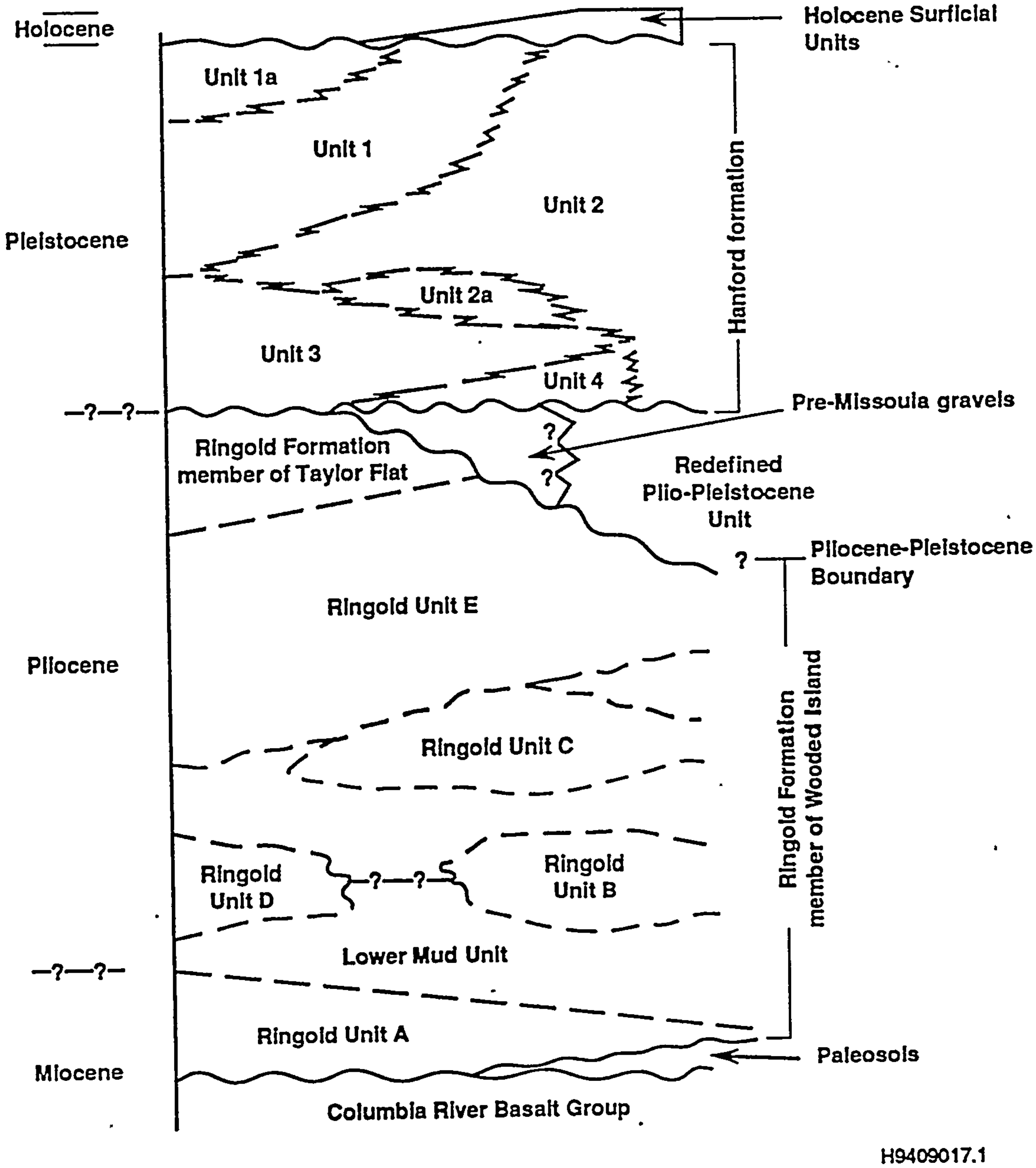


Figure 3-2. Water-Table Map, June 1995.

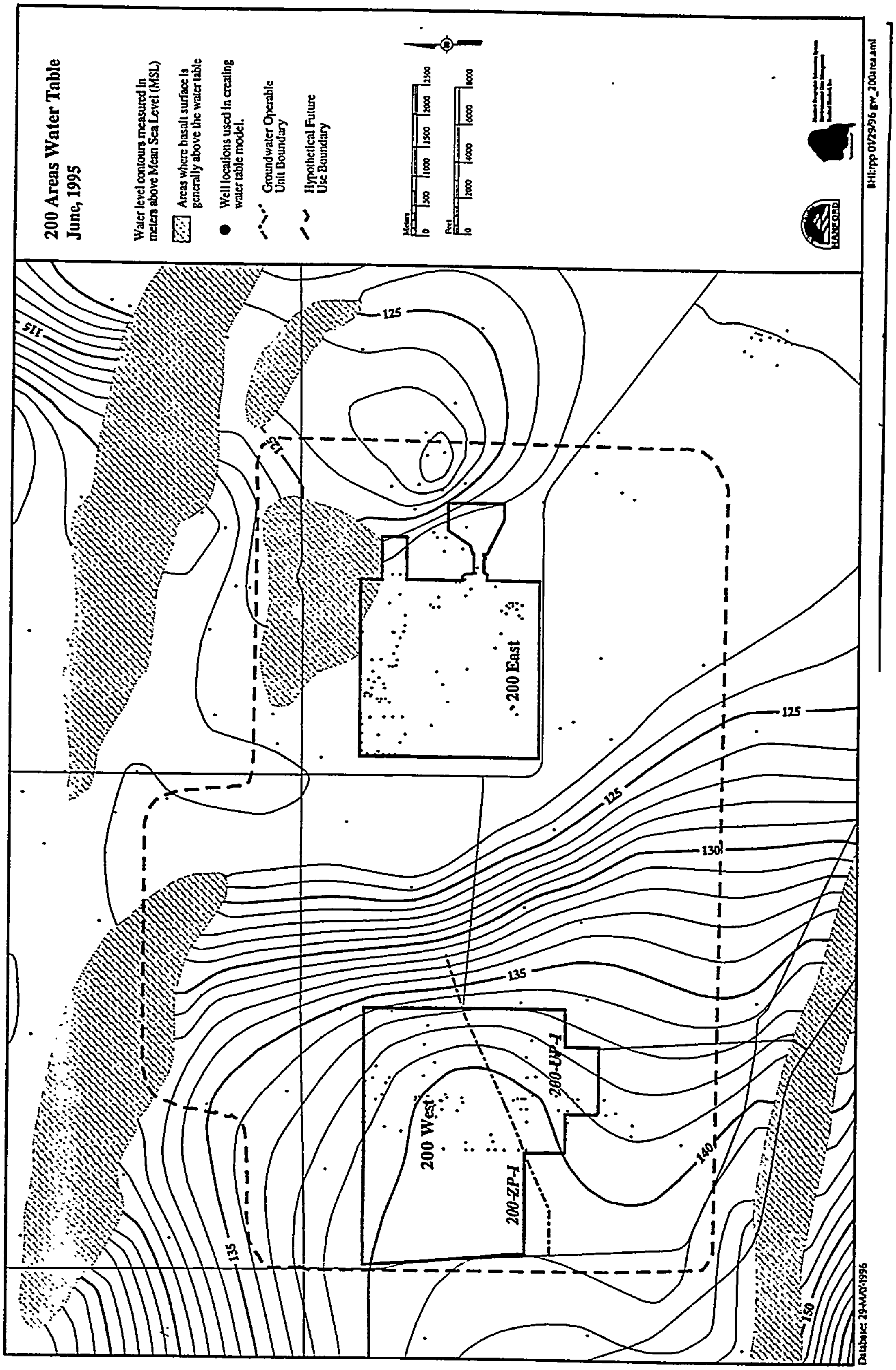
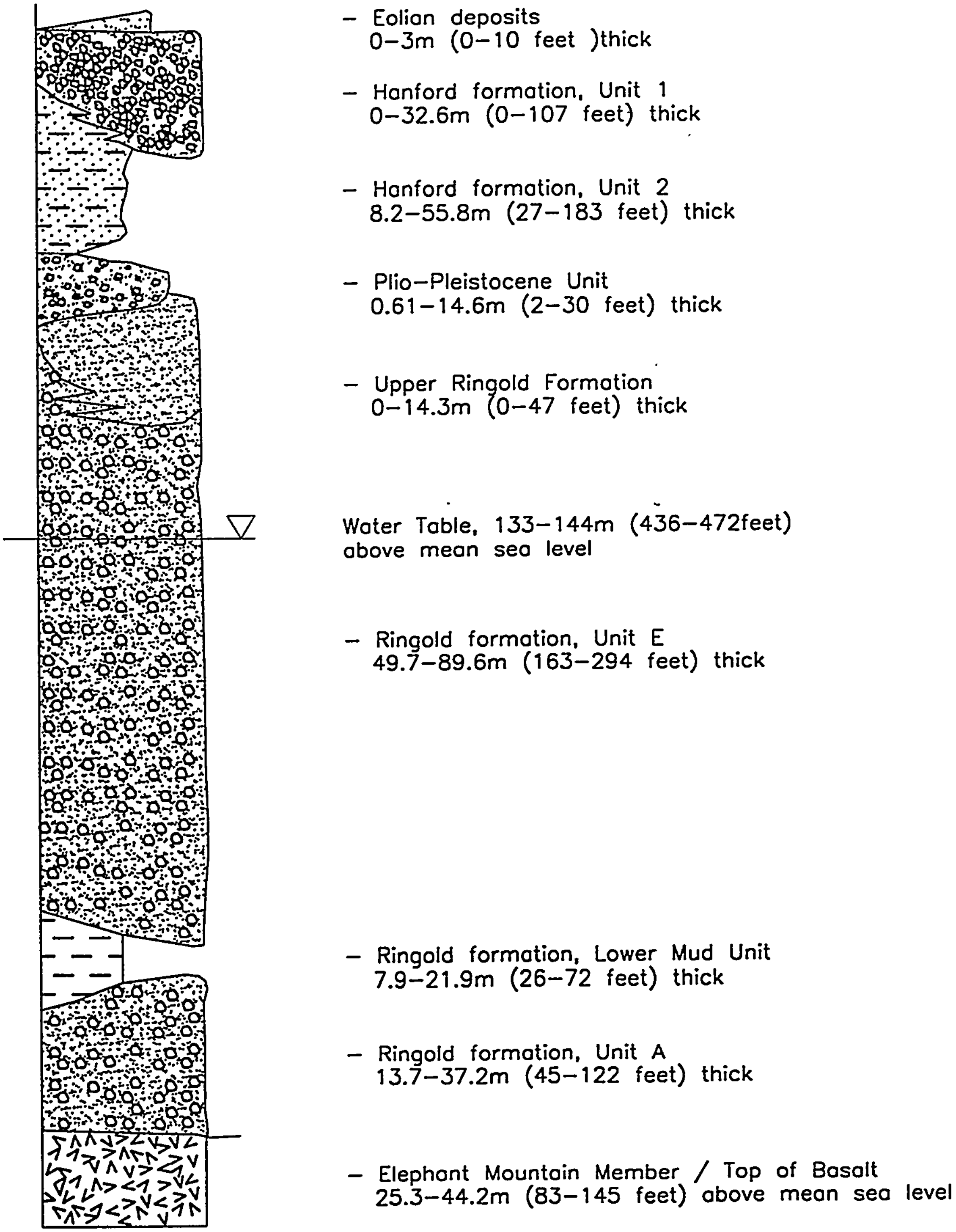
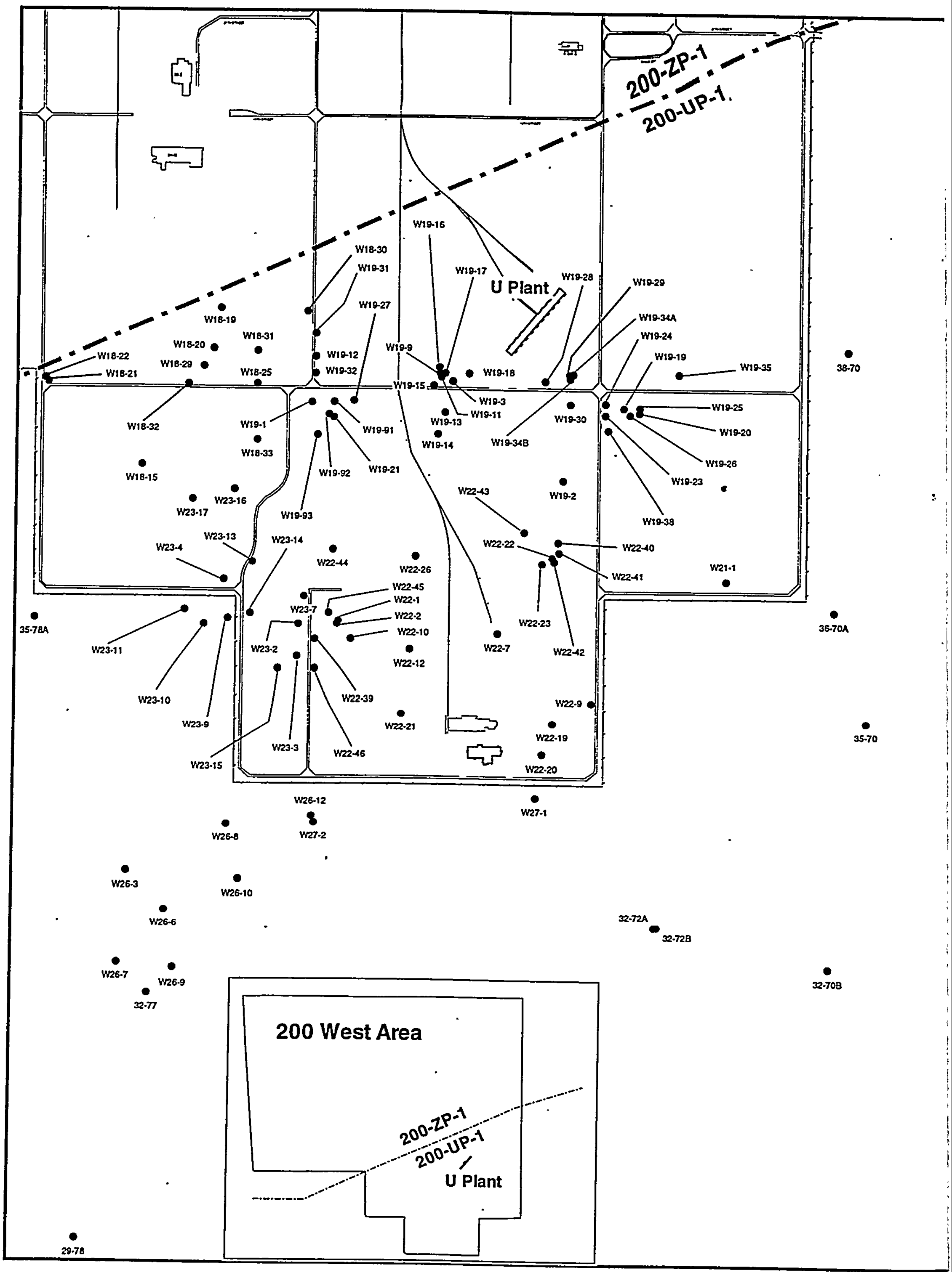


Figure 3-3. Generalized Stratigraphic Column for the 200-UP-1 Operable Unit.




200-ZP-1
200-UP-1
U Plant
W19-16
W19-17
W19-28
W19-29
W19-34A
W19-24
W19-19
W19-35
38-70
W18-30
W18-31
W19-27
W18-19
W18-31
W18-20
W18-29
W18-22
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W18-25
W19-12
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W19-9
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W19-34B
W19-30
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W19-26
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W19-38
W18-32
W19-1
W19-91
W18-33
W19-92
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W18-15
W23-16
W23-17
W19-93
W22-43
W19-2
W23-13
W23-14
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W22-26
W22-22
W22-40
W22-41
W21-1
W22-45
W22-1
W22-2
W22-10
W23-7
35-78A
W23-11
W23-2
W22-12
W22-7
W22-23
W22-42
36-70A
W23-10
W22-39
W23-9
W22-9
W22-21
W22-19
35-70
W23-3
W22-46
W23-15
W22-20
W26-12
W27-1
W26-8
W27-2
W26-3
W26-10
W26-6
32-72A
32-72B
W26-7
W26-9
32-77
32-70B
200 West Area
200-ZP-1
200-UP-1
U Plant
29-78

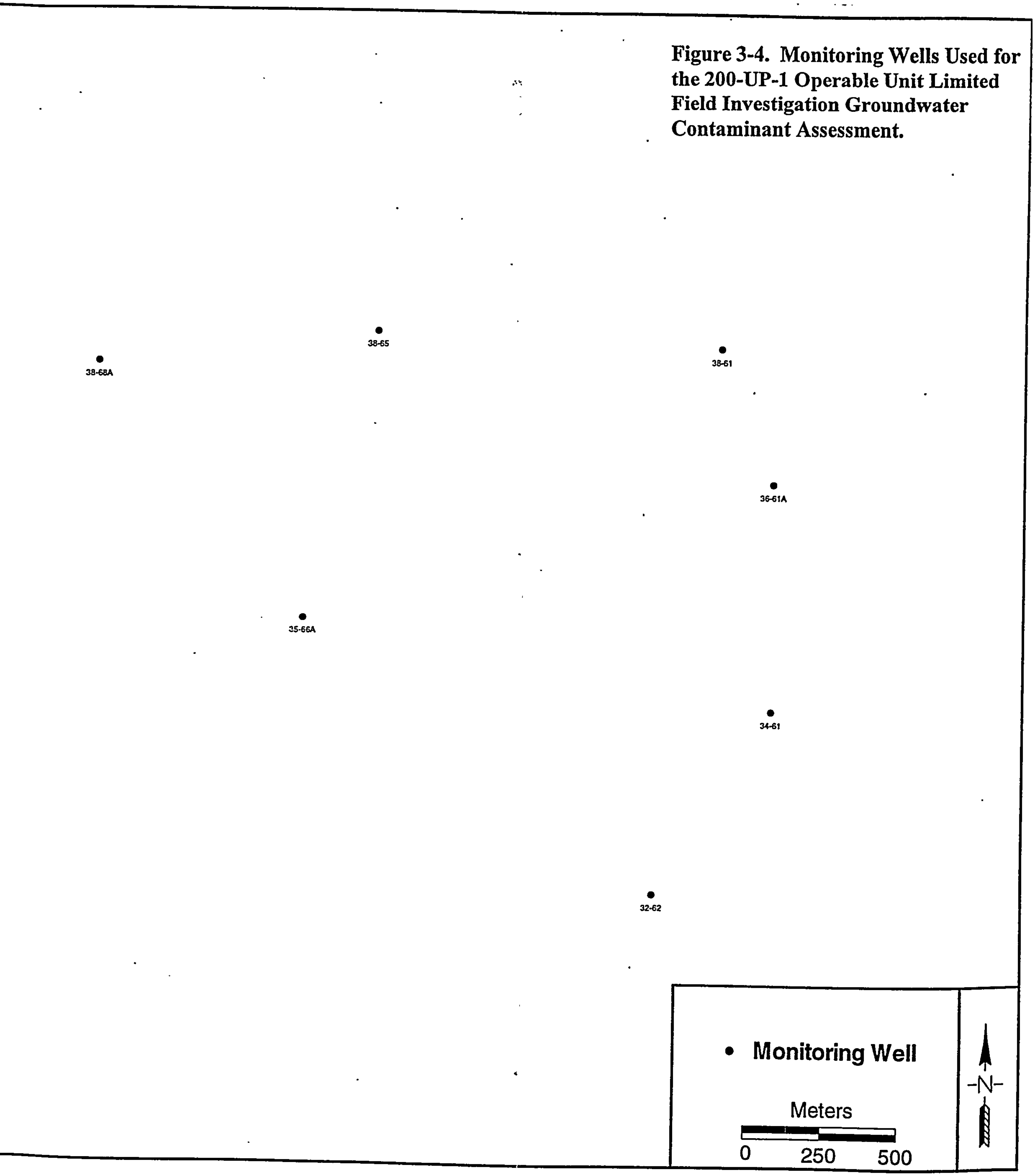


Figure 3-4. Monitoring Wells Used for the 200-UP-1 Operable Unit Limited Field Investigation Groundwater Contaminant Assessment.

Figure 3-5. Carbon Tetrachloride Plume in the 200 West Area.

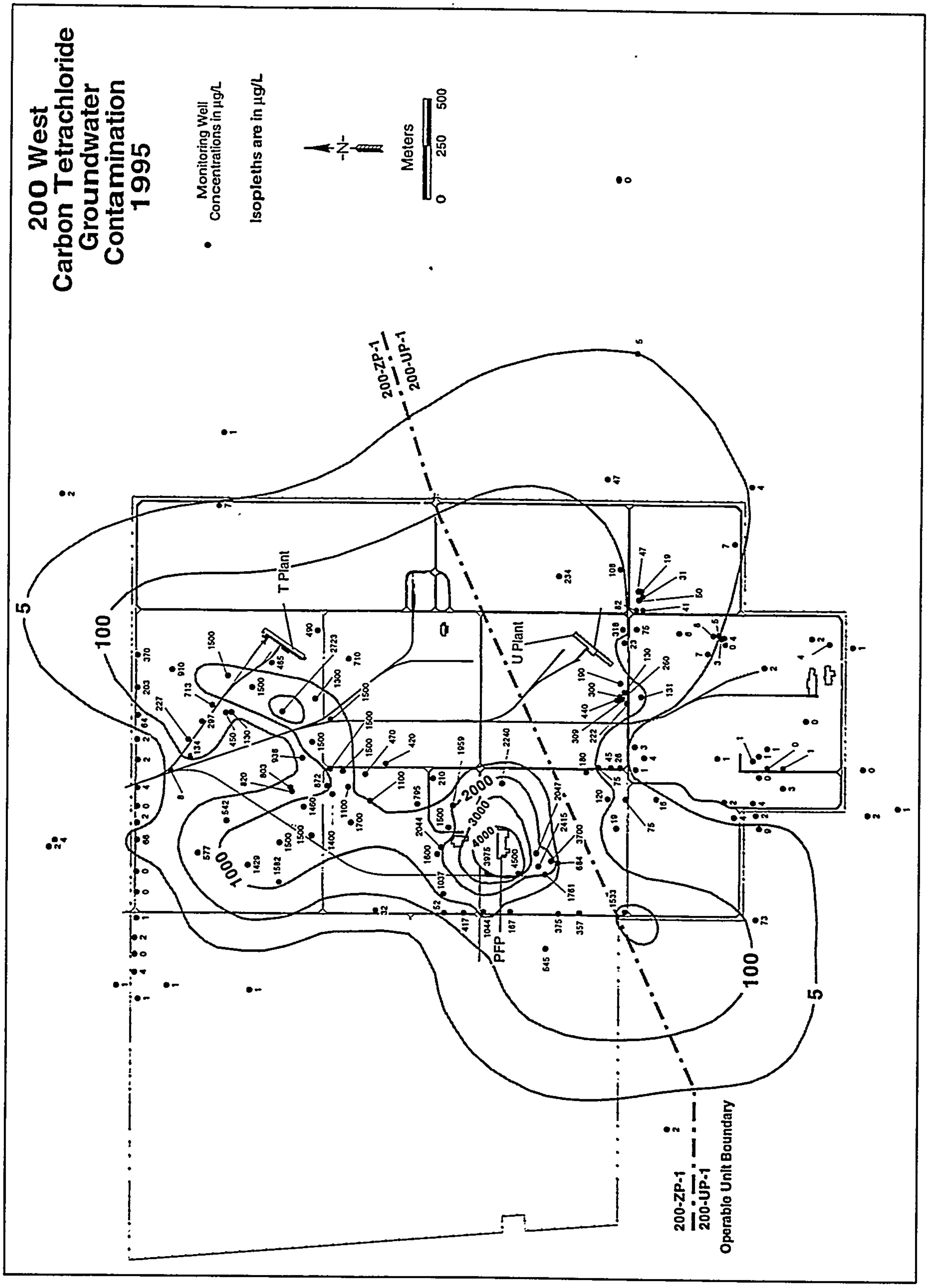


Figure 3-6. Carbon Tetrachloride Concentration Trend Plots for Wells 299-W18-21, 299-W19-16, 299-W19-34A, 299-W19-29, 299-W22-9, and 299-W23-14 in the 200-UP-1 Operable Unit. (sheet 1 of 2)

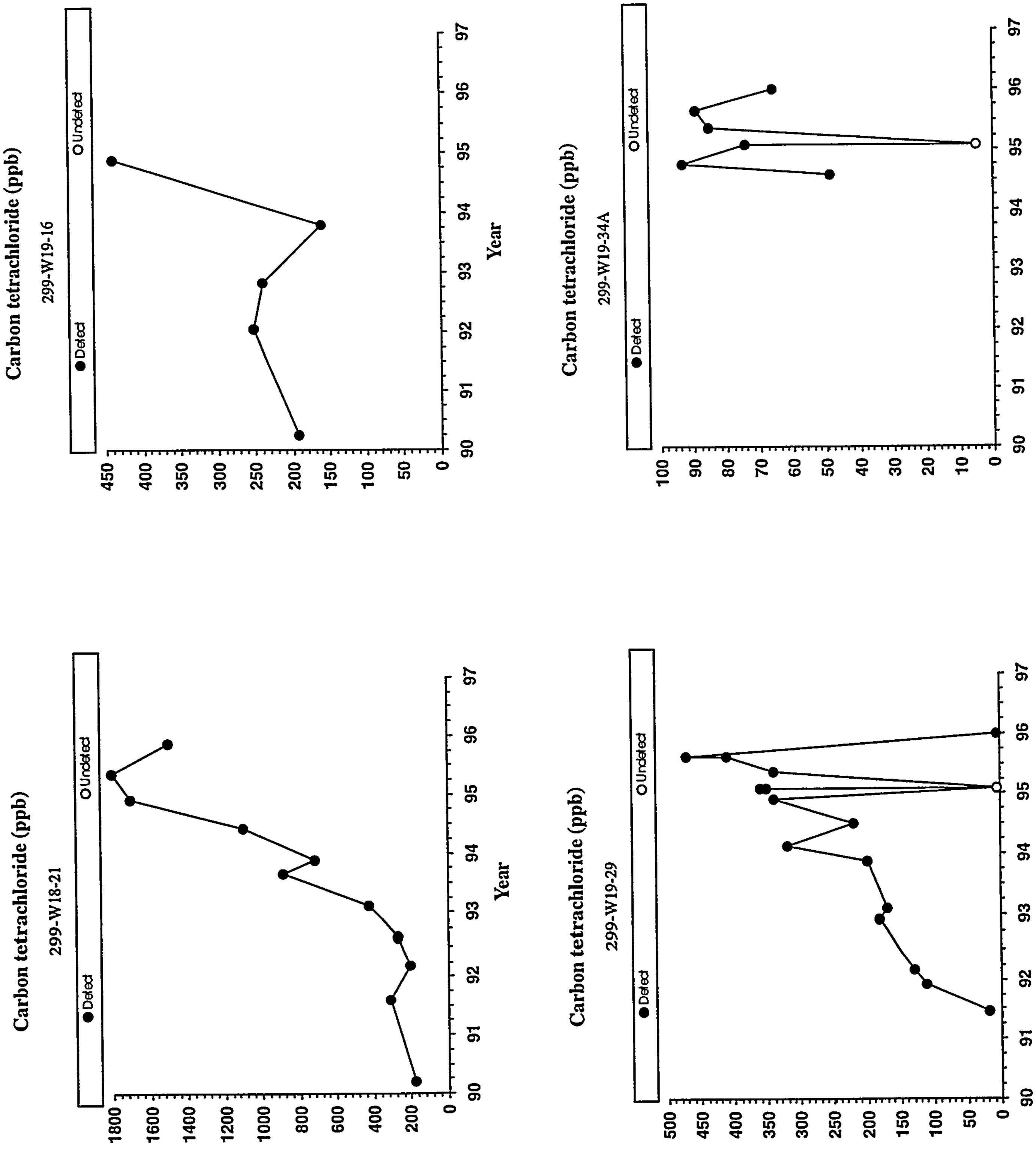
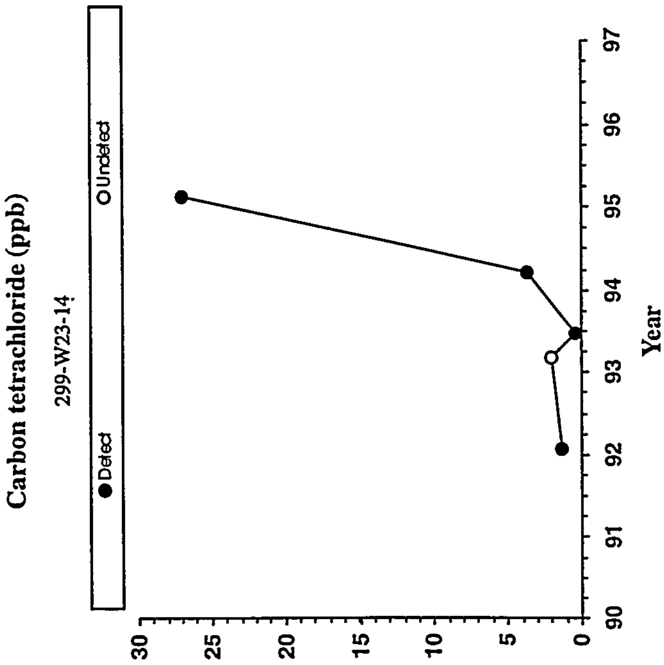


Figure 3-6. Carbon Tetrachloride Concentration Trend Plots for Wells 299-W18-21, 299-W19-16, 299-W19-34A, 299-W19-29, 299-W22-9, and 299-W23-14 in the 200-UP-1 Operable Unit. (sheet 2 of 2)



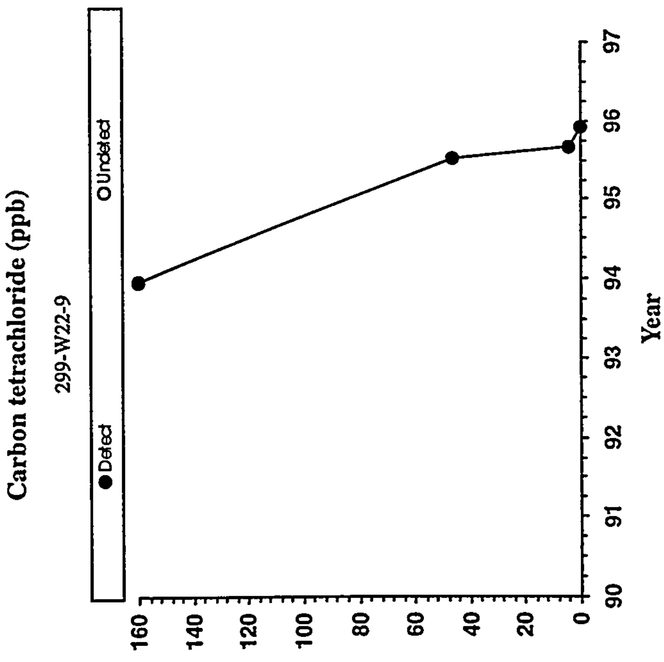


Figure 3-7. Chloroform Plumes in the 200 West Area.

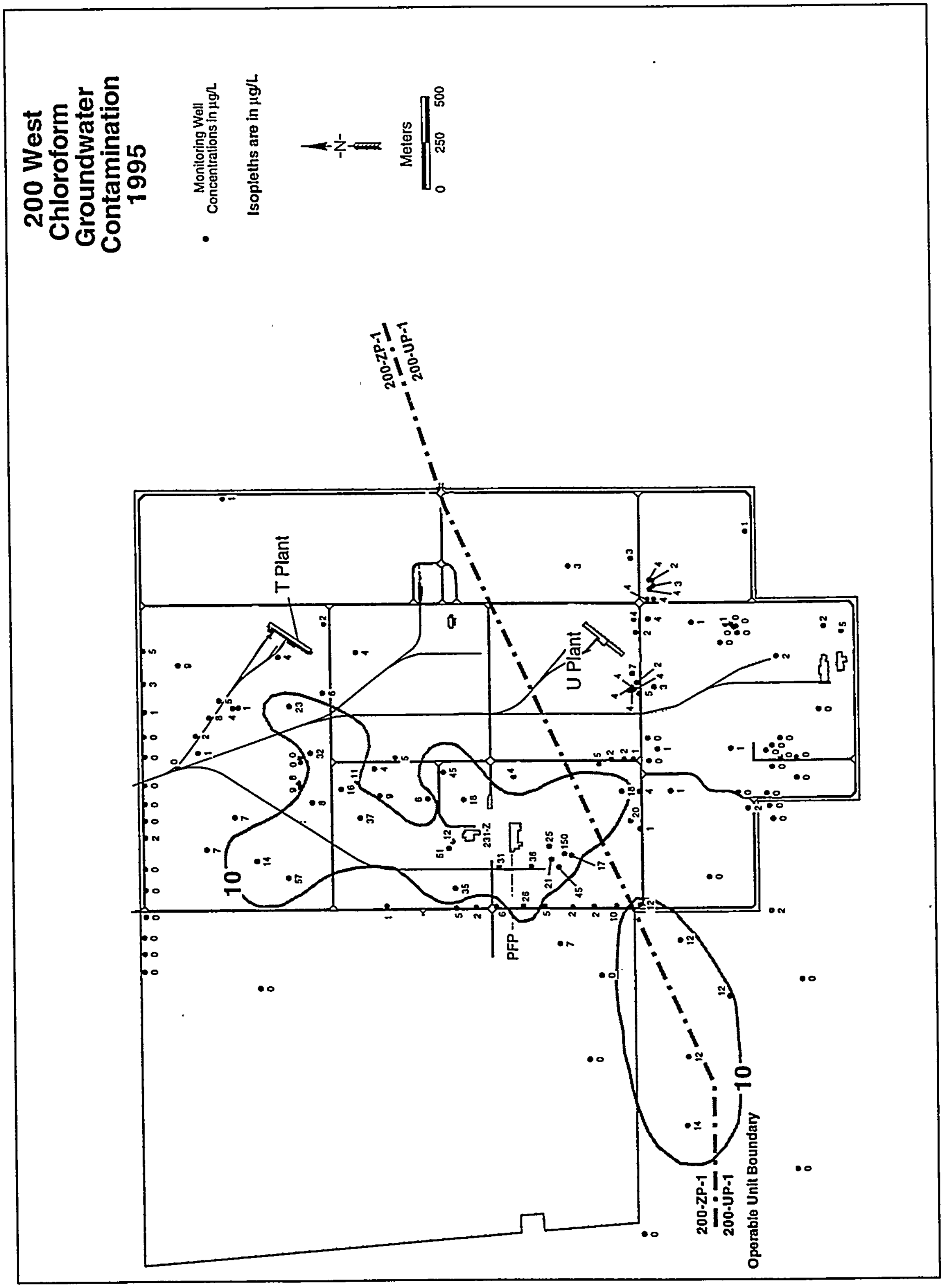


Figure 3-8. Chloroform Concentration Trend Plots for Five of the High-Concentration Northern Wells and the Two Southern Wells in the 200-UP-1 Operable Unit. (sheet 1 of 2)

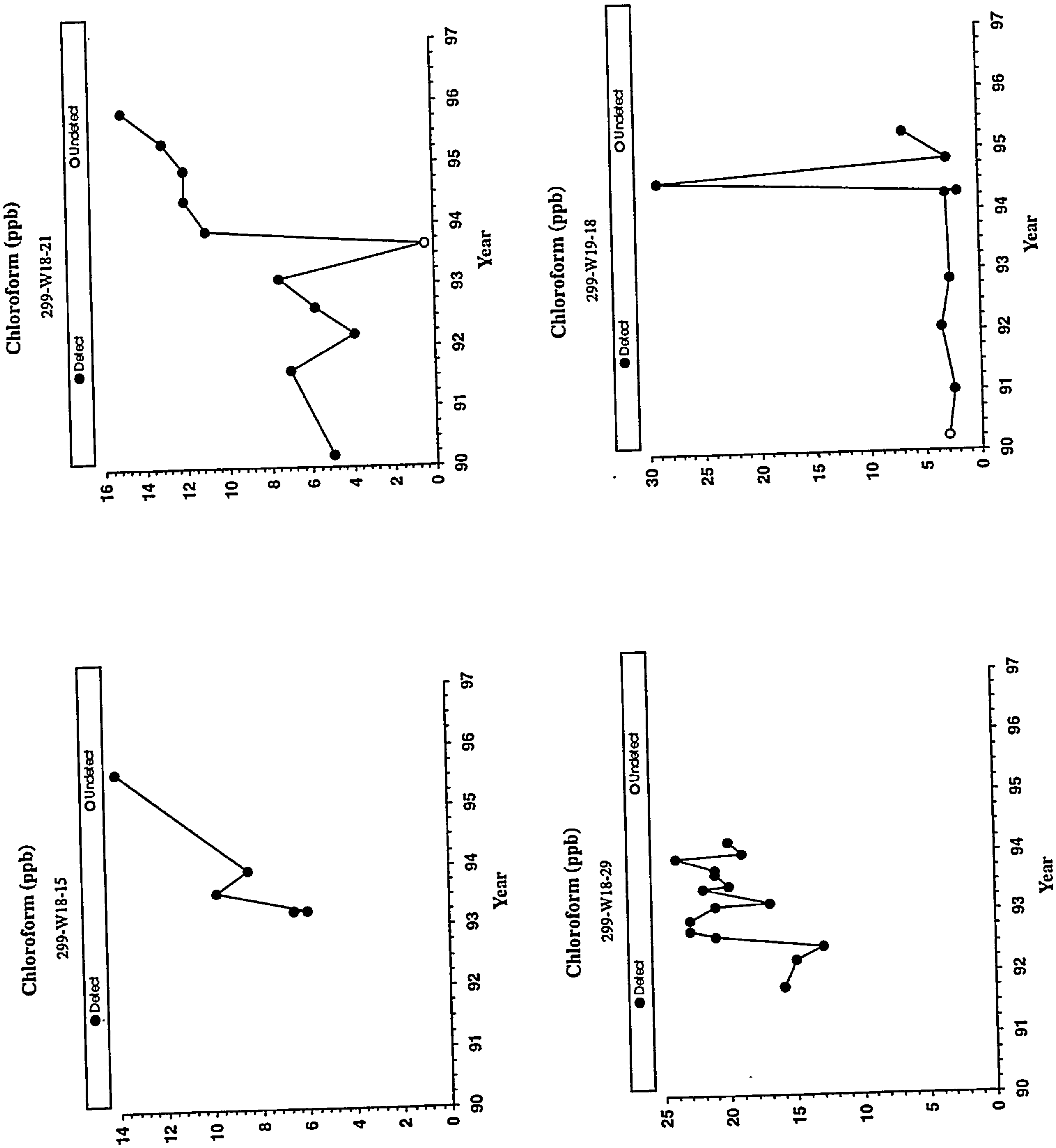
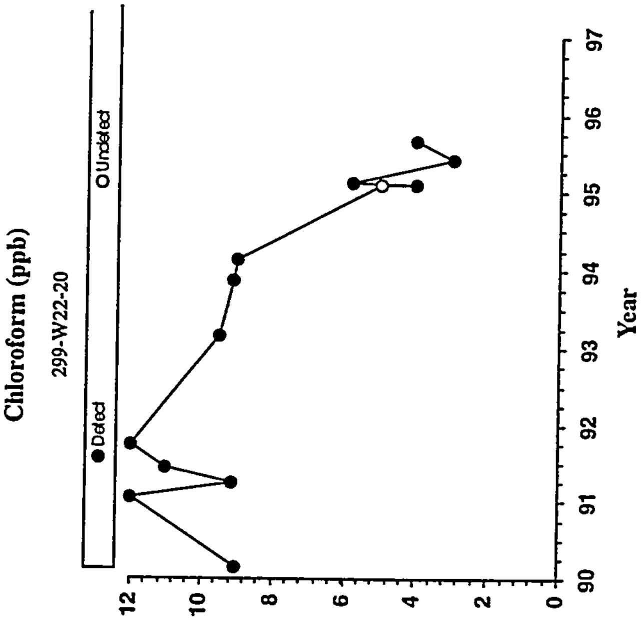
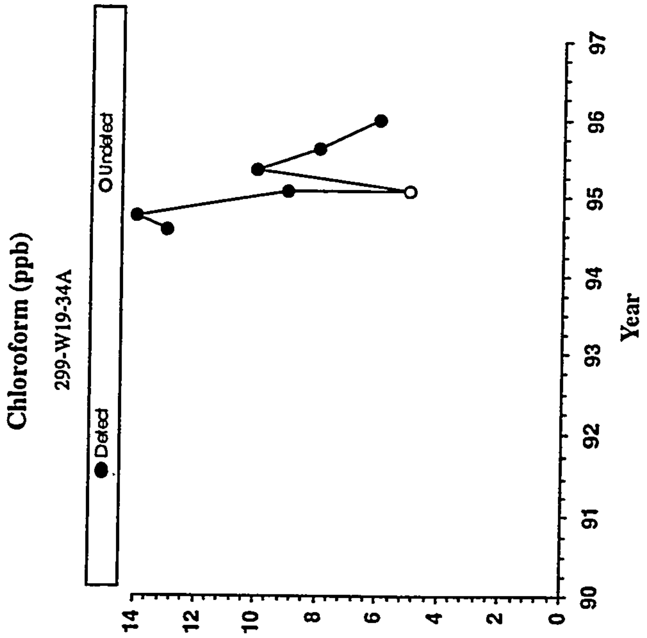


Figure 3-8. Chloroform Concentration Trend Plots for Five of the High-Concentration Northern Wells and the Two Southern Wells in the 200-UP-1 Operable Unit. (sheet 2 of 2)





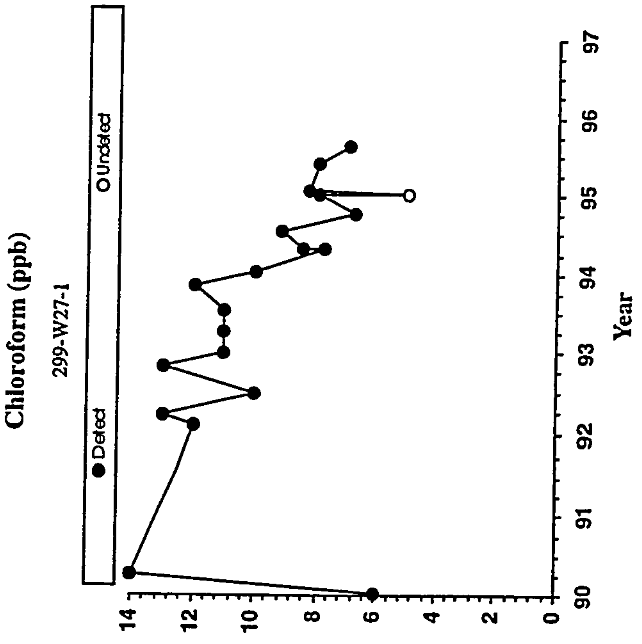


Figure 3-9 Concentration Trend Plots for Wells in the 200-UP-1 Operable Unit with More Than 5 μg/L Trichloroethene. (sheet 1 of 2)

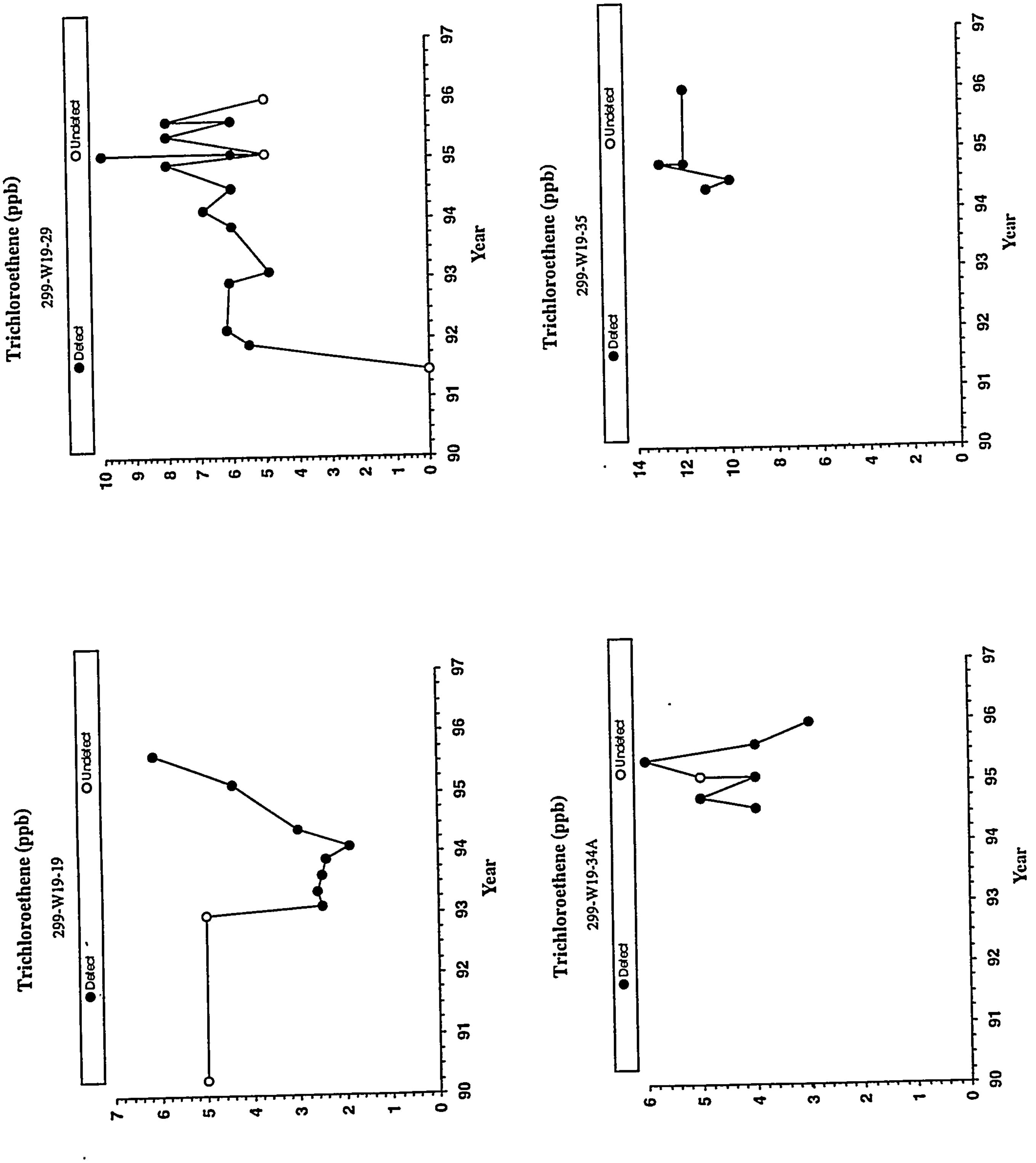
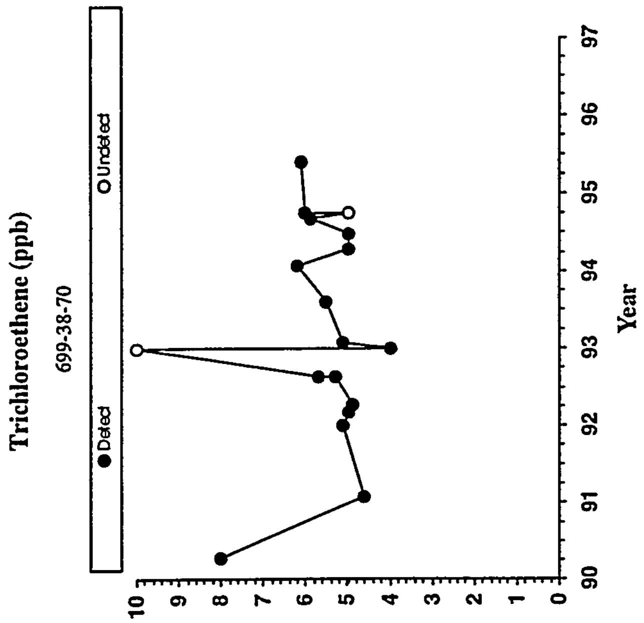


Figure 3-9 Concentration Trend Plots for Wells in the 200-UP-1 Operable Unit with More Than 5 µg/L Trichloroethene. (sheet 2 of 2)



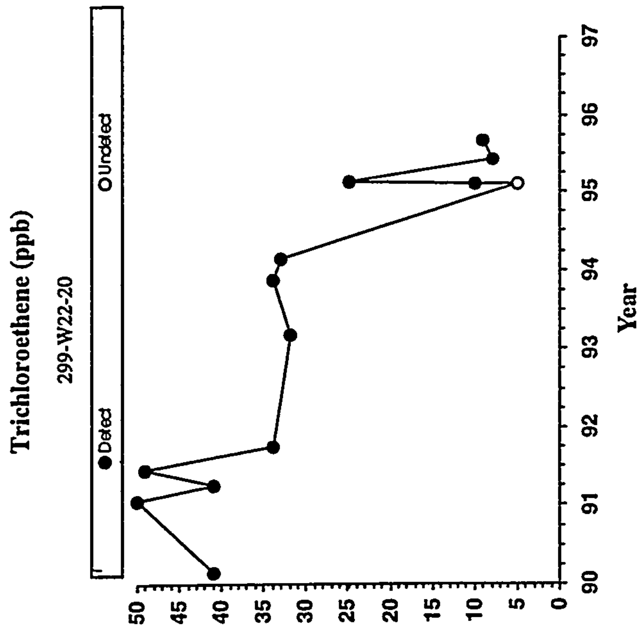


Figure 3-10. Potassium-40 Concentration Trend Plots, 200-UP-1 Operable Unit. (sheet 1 of 2)

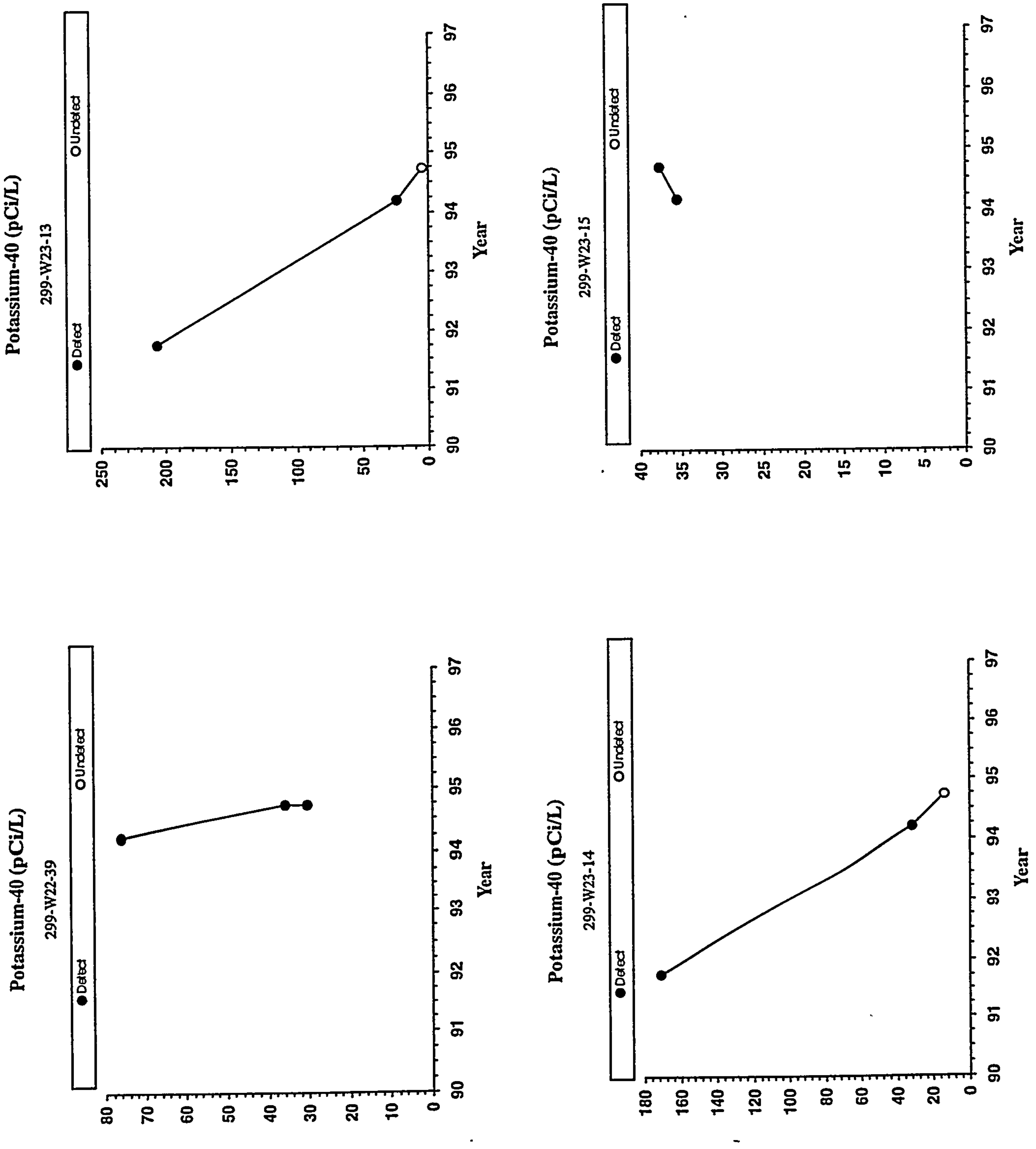


Figure 3-10. Potassium-40 Concentration Trend Plots, 200-UP-1 Operable Unit. (sheet 2 of 2)

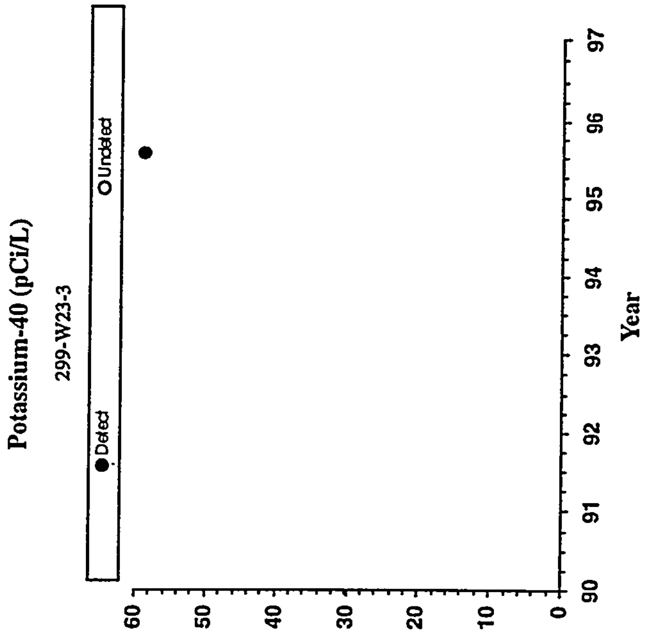


Figure 3-11. Strontium-90 Concentration Trend Plots for Well 299-W22-10 and Concentrations for Wells 299-W19-24 and 299-W22-1, 200-UP-1 Operable Unit.

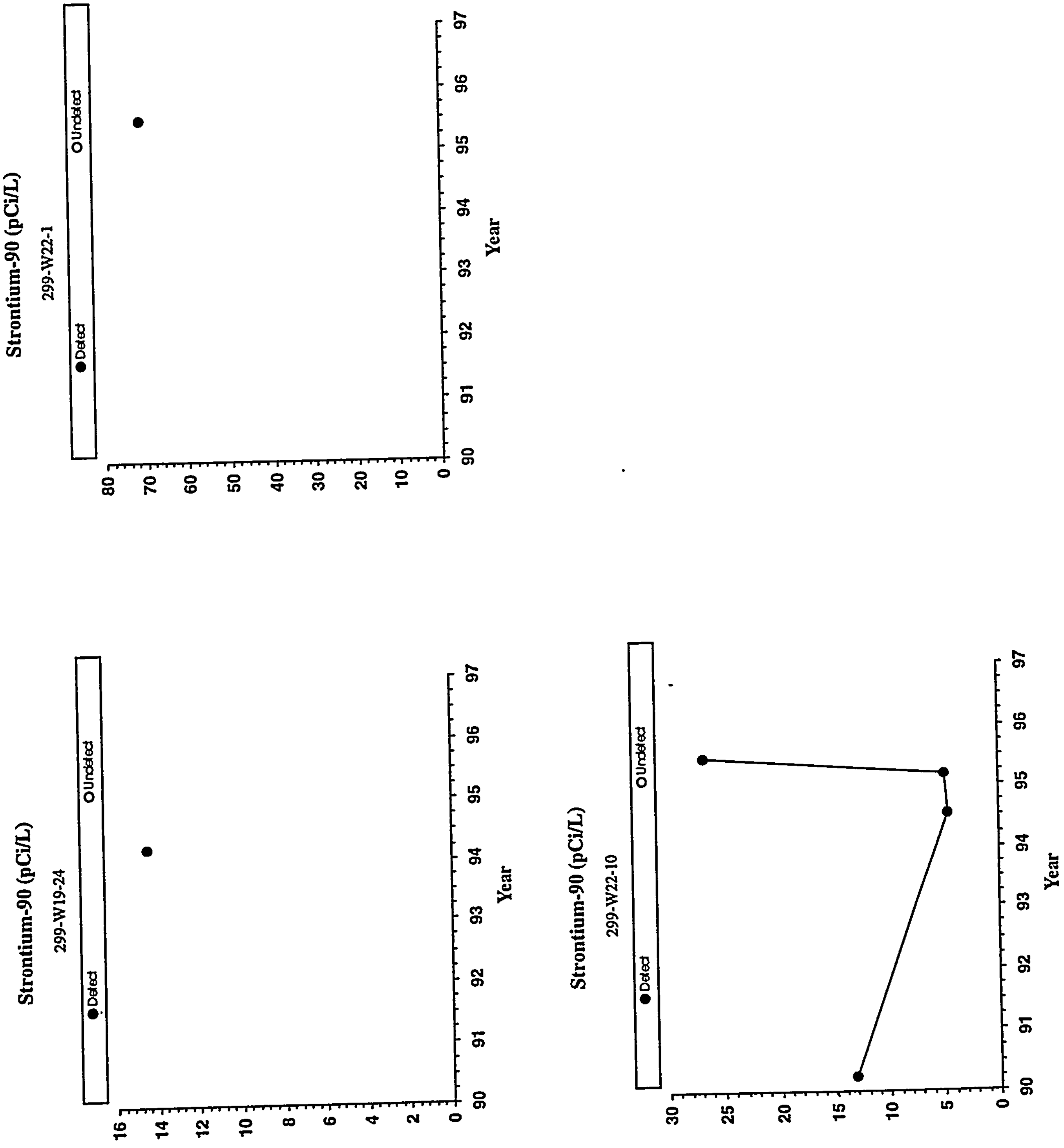
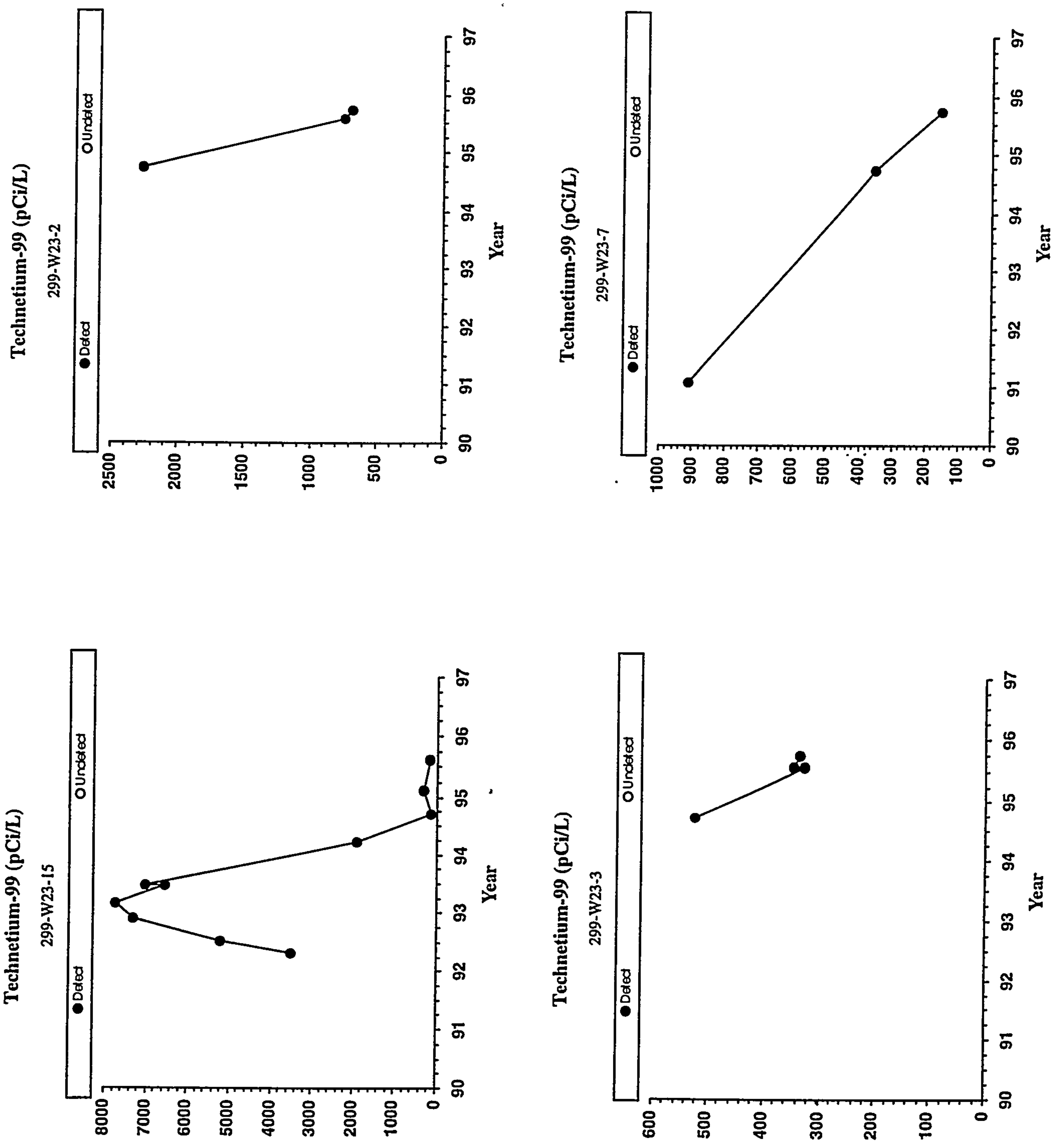
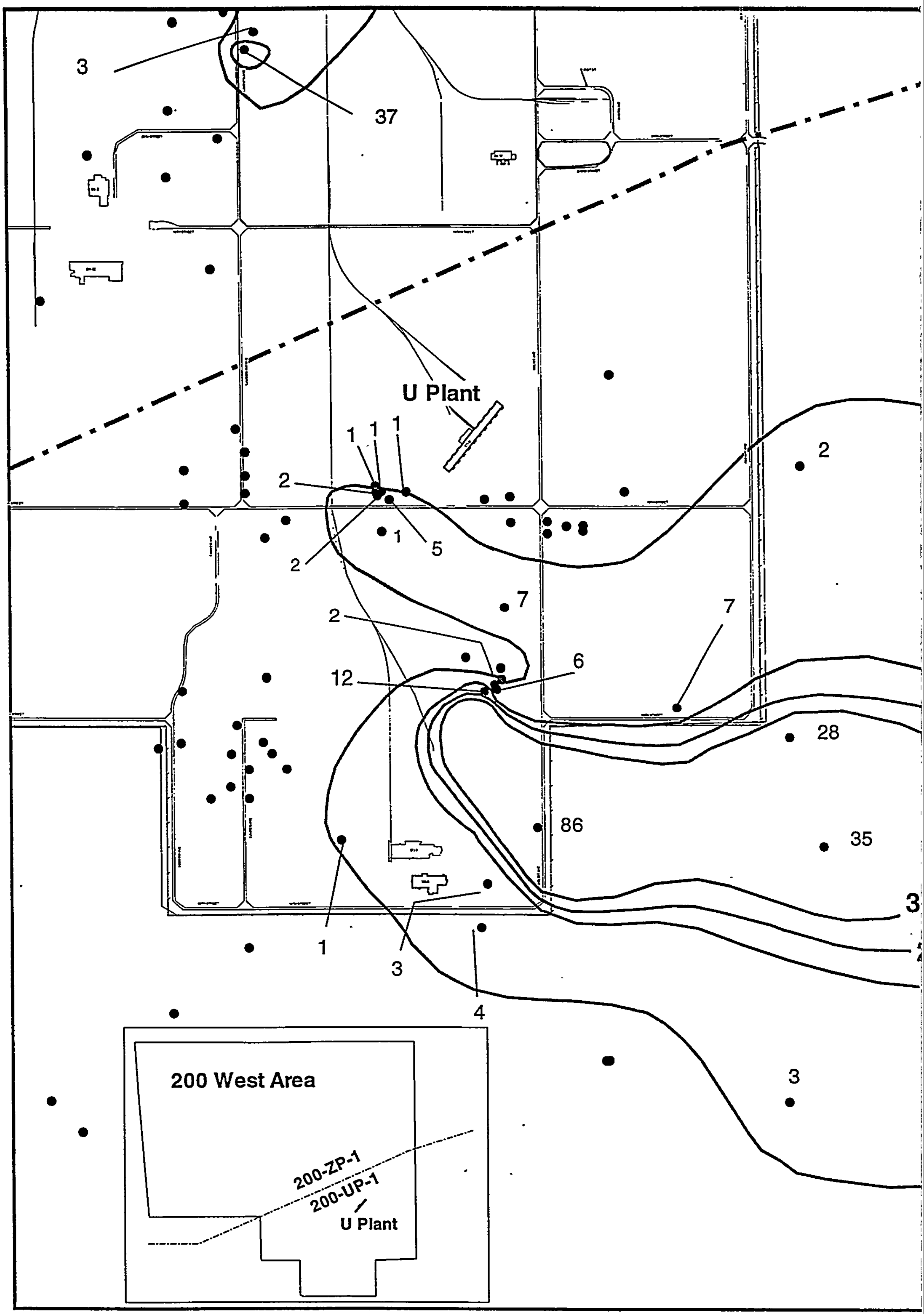


Figure 3-12. Technetium-99 Concentration Trend Plots for Wells Monitoring the 241-S/SX Tank Farm, 200-UP-1 Operable Unit.

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86
35
3
1
3
4
3
200 West Area
200-ZP-1
200-UP-1
U Plant

Figure 3-13. The 200-UP-1 Operable Unit Iodine-129 Plume, as Derived from the Maximum 1994 and 1995 Concentrations.

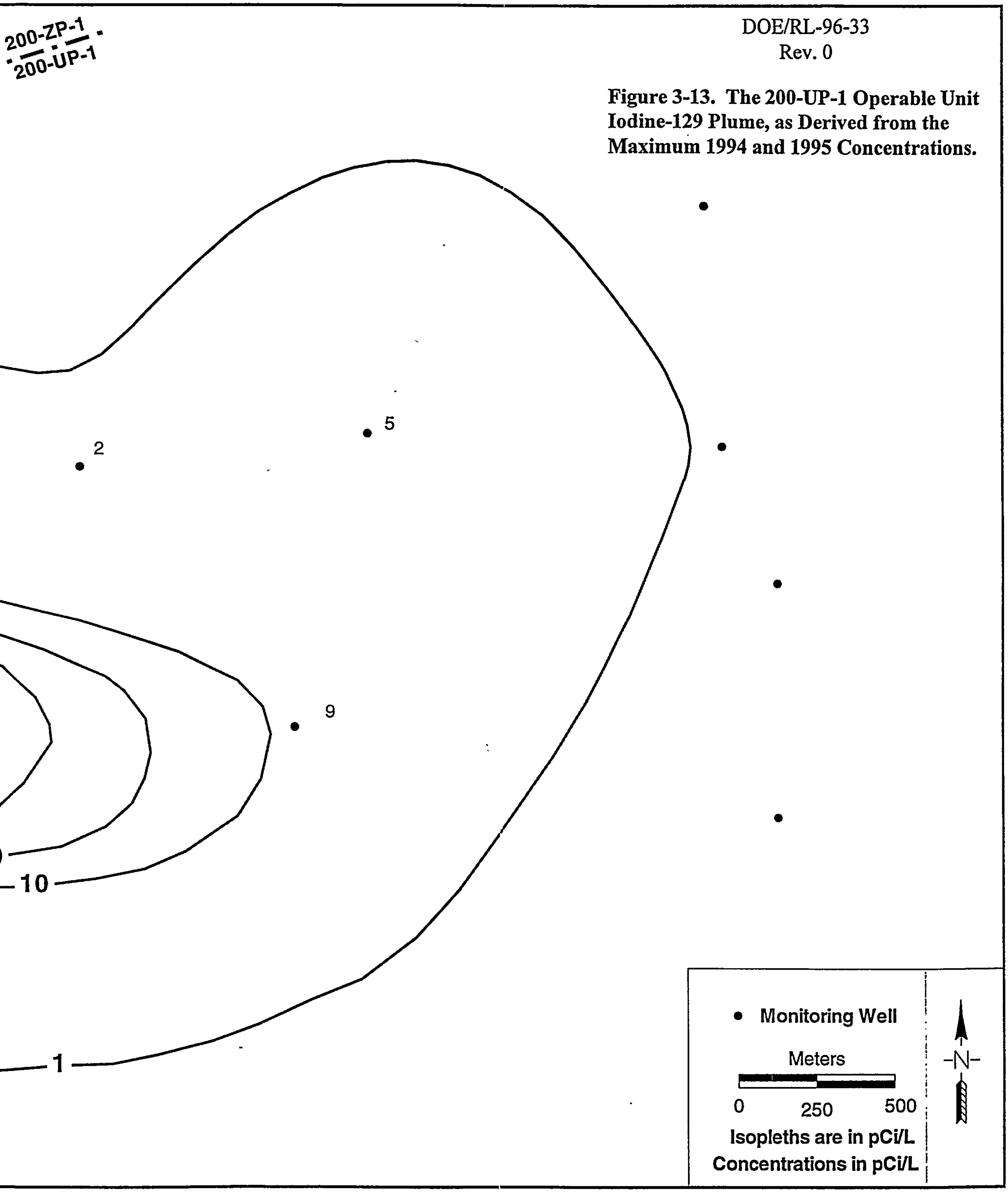
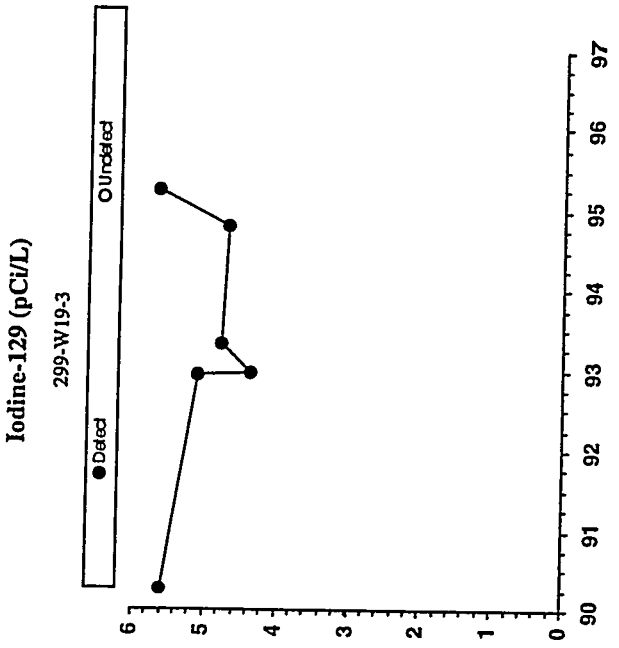
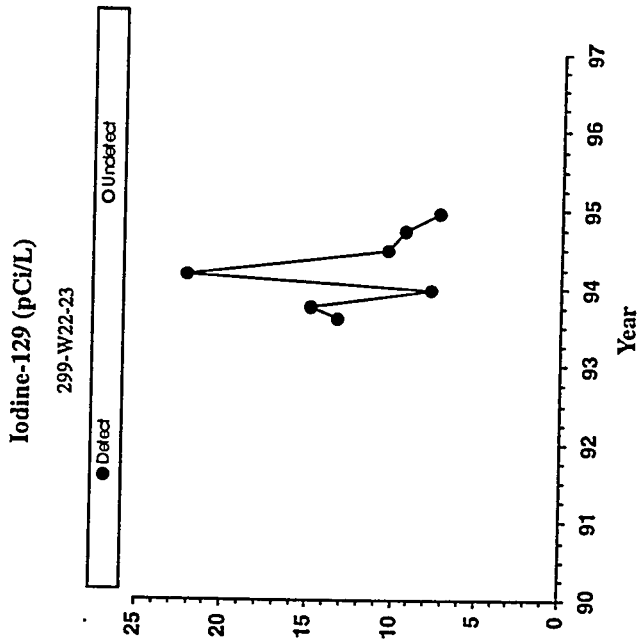
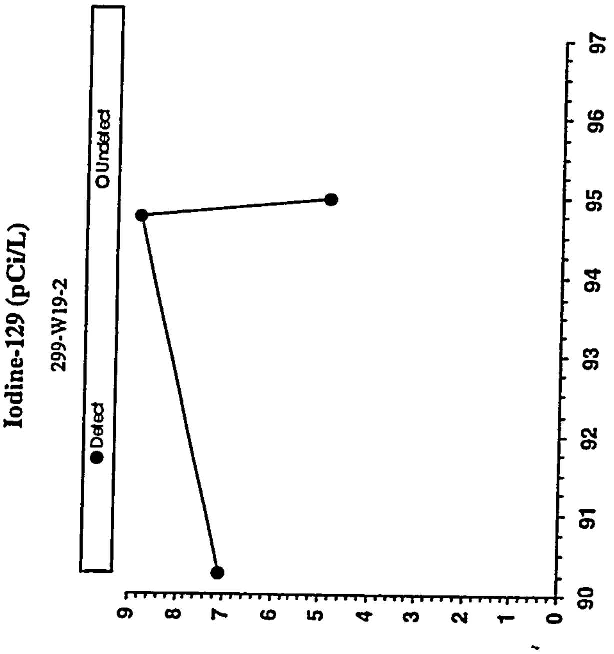


Figure 3-14. Iodine-129 Concentration Trend Plots for Many of the 200-UP-1 Wells Showing High Concentrations of Iodine-129 in the 200-UP-1 Operable Unit. (sheet 1 of 3)







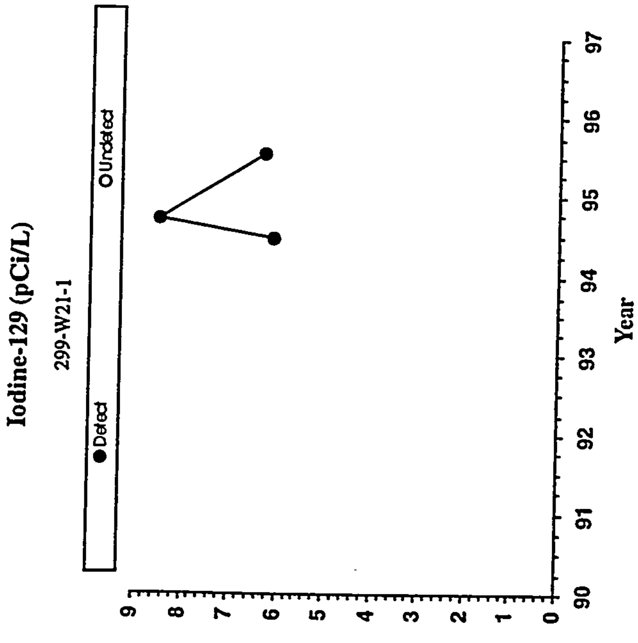


Figure 3-14. Iodine-129 Concentration Trend Plots for Many of the 200-UP-1 Wells Showing High Concentrations of Iodine-129 in the 200-UP-1 Operable Unit. (sheet 2 of 3)

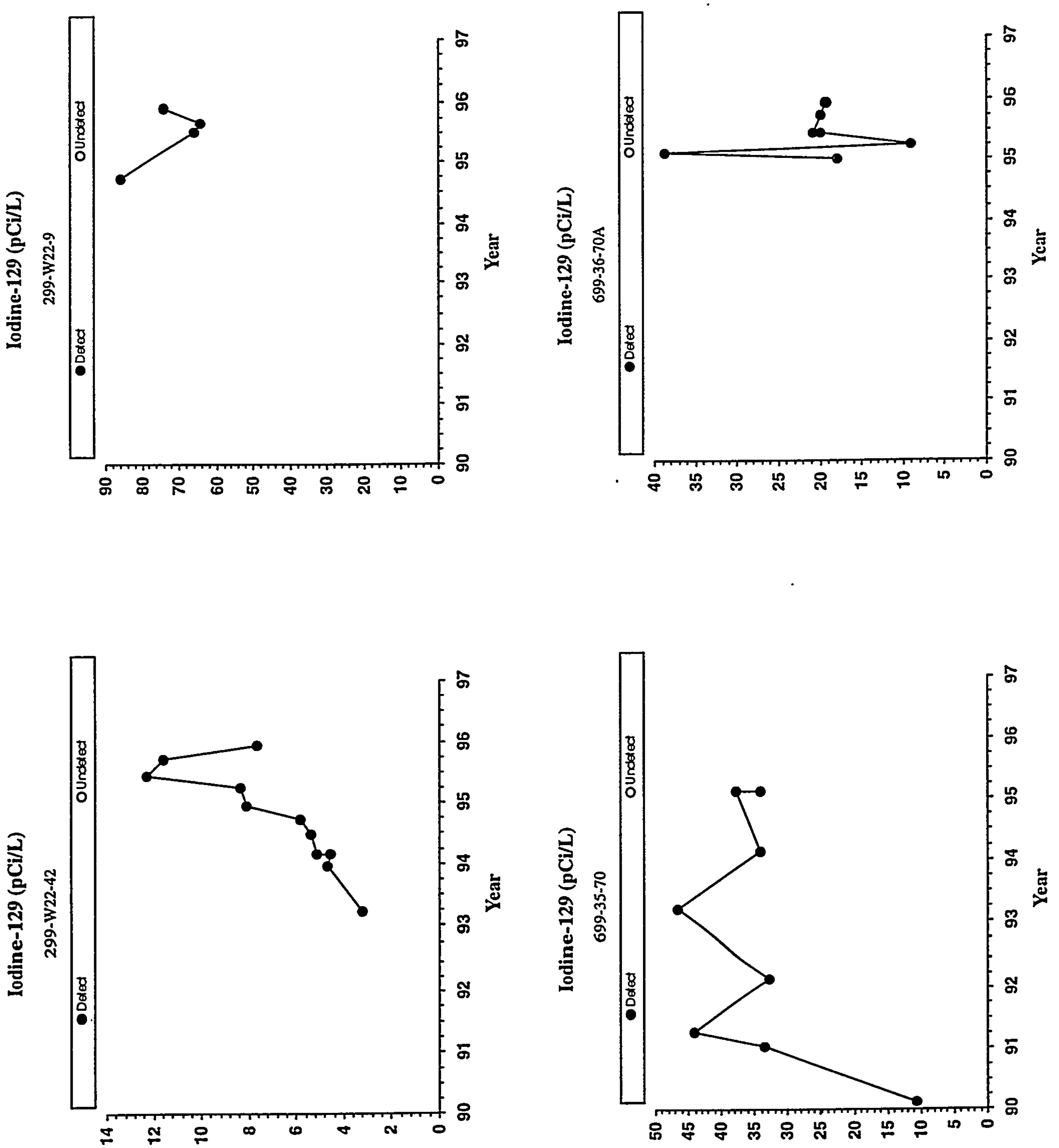


Figure 3-14. Iodine-129 Concentration Trend Plots for Many of the 200-UP-1 Wells Showing High Concentrations of Iodine-129 in the 200-UP-1 Operable Unit. (sheet 3 of 3)

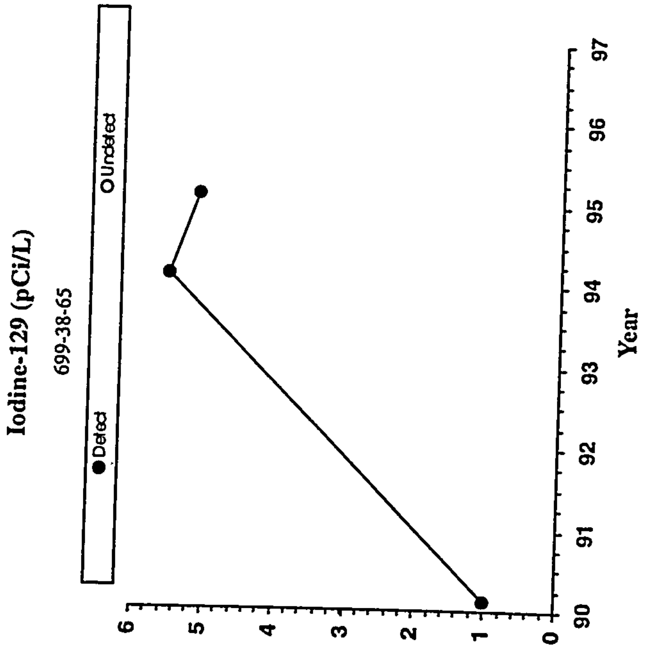


Figure 3-15. Plutonium-238 Concentration Trend Plots for Wells 299-W18-21, 299-W18-24, 299-W18-29, 299-W18-30, and 299-W23-13, 200-UP-1 Operable Unit. (sheet 1 of 2)

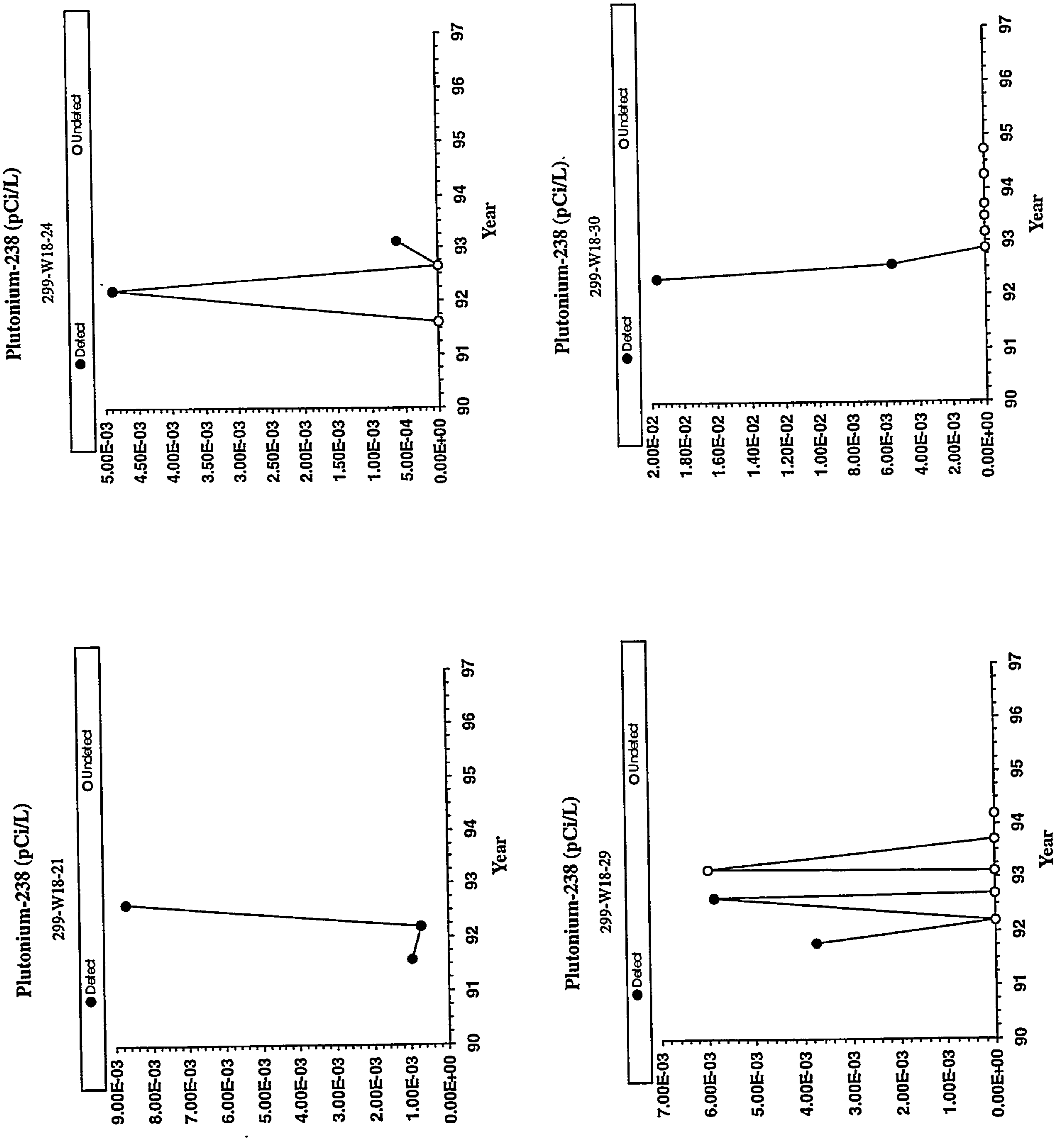


Figure 3-15. Plutonium-238 Concentration Trend Plots for Wells 299-W18-21, 299-W18-24, 299-W18-29, 299-W18-30, and 299-W23-13, 200-UP-1 Operable Unit. (sheet 2 of 2)

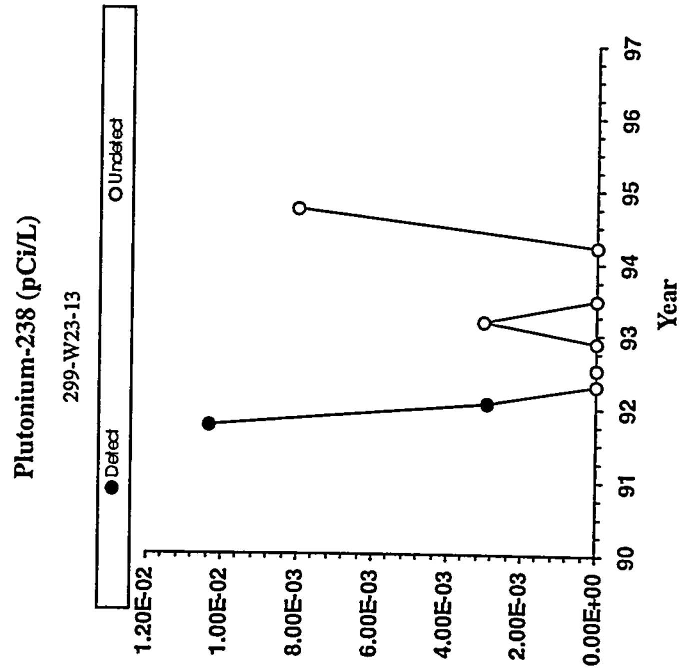


Figure 3-16. Uranium Concentration Trend Plots for the 200-UP-1 Operable Unit. (sheet 1 of 4)

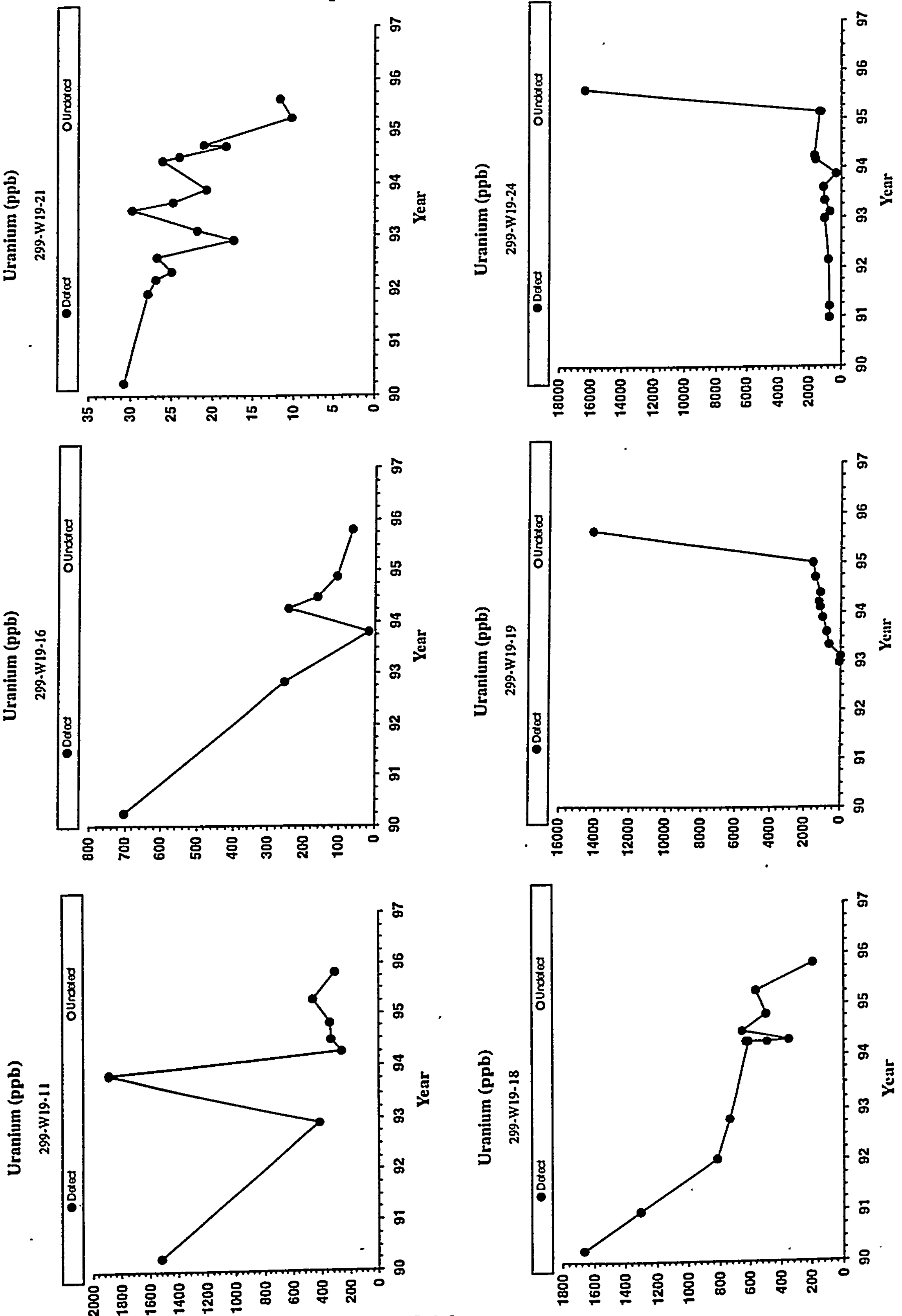


Figure 3-16. Uranium Concentration Trend Plots for the 200-UP-1 Operable Unit. (sheet 2 of 4)

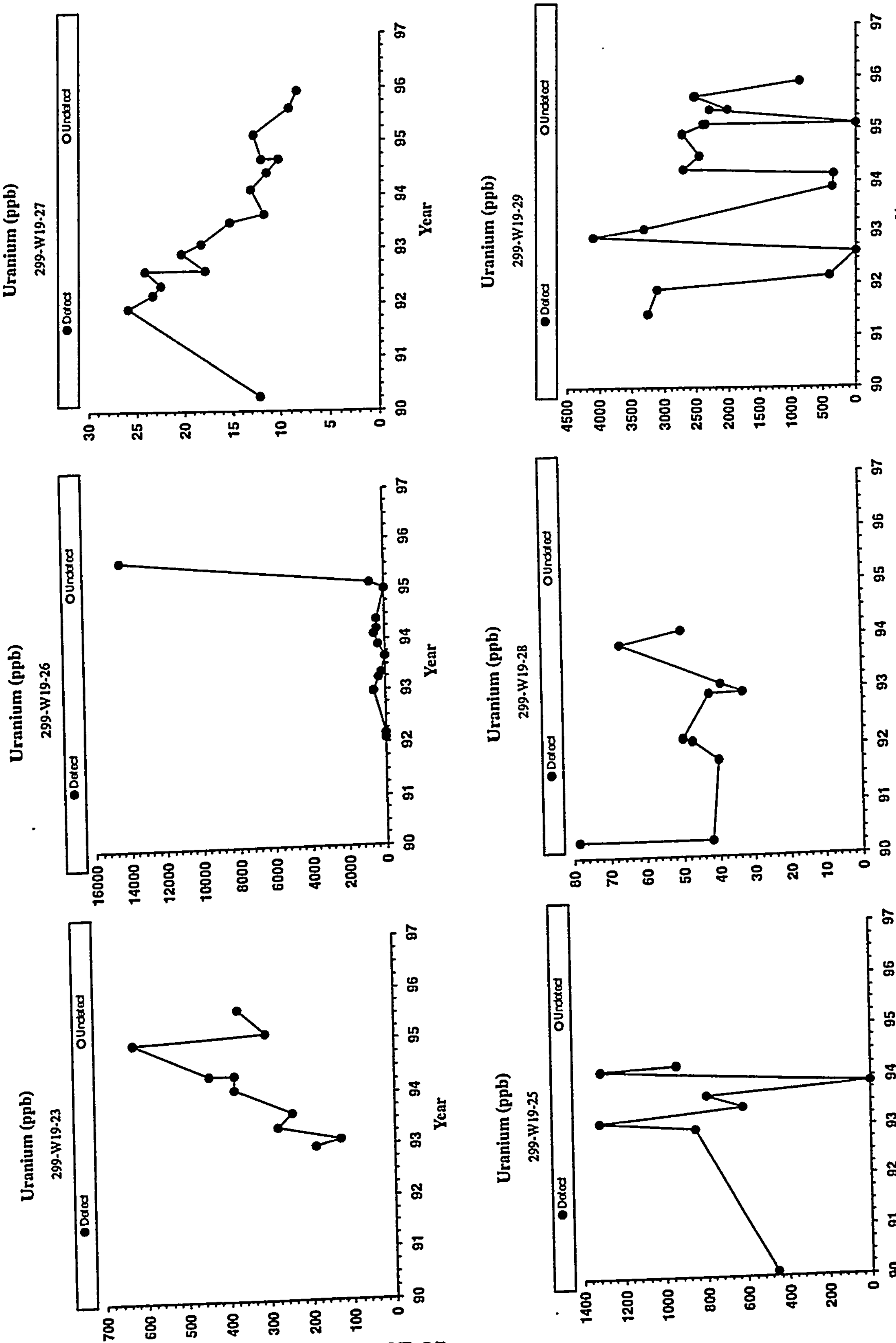
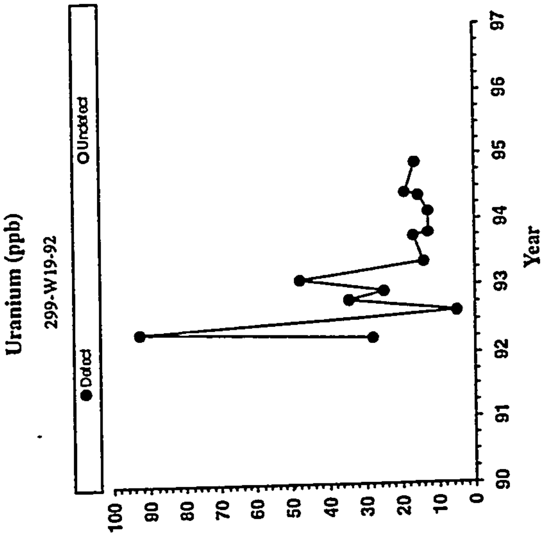
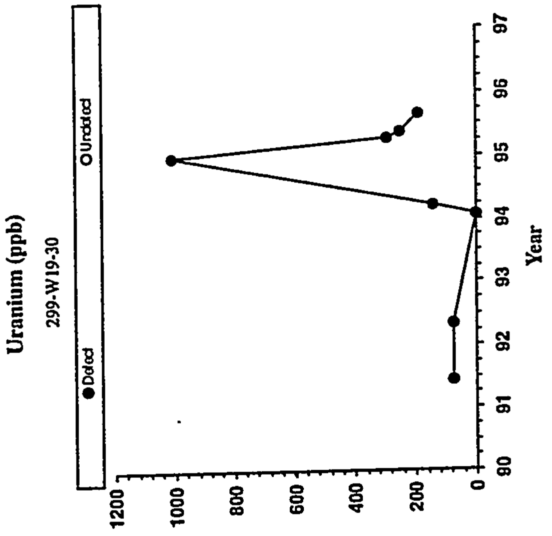
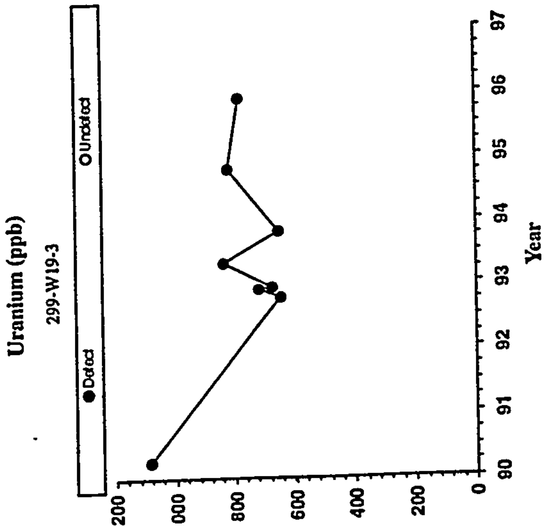
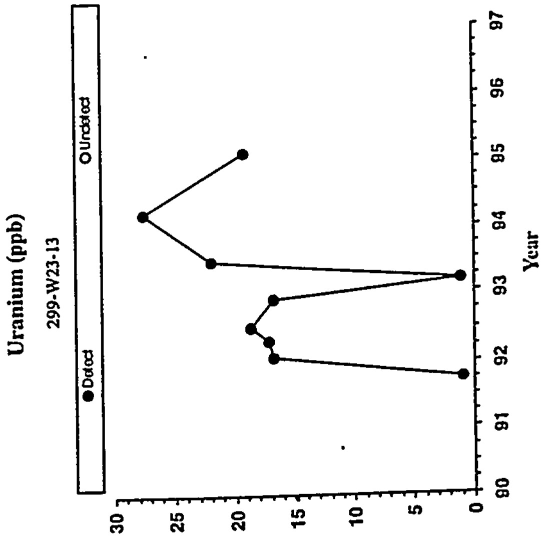


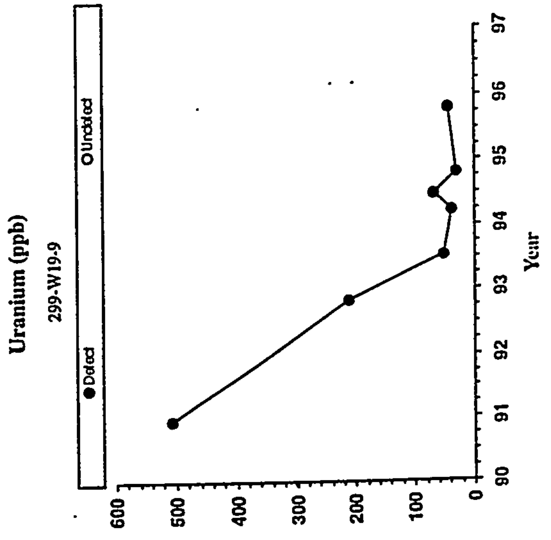
Figure 3-16. Uranium Concentration Trend Plots for the 200-UP-1 Operable Unit. (sheet 3 of 4)











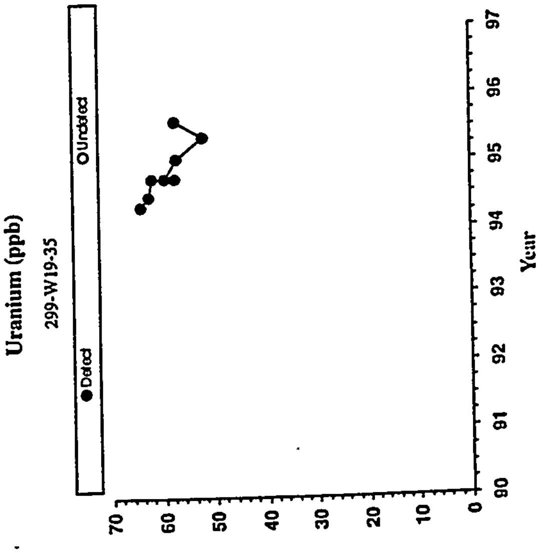


Figure 3-16. Uranium Concentration Trend Plots for the 200-UP-1 Operable Unit. (sheet 4 of 4)

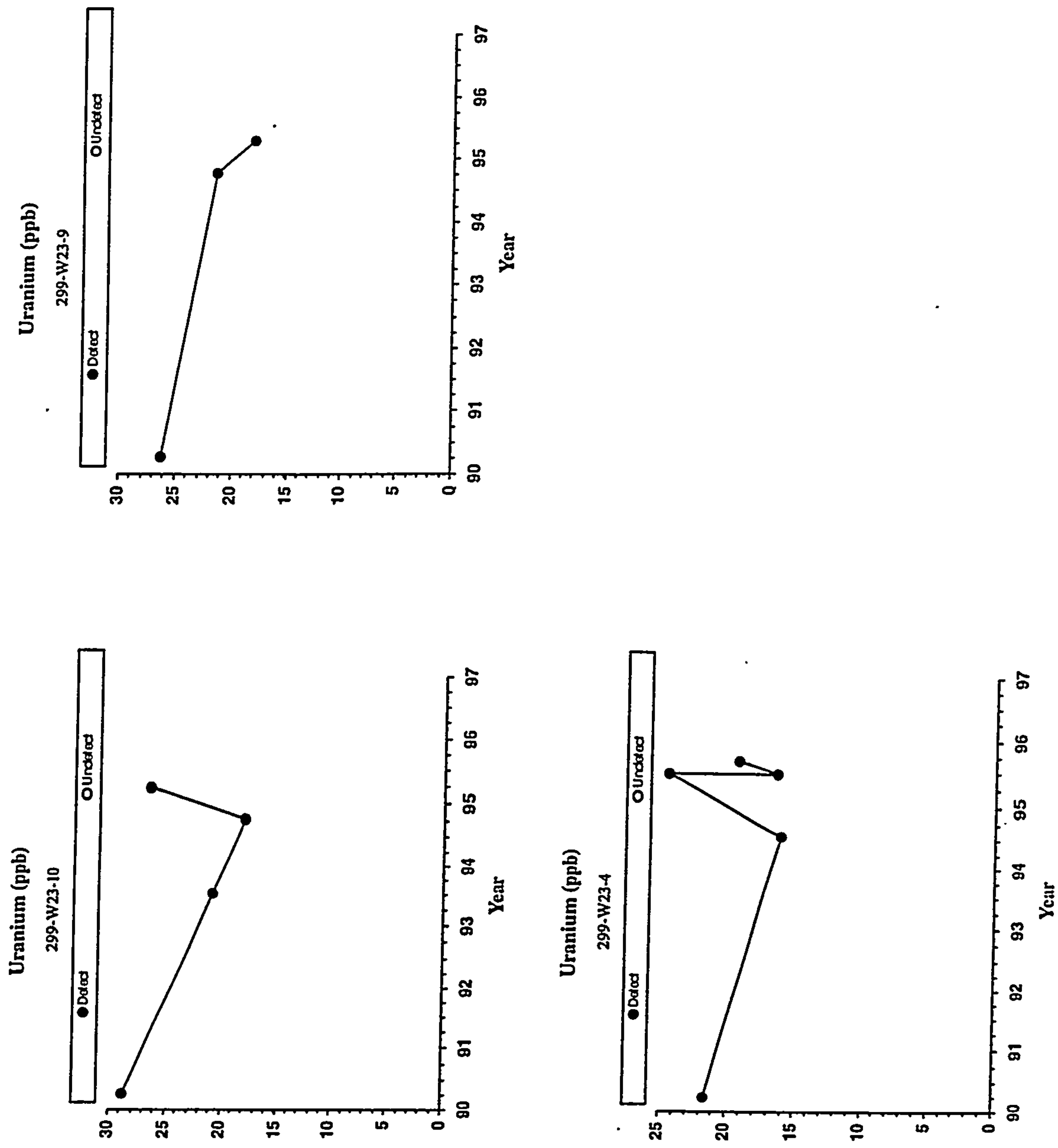


Figure 3-17. Chromium Concentration Trend Plots for the Wells that have Exceeded Hanford Site Background Concentration of <30 μg/L, 200-UP-1 Operable Unit, 1990 Through 1995. (sheet 1 of 2)

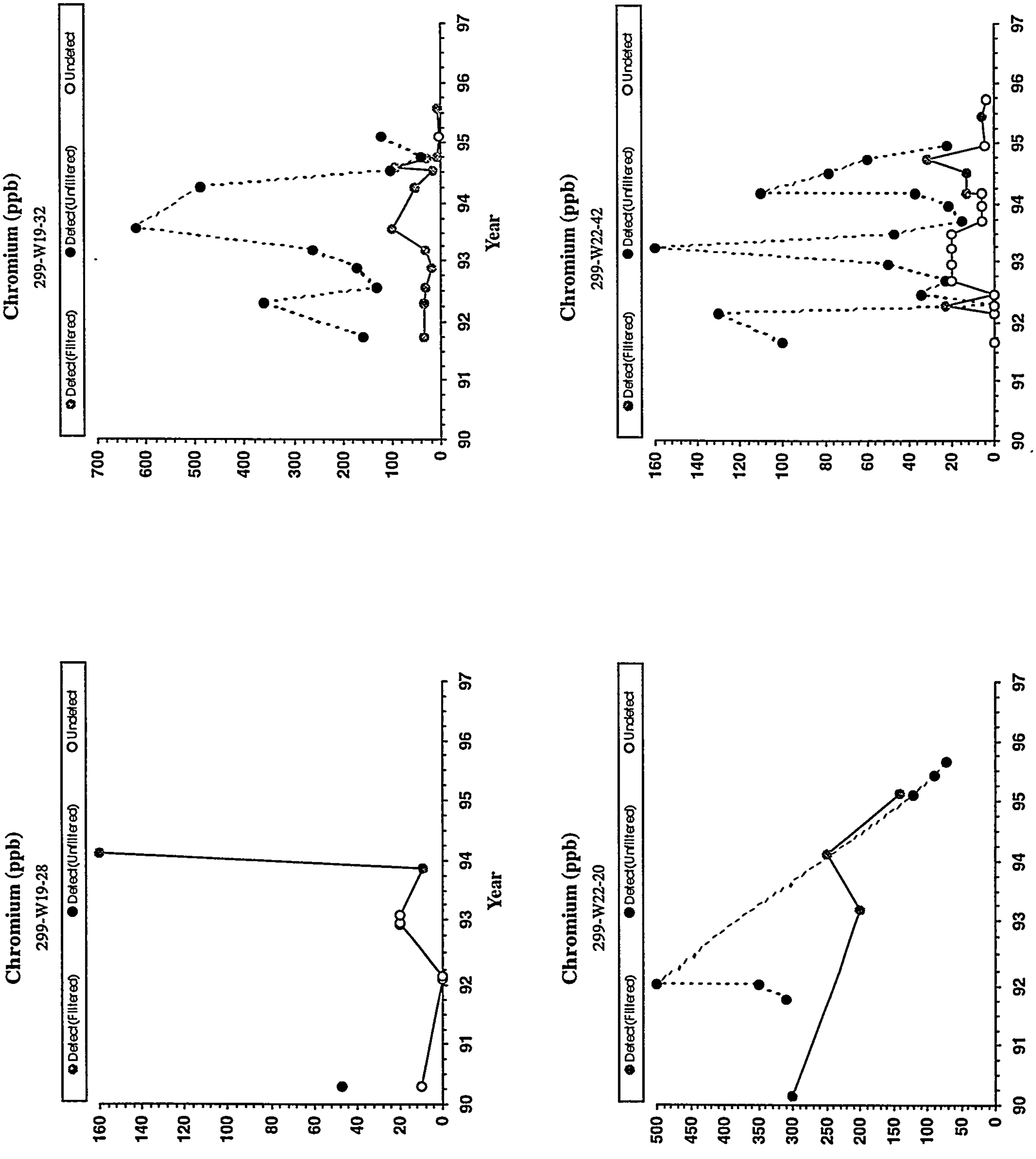
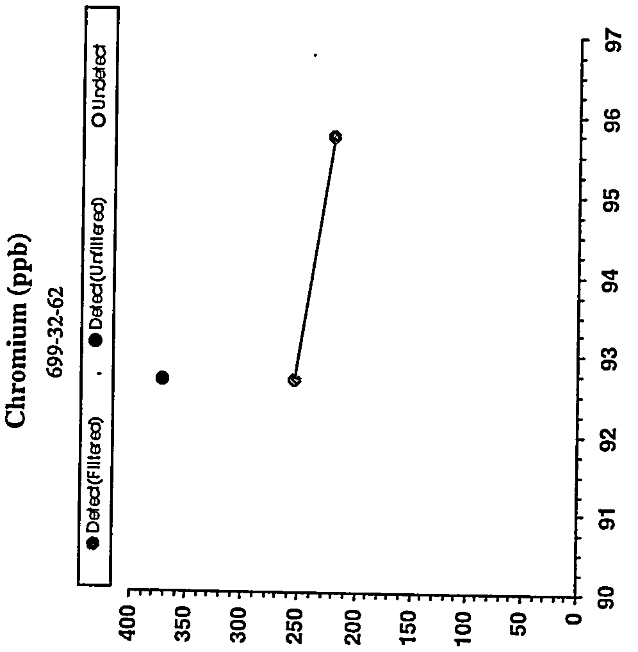
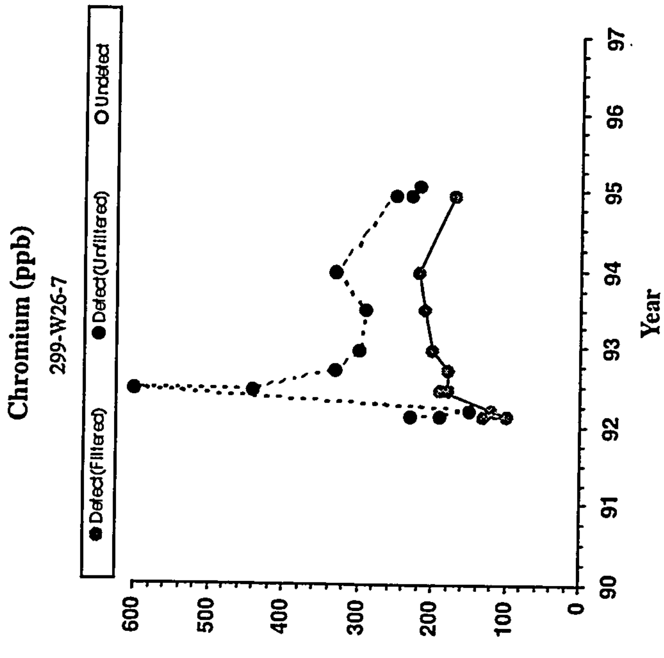
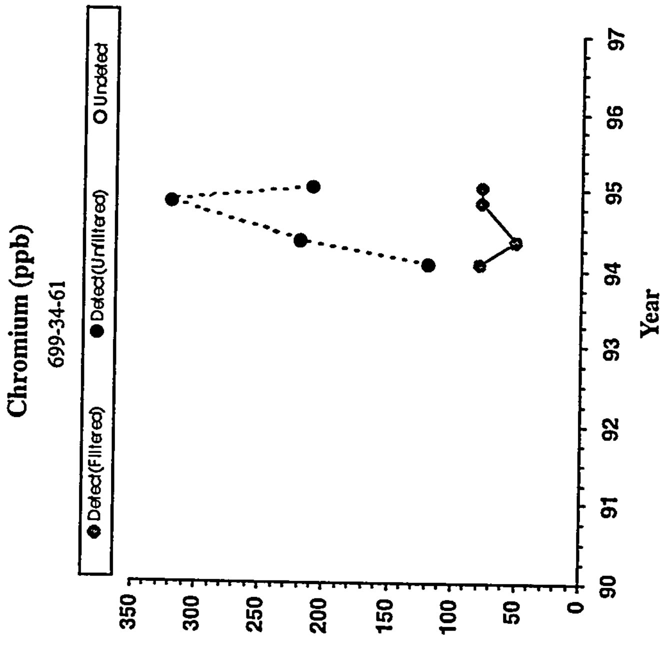
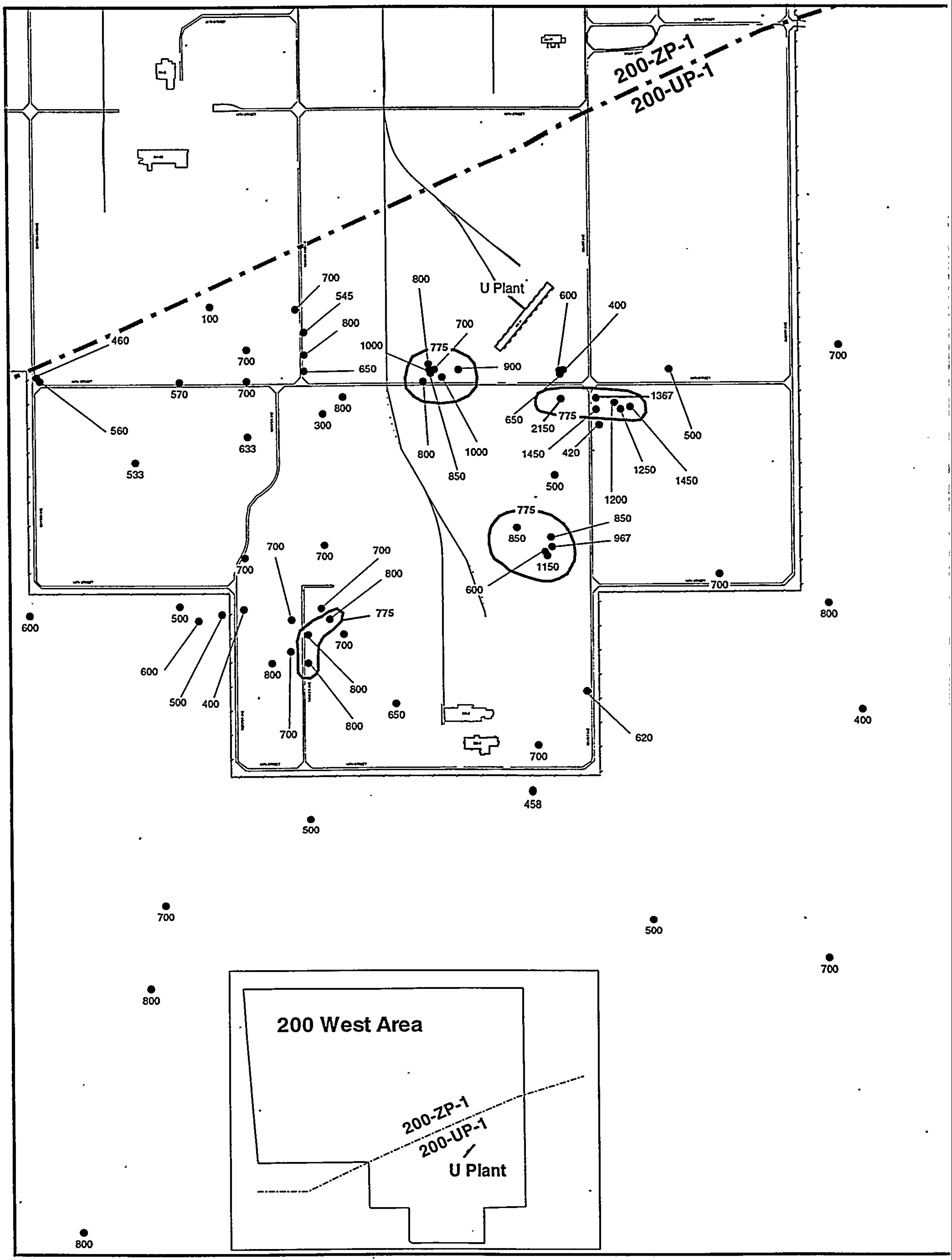


Figure 3-17. Chromium Concentration Trend Plots for the Wells that have Exceeded Hanford Site Background Concentration of <30 µg/L, 200-UP-1 Operable Unit, 1990 Through 1995. (sheet 2 of 2)








200-ZP-1
200-UP-1
U Plant
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200 West Area
200-ZP-1
200-UP-1
U Plant

Figure 3-18. Average 1995 Fluoride Concentrations, 200-UP-1 Operable Unit.

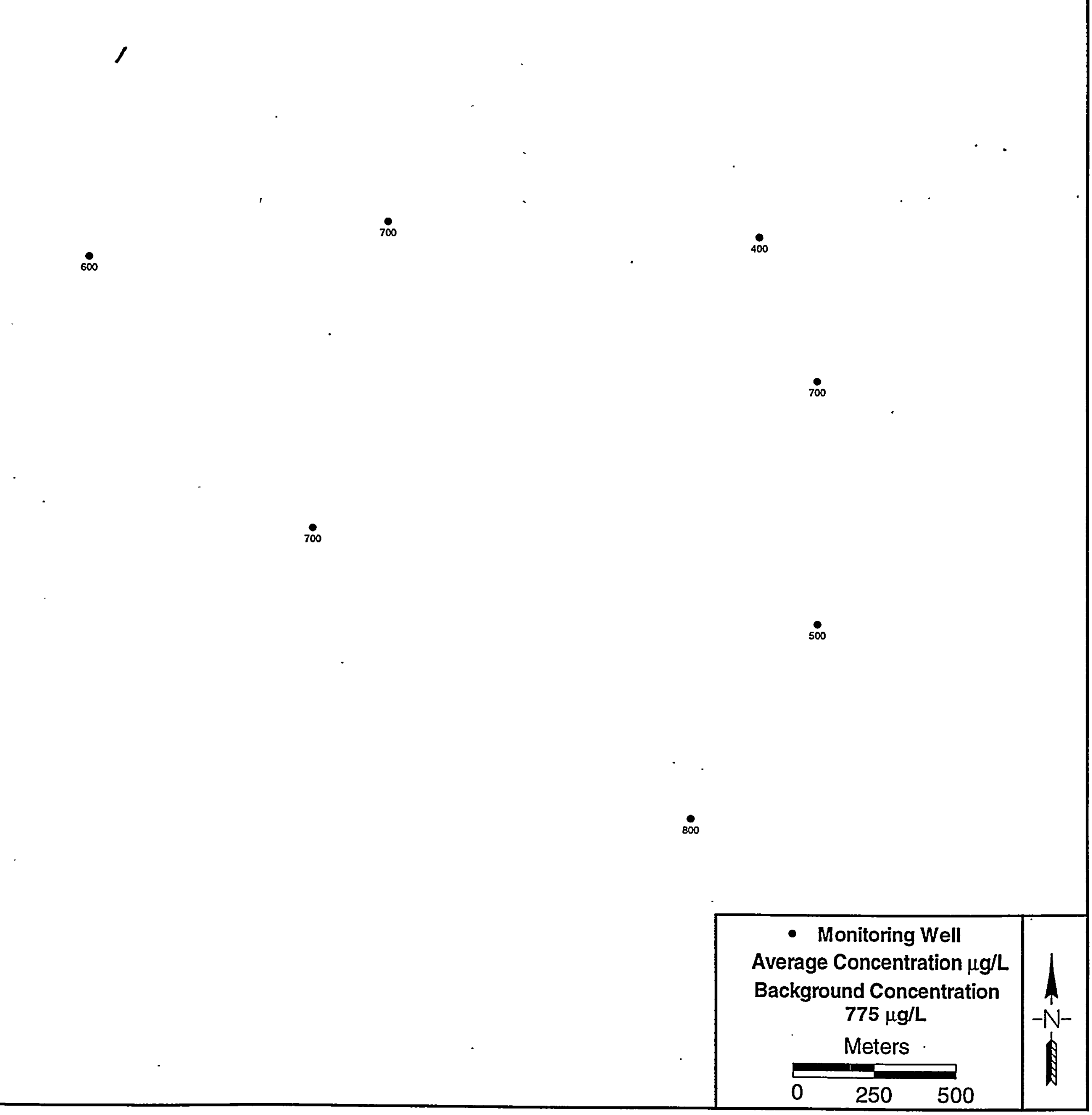

Figure 3-19. **Fluoride Concentration Trends Plots for Wells At or Near the 200-UP-1 Interim Remedial Measure Site.** (sheet 1 of 2)

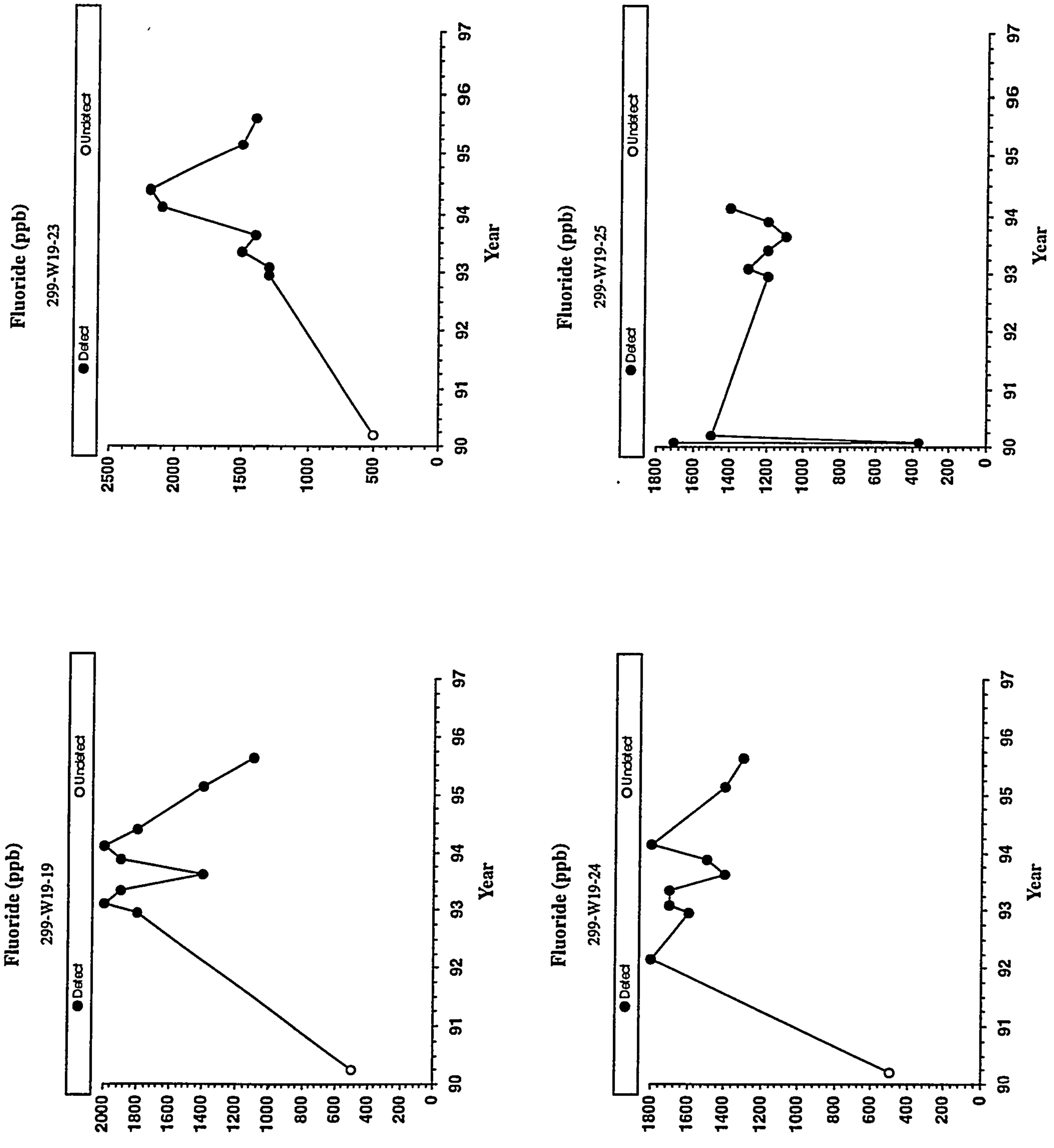

Figure 3-19. Fluoride Concentration Trends Plots for Wells At or Near the 200-UP-1 Interim Remedial Measure Site. (sheet 2 of 2)

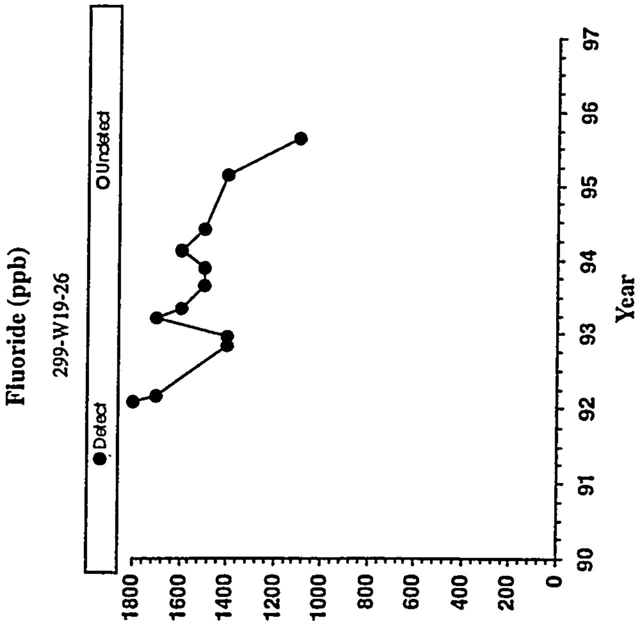

Figure 3-20. Section Line Relative to the Uranium and Technetium Plume (from Ford 1995).

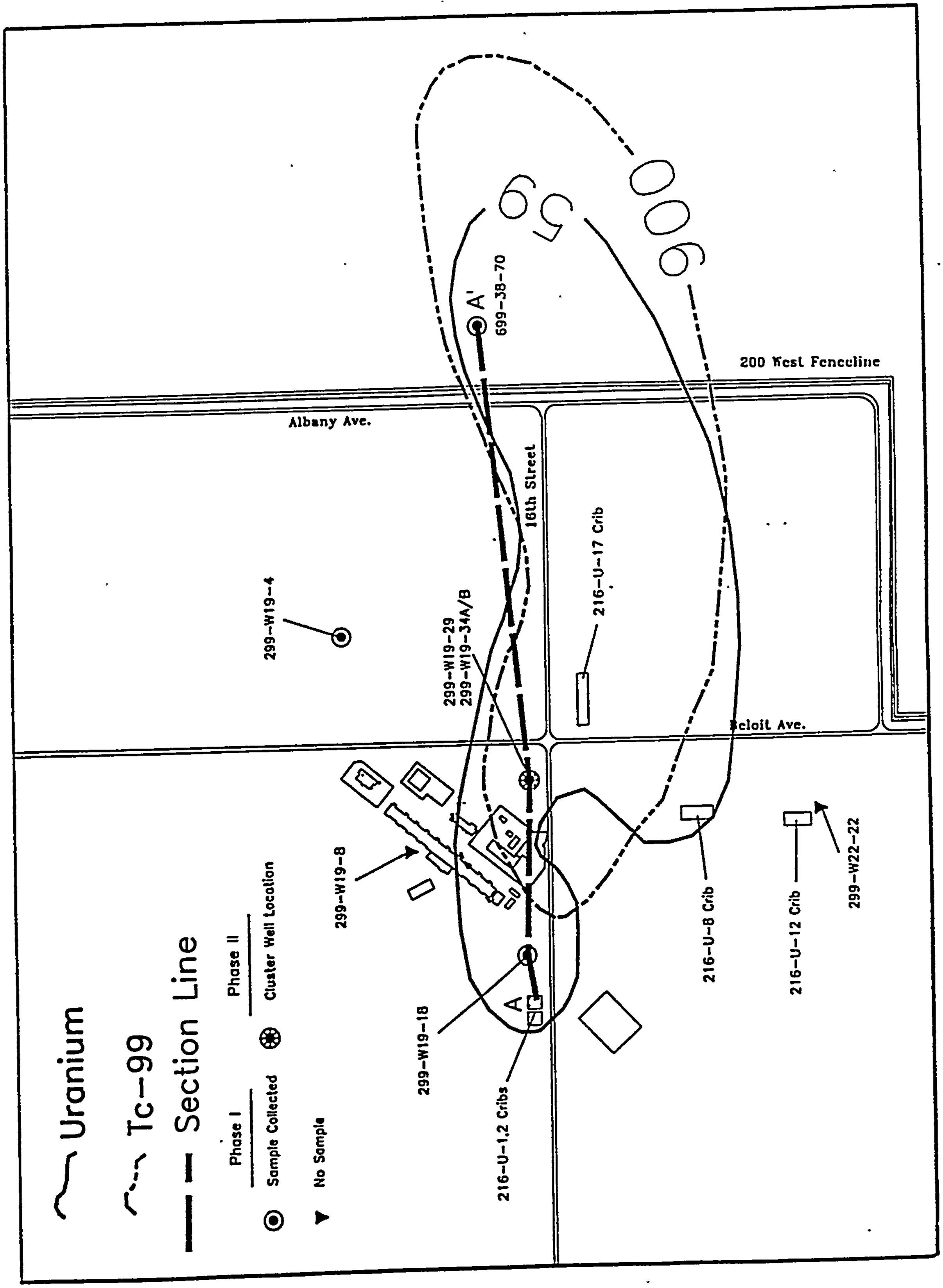

Figure 3-21. Section Line Relative to the Carbon Tetrachloride Plume (from Ford 1995).

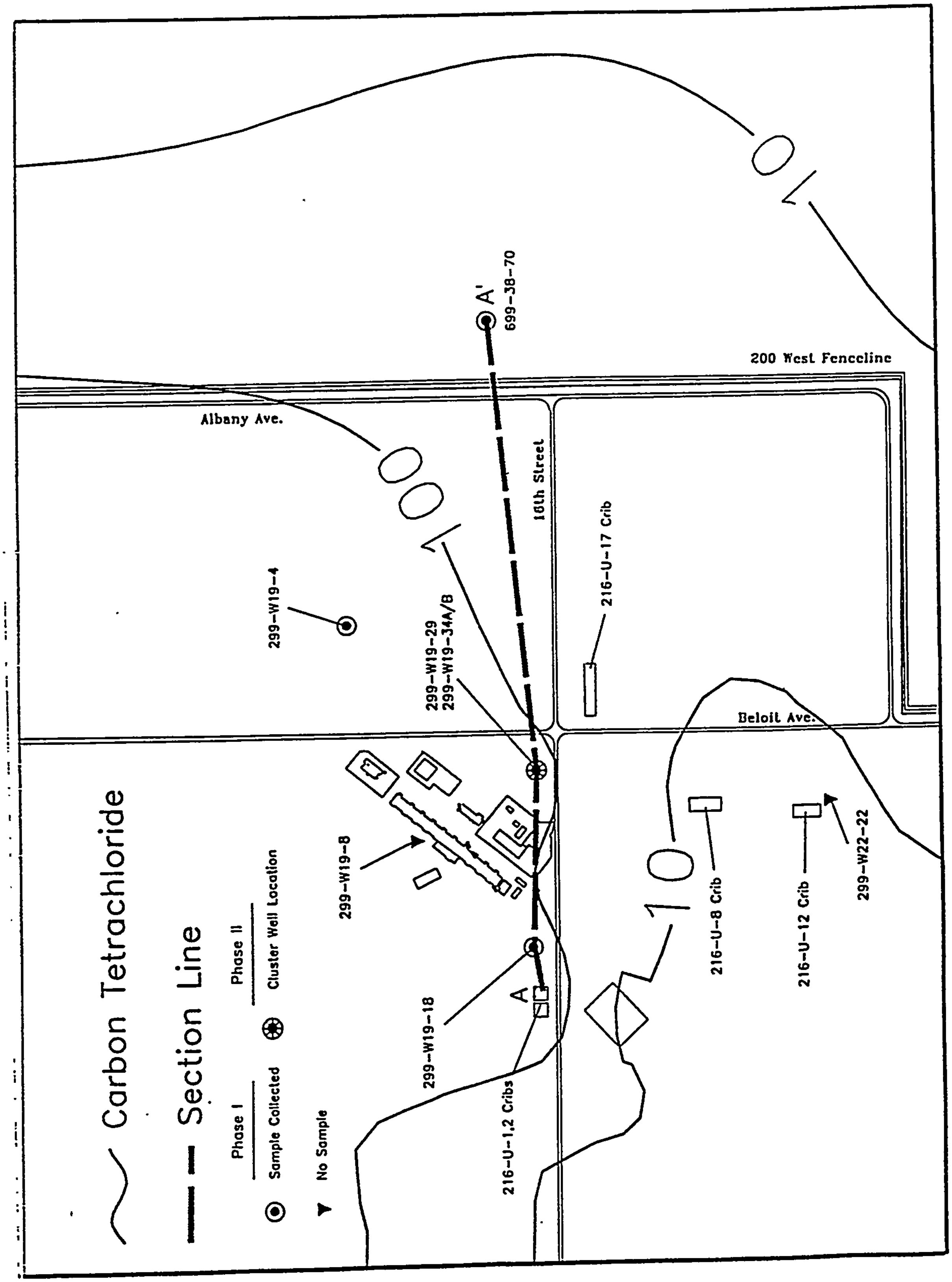

Figure 3-22. Vertical Distribution of Uranium Along Cross-Section A-A'.

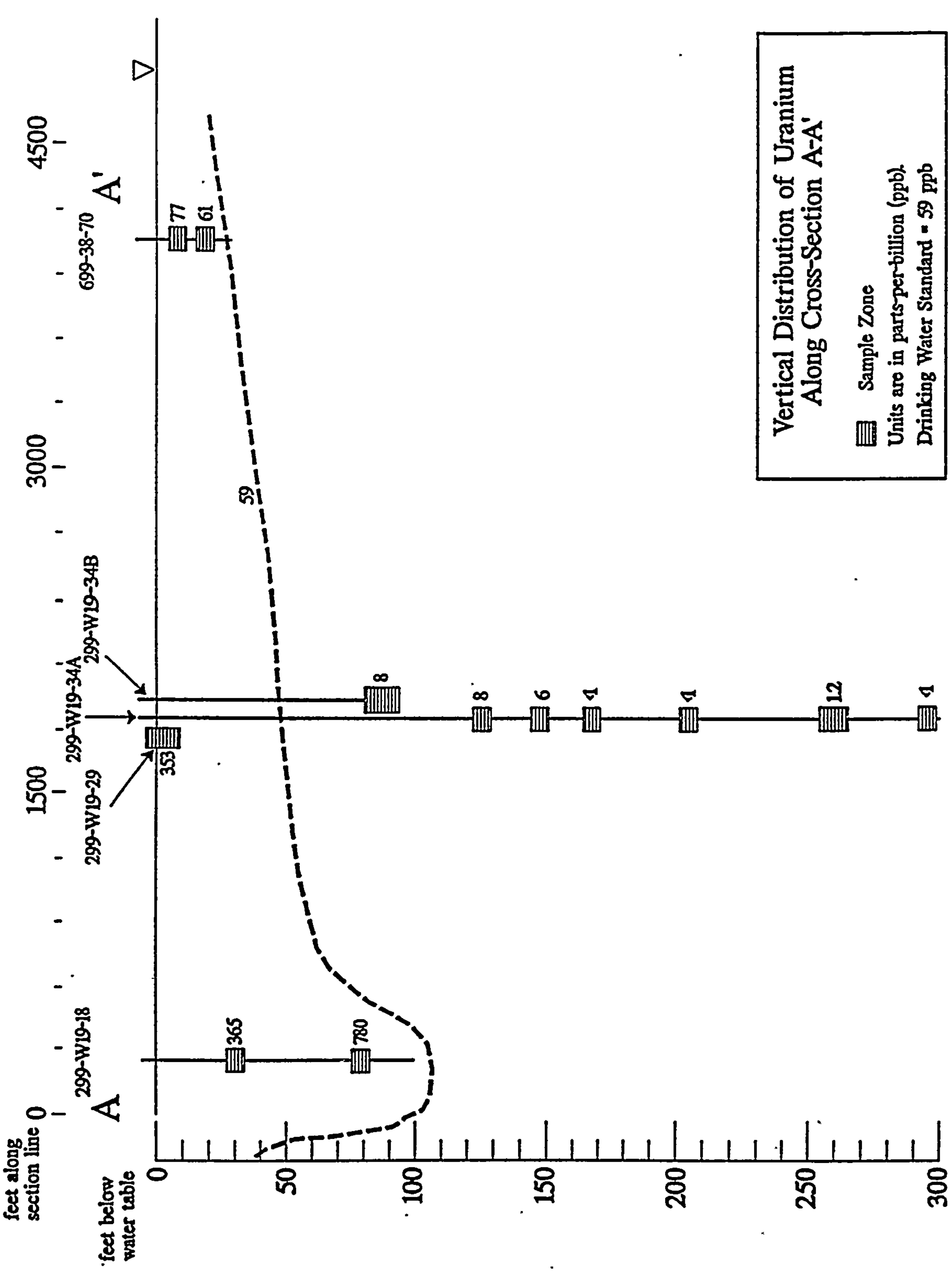

Figure 3-23. Vertical Distribution of Technetium-99 Along Cross-Section A-A'.

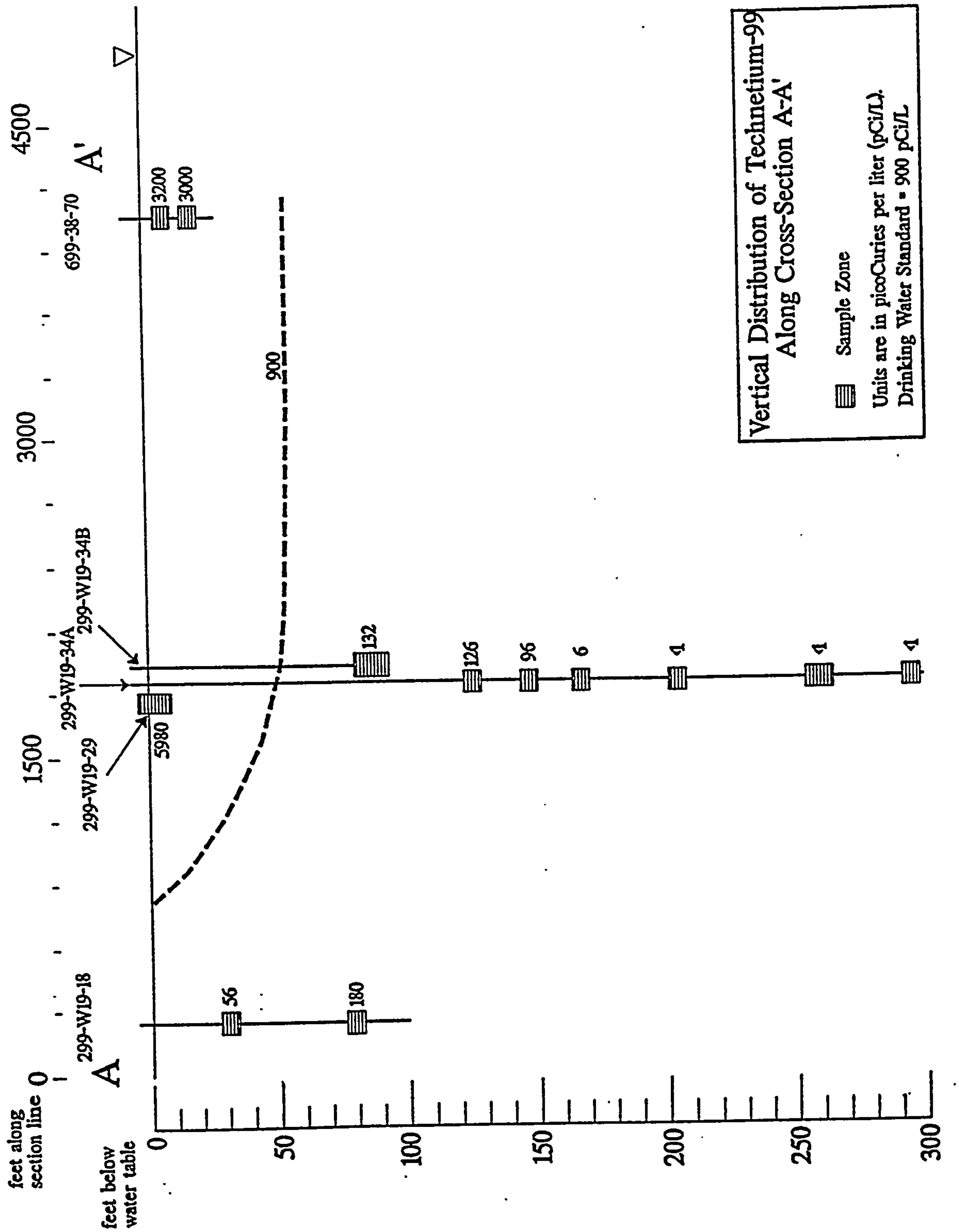

Figure 3-24. Vertical Distribution of Carbon Tetrachloride Along Cross-Section A-A'.

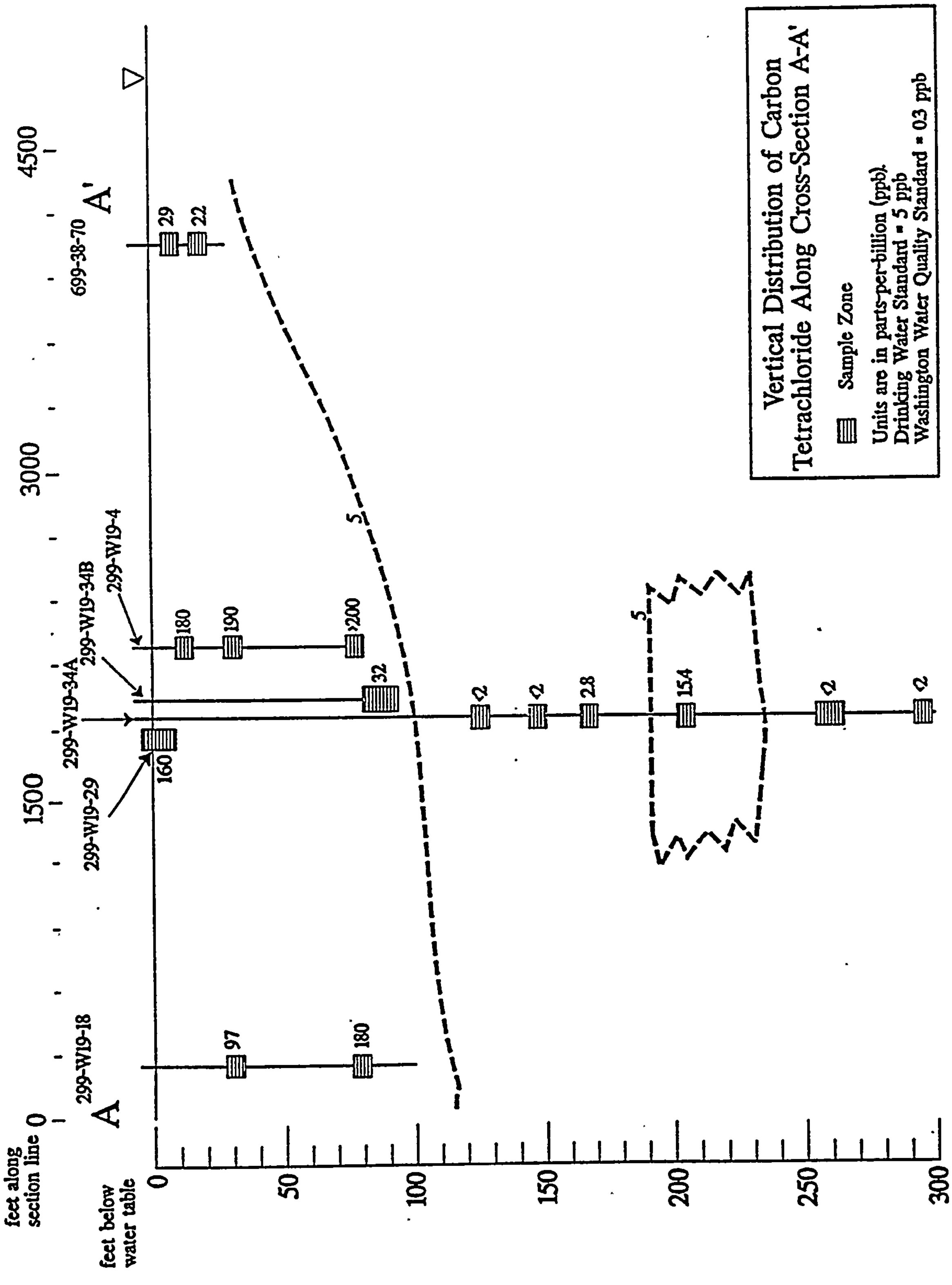

Figure 3-25. Vertical Distribution of Dissolved Oxygen Along Cross-Section A-A'.

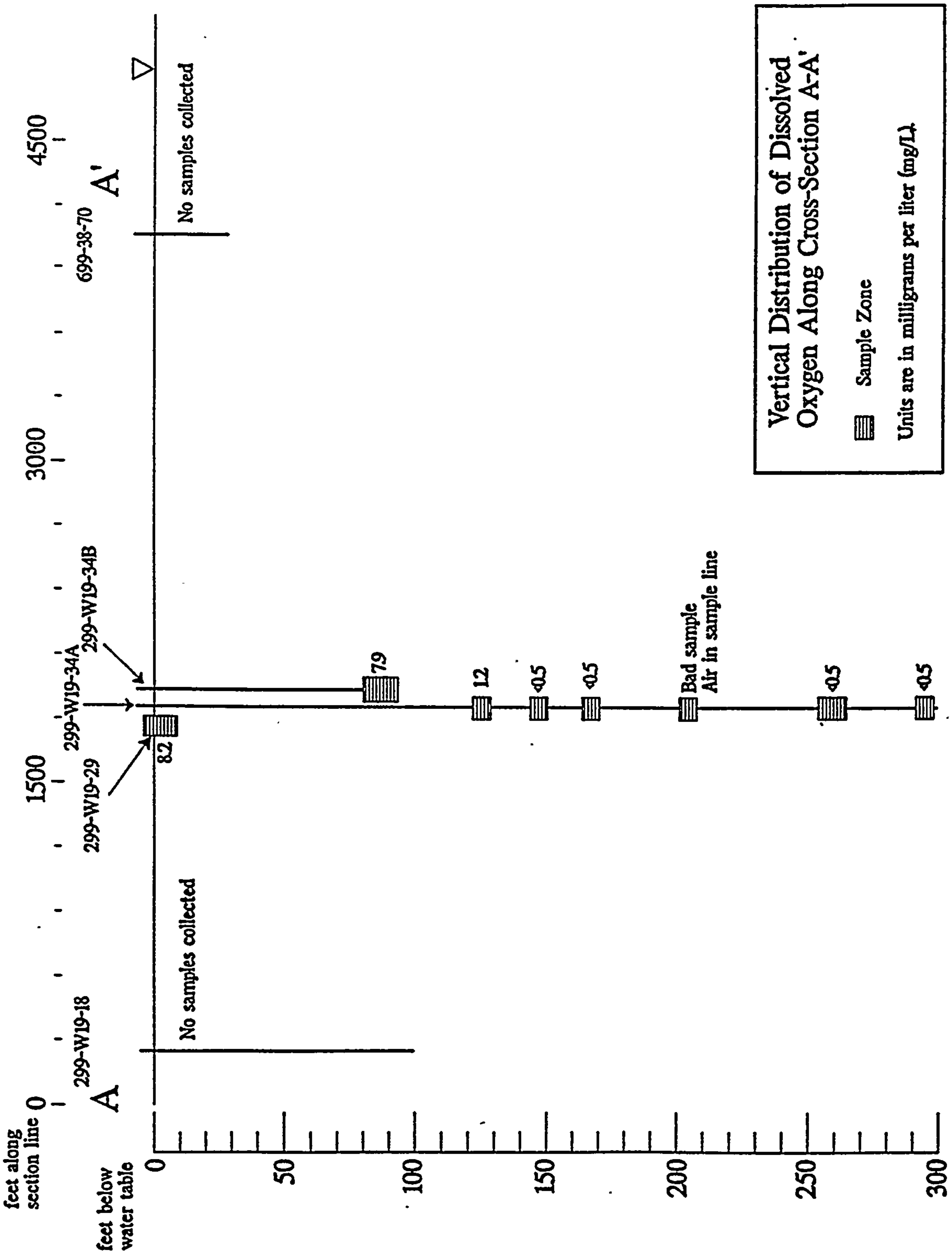

Figure 3-26. Vertical Distribution of Redox Potential Along Cross-Section A-A'.

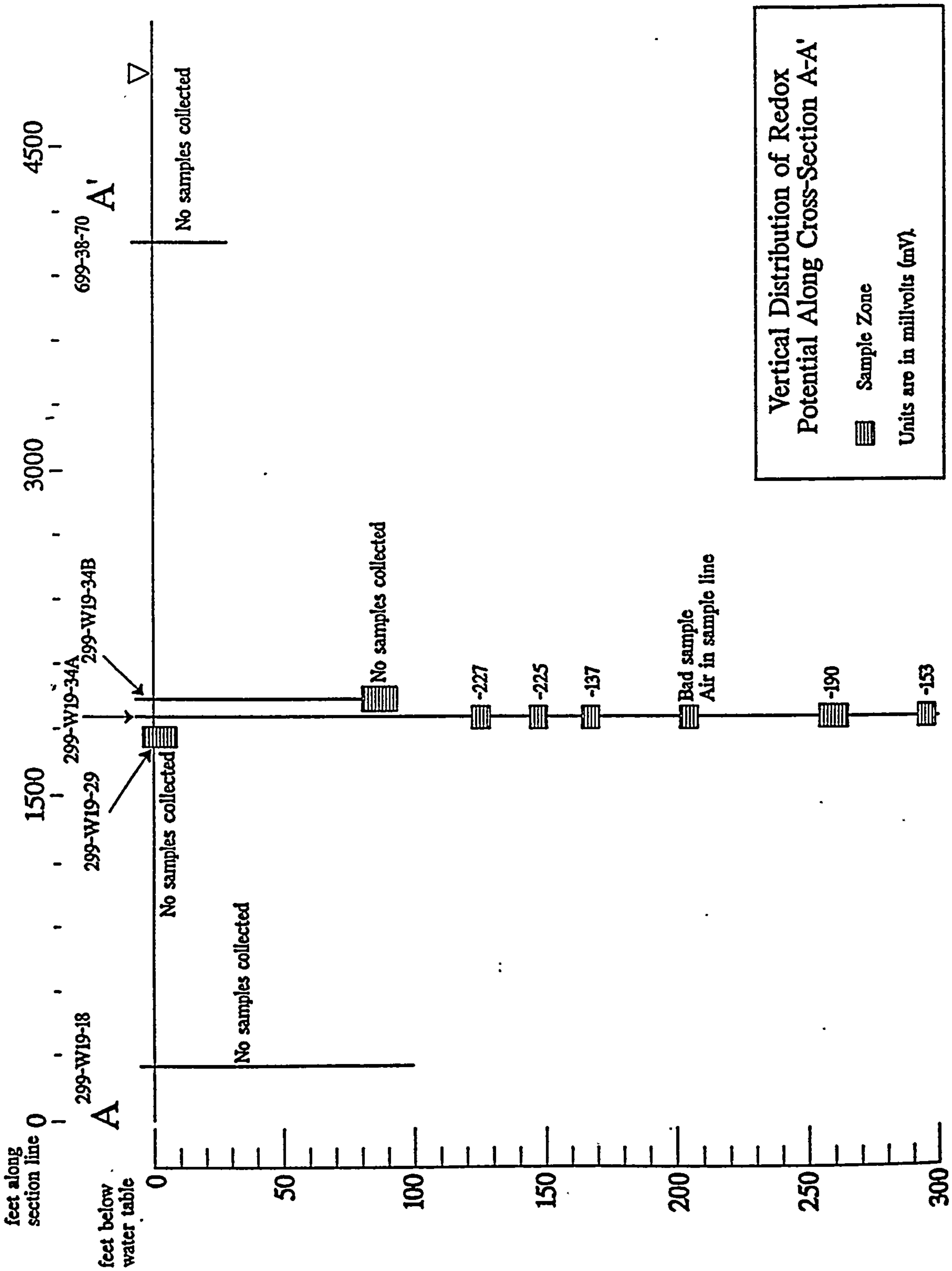

Table 3-1. Summary of Geodetic Survey Data. (sheet 1 of 2)

WELL	Easting (83)	Northing (83)	El NAVD88	El NGVD29	WELL	Easting (83)	Northing (83)	El NGVD29	Dif Easting	Dif Northing	Dif El 88 and 29
	USACE	USACE	USACE	USACE		Kaiser	Kaiser	Kaiser	USACE-Kaiser	USACE-Kaiser	USACE-Kaiser
2-W14-10	567981.068	135898.313	222.426	221.394	2-W14-10	567977.506	135902.857	NS	3.56	-4.544	NA
2-W18-15	566380.033	134733.478	202.219	201.188	2-W18-15	566381.427	134734.711	201.400	-1.394	-1.233	0.819
2-W18-20	566590.085	135081.76	205.338	204.307	2-W18-20	566590.085	135081.76	NS	0	0	NA
2-W19-2	567646.642	134694.649	212.543	211.512	2-W19-2	567646.806	134694.92	211.544	-0.164	-0.271	0.999
2-W19-3	567311.104	134989.178	213.667	212.638	2-W19-3	567311.464	134989.702	211.873	-0.36	-0.524	1.794
2-W19-4	567849.931	135350.792	219.023	217.991	2-W19-4	567950.235	135351.193	218.012	-0.304	-0.401	1.011
2-W19-8	NS	NS	NS	NS	2-W19-8	567563.839	135220.41	213.361	NA	NA	NA
2-W19-9	567272.361	135012.07	213.767	212.736	2-W19-9	567272.704	135012.767	211.462	-0.343	-0.697	2.305
2-W19-11	567276.81	135001.502	213.151	212.12	2-W19-11	567276.81	135001.502	212.050	0	0	1.101
2-W19-12	566897.131	135059.446	206.232	205.201	2-W19-12	566897.131	135059.446	205.207	0	0	1.025
2-W19-13	567288.87	134897.262	212.966	211.935	2-W19-13	567288.87	134897.262	211.861	0	0	1.105
2-W19-16	567270.681	135029.208	212.915	211.884	2-W19-16	567270.681	135029.208	211.815	0	0	1.100
2-W19-18	567360.647	135012.357	213.983	212.952	2-W19-18	567360.647	135012.357	212.964	0	0	1.019
2-W19-19	567826.905	134914.447	212.901	211.87	2-W19-19	567826.905	134914.447	211.806	0	0	1.095
2-W19-20	567873.965	134901.071	211.717	210.685	2-W19-20	567874.281	134901.369	210.630	-0.316	-0.298	1.087
2-W19-21	566953.376	134879.771	207.919	206.888	2-W19-21	566953.744	134880.147	206.817	-0.368	-0.376	1.102
2-W19-23	567771.6	134893.051	213.98	212.949	2-W19-23	567771.935	134893.407	212.885	-0.335	-0.356	1.095
2-W19-24	567771.555	134927.743	NS	NS	2-W19-24	567771.85	134928.118	212.431	-0.295	-0.375	NA
2-W19-25	567874.66	134916.359	NS	NS	2-W19-25	567874.944	134916.669	210.813	-0.284	-0.31	NA
2-W19-27	567014.387	134930.575	209.481	208.45	2-W19-27	567014.876	134931.124	208.377	-0.489	-0.549	1.104
2-W19-28	567589.789	134991.193	215.388	214.357	2-W19-28	567589.99	134991.49	214.382	-0.201	-0.297	1.006
2-W19-29	567664.106	134999.512	215.023	213.992	2-W19-29	567664.18	134999.78	214.010	-0.074	-0.268	1.013
2-W19-31	NS	NS	NS	NS	2-W19-31	566897	135127.48	205.494	NA	NA	NA
2-W19-32	NS	NS	NS	NS	2-W19-32	566896.55	135009.29	204.802	NA	NA	NA
2-W21-1	568143.367	134396.339	214.144	213.112	2-W21-1	568140.639	134397.186	213.135	2.728	-0.847	1.009
2-W22-1	566974.564	134268.11	205.245	204.214	2-W22-1	566974.82	134268.43	203.830	-0.256	-0.32	1.415
2-W22-2	566970.66	134260.126	204.731	203.7	2-W22-2	566970.93	134260.46	203.680	-0.27	-0.334	1.051
2-W22-7	567499.465	134248.07	210.54	209.509	2-W22-7	567455.949	134233.667	209.523	43.516	14.403	1.017
2-W22-9	567739.688	134042.732	207.515	206.484	2-W22-9	567736.514	134192.409	207.265	3.174	-149.677	0.250
2-W22-10	567012.978	134215.144	205.864	204.833	2-W22-10	567003.591	134225.239	204.890	9.387	-10.095	0.974
2-W22-19	567623.227	133975.284	208.649	207.618	2-W22-19	567618.488	133981.226	207.649	4.739	-5.942	1.000
2-W22-20	567593.094	133879.246	207.091	206.06	2-W22-20	567593.573	133879.697	206.085	-0.479	-0.451	1.006
2-W22-21	567167.704	134004.303	205.649	204.617	2-W22-21	567160.946	134008.027	204.217	6.758	-3.724	1.432
2-W23-2	566853.868	134258.585	203.254	202.223	2-W23-2	566854.15	134258.91	202.229	-0.282	-0.325	1.025
2-W23-3	566851.07	134162.585	203.28	202.249	2-W23-3	566851.34	134162.91	202.104	-0.27	-0.325	1.176
2-W23-4	566628.216	134391.881	202.999	201.968	2-W23-4	566628.5	134392.22	201.970	-0.284	-0.339	1.029
2-W23-5	NS	NS	NS	NS	2-W23-5	566871.01	134190.35	202.437	NA	NA	NA

Table 3-1. Summary of Geodetic Survey Data. (sheet 2 of 2)

WELL	Easting (83)	Northing (83)	El NAVD88	El NGVD29	WELL	Easting (83)	Northing (83)	El NGVD29	Dif Easting	Dif Northing	Dif El 88 and 29
	USACE	USACE	USACE	USACE		Kaiser	Kaiser	Kaiser	USACE-Kaiser	USACE-Kaiser	USACE-Kaiser
2-W23-7	566870.358	134342.347	203.304	202.273	2-W23-7	566870.63	134342.65	202.126	-0.272	-0.303	1.178
2-W23-9	566641.985	134274.625	203.708	202.677	2-W23-9	566642.451	134275.07	202.540	-0.466	-0.445	1.168
2-W23-10	566570.346	134256.322	203.79	202.759	2-W23-10	566570.891	134256.642	202.623	-0.545	-0.32	1.167
2-W23-11	566512.273	134299.012	203.552	202.521	2-W23-11	566512.915	134299.176	202.430	-0.642	-0.164	1.122
2-W23-13	NS	NS	NS	NS	2-W23-13	566712.8	134445.93	202.187	NA	NA	NA
2-W23-14	NS	NS	NS	NS	2-W23-14	566708.67	134290.17	202.388	NA	NA	NA
2-W26-1	566433.606	133436.036	200.364	199.333	2-W26-1	566433.606	133436.036	198.121	0	0	2.243
2-W26-6	566463.375	133406.002	200.083	199.052	2-W26-6	566463.025	133407.762	NS	0.35	-1.76	NA
2-W26-7	NS	NS	NS	NS	2-W26-7	566325.45	133242.42	197.691	NA	NA	NA
2-W26-8	566645.678	133663.488	204.197	203.166	2-W26-8	566645.93	133663.818	202.184	-0.252	-0.33	2.013
2-W26-9	566491.847	133228.77	200.5	199.468	2-W26-9	566492.099	133229.16	198.489	-0.252	-0.39	2.011
2-W27-1	567575.12	133750.345	206.85	205.818	2-W27-1	567575.12	133750.345	NS	0	0	NA
6-32-62	571009.564	133215.925	216.562	215.531	6-32-62	571009.574	133215.938	215.522	-0.01	-0.013	1.040
6-35-78A	566063.586	134271.27	202.383	201.352	6-35-78A	566066.623	134273.272	201.367	-3.037	-2.002	1.016
6-36-61A	571395.472	134557.106	229.031	228	6-36-61A	571395.054	134557.005	228.025	0.418	0.101	1.006
6-36-70A	NS	NS	NS	NS	6-36-70A	568466.679	134308.839	214.196	NA	NA	NA
6-38-70	568500.94	135089.205	217.704	216.672	6-38-70	NS	NS	NS	NA	NA	NA
6-40-62	571164.292	135764.444	228.93	227.898	6-40-62	571164.292	135764.444	227.924	0	0	1.006

Elevations surveyed in meters to top of casing.

Northings and Eastings reported in meters, Washington Coordinate System (WCS831991).

NS=no information available or no survey performed.

Dif Northing= difference in the northing between US Army Corp. of Engineering survey results and Kaiser survey results

Dif Easting= difference in the easting between US Army Corp. of Engineering survey results and Kaiser survey results

Dif El 88 and 29=difference in the elevation between US Army Corp. of Engineering NAVD88 survey results and Kaiser NGVD29 survey results

NA=Not applicable

Surveys to NAVD88 are considered more accurate than NAVG29.

Table 3-2. Summary of Aquifer Testing Results.

Well Name	Test Method	Aquifer Type	Formation	K (ft/day) T (ft^2/day)	Reference
299-W11-10	Slug[a]	Unconfined	Ringold Unit E	6	BHI (1994)
299-W12-1	Slug[a]	Unconfined	Ringold Unit E	21	BHI (1994)
299-W18-33	Slug	Unconfined	Ringold Unit E	4	Singleton and Lindsey (1994), Appendix G
299-W19-4	Slug	Unconfined	Ringold Unit E	20/535	BHI (1994)
299-W19-20	Pumping recovery	Unconfined	Ringold Unit E	49 55	Swanson (1996)
299-W19-25	Pumping recovery	Unconfined	Ringold Unit E	56 60	Swanson (1996)
299-W19-26	Pumping recovery	Unconfined	Ringold Unit E	57 55	Swanson (1996)
299-W19-29	Slug	Unconfined	Ringold Unit E	55	Kelty et al. (1995a)
299-W19-34A	Slug	Unconfined	Ringold Unit E	4.5	Kelty et al. (1995a)
299-W19-34B	Slug interference	Unconfined	Ringold Unit E	13	Kelty et al. (1995a)
299-W19-34B	Slug interference	Unconfined or semiconfined	Ringold Unit E	0.4	Kelty et al. (1995a)
299-W19-34B	Slug	Unconfined or semiconfined	Ringold Unit E.	245	Kelty et al. (1995a)
299-W19-34B	Slug	Confined	Ringold Unit A	2.5	Kelty et al. (1995a)
299-W19-34B	Slug	Confined	Ringold Unit A	19	Kelty et al. (1995a)
299-W19-39	Recovery	Unconfined	Ringold Unit E	-/2397	Swanson (1996)
299-W22-41	Slug	Unconfined	Ringold Unit E	14	BHI (1994)
299-23-16	Slug	Unconfined	Ringold Unit E	2	Singleton and Lindsey (1994), Appendix G
299-23-17	Slug	Unconfined	Ringold Unit E	5	Singleton and Lindsey (1994), Appendix G
699-35-70	Slug	Unconfined	Ringold Unit E	175	BHI (1994)
699-37-82A	Slug	Unconfined	Ringold Unit E	190	BHI (1994)
699-38-70	Slug	Unconfined	Ringold Unit E	435	BHI (1994)

[a] Pumpt test attemped but not successful.
K = hydraulic conductivity
T = transmissivity

Table 3-3. 200-UP-1 Operable Unit Sampling and Analysis Summary Statistics, 1990 Through 1995 and 1994 Through 1995.

Constituent	Units	1990 Through 1995 Sampling and Analyses								1994 Through 1995 Sampling and Analyses							
		Samp. Filt.	Number of		Number of		Concentration			Samp. Filt.	Number of		Number of		Concentration		
			Wells	Results	Detects	Well Detects	Minimum	Maximum	Average		Wells	Results	Detects	Well Detects	Minimum	Maximum	Average
1,1-Dichloroethene	µg/L	No	58	144	7	1	1.70E+00	5.70E+00	2.80E+00	No	30	96	5	1	2.00E+00	3.20E+00	2.44E+00
1,2-Dichloroethane	µg/L	No	102	685	13	3	1.10E-01	5.50E+00	4.26E+00	No	87	282	7	3	1.10E-01	5.50E+00	4.16E+00
4,4'-DDD	µg/L	No	69	248	2	2	8.00E-03	3.20E-01	1.64E-01	No	19	28	1	1	8.00E-03	8.00E-03	8.00E-03
4,4'-DDT	µg/L	No	69	248	2	2	1.00E-01	4.20E+00	2.15E+00	No	19	28	0	0	na	na	na
Aldrin	µg/L	No	69	248	1	1	1.80E+00	1.80E+00	1.80E+00	No	19	28	0	0	na	na	na
Arsenic	µg/L	Yes	54	242	136	48	1.00E+00	2.50E+01	7.41E+00	Yes	19	35	30	17	1.30E+00	1.80E+01	6.13E+00
Arsenic	µg/L	No	73	281	146	55	1.20E+00	2.70E+01	7.07E+00	No	24	39	34	22	1.20E+00	1.71E+01	5.14E+00
Bis(2-ethylhexyl) phthalate	µg/L	No	41	64	8	8	1.00E+00	3.10E+02	6.63E+01	No	8	8	0	0	na	na	na
Cadmium	µg/L	Yes	83	557	7	7	1.10E+00	7.20E+00	3.10E+00	Yes	75	204	7	7	1.10E+00	7.20E+00	3.10E+00
Cadmium	µg/L	No	86	452	9	8	2.00E+00	6.60E+02	9.85E+01	No	63	130	6	5	2.00E+00	6.60E+02	1.26E+02
Carbon tetrachloride	µg/L	No	102	686	518	90	5.30E-02	1.80E+03	1.17E+02	No	87	282	220	76	5.30E-02	1.80E+03	1.40E+02
Chloroform	µg/L	No	105	690	456	87	5.00E-02	1.83E+02	6.03E+00	No	87	282	198	70	5.00E-02	2.90E+01	4.39E+00
Chromium	µg/L	Yes	83	557	177	62	3.60E+00	2.50E+03	4.78E+01	Yes	75	204	118	59	3.60E+00	2.50E+03	4.28E+01
Chromium	µg/L	No	88	468	375	74	3.40E+00	2.40E+03	1.42E+02	No	69	146	125	63	3.40E+00	2.40E+03	1.58E+02
Dieldrin	µg/L	No	69	248	1	1	3.80E+00	3.80E+00	3.80E+00	No	19	28	0	0	na	na	na
Endrin	µg/L	No	69	253	3	3	1.50E-02	4.40E+00	1.48E+00	No	19	28	0	0	na	na	na
Endrin aldehyde	µg/L	No	64	242	1	1	6.70E-01	6.70E-01	6.70E-01	No	19	28	0	0	na	na	na
Fluoride	µg/L	No	104	839	794	102	1.00E+02	4.00E+03	6.65E+02	No	95	311	308	95	1.00E+02	2.40E+03	7.24E+02
Gamma-BHC (Lindane)	µg/L	No	69	253	1	1	1.70E+00	1.70E+00	1.70E+00	No	19	28	0	0	na	na	na
Heptachlor	µg/L	No	69	248	2	2	3.00E-03	1.70E+00	8.52E-01	No	19	28	0	0	na	na	na
Iodine-129	pCi/L	No	86	365	208	69	4.12E-03	8.61E+01	5.72E+00	No	73	188	106	53	4.12E-03	8.61E+01	7.84E+00
N-Nitrosodimethylamine	µg/L	No	28	30	0	0	na	na	na	No	1	1	0	0	na	na	na
Plutonium-238	pCi/L	No	65	192	28	20	8.97E-06	2.36E-02	4.82E-03	No	20	38	3	3	2.24E-03	4.15E-03	2.98E-03
Potassium-40	pCi/L	No	45	79	74	43	6.31E+00	3.73E+02	8.38E+01	No	23	37	32	21	1.55E+01	1.42E+02	4.63E+01
Selenium	µg/L	Yes	53	241	38	22	1.30E+00	1.28E+01	3.66E+00	Yes	16	32	19	10	1.30E+00	1.28E+01	3.96E+00
Selenium	µg/L	No	73	291	43	26	1.00E+00	3.50E+01	5.21E+00	No	20	36	17	10	1.80E+00	8.60E+00	4.09E+00
Strontium-90	pCi/L	Yes	1	1	0	0	na	na	na	Yes	1	1	0	0	na	na	na
Strontium-90	pCi/L	No	78	267	48	32	8.31E-03	7.82E+03	1.68E+02	No	55	120	33	27	8.31E-03	7.13E+01	4.93E+00
Technetium-99	pCi/L	Yes	1	1	1	1	6.55E+00	6.55E+00	6.55E+00	Yes	1	1	1	1	6.55E+00	6.55E+00	6.55E+00
Technetium-99	pCi/L	No	99	568	503	90	3.32E-02	2.85E+04	1.56E+03	No	78	288	265	73	5.86E-02	2.14E+04	1.59E+03
Trichloroethene	µg/L	No	102	686	227	50	5.00E-02	5.00E+01	3.97E+00	No	87	282	118	42	5.00E-02	3.30E+01	3.47E+00
Uranium	µg/L	Yes	2	2	2	2	7.47E-01	8.43E+01	4.25E+01	Yes	2	2	2	2	7.47E-01	8.43E+01	4.25E+01
Uranium	µg/L	No	96	726	725	96	8.00E-03	1.64E+04	2.19E+02	No	80	275	274	80	2.50E-02	1.64E+04	3.75E+02

Notes: Samp. Filt. - Sample filtered na - not applicable

Number of Wells - Number of wells sampled for the constituent Number of Results - Number of analyses for the constituent

Number of Detects - Number of detections for the constituent Number of Well Detects - Number of wells in which the constituent was detected

Maximum concentration for chromium, filtered, i.e., 2.50E+03, is suspect, 2.50E+02 is a more reliable maximum.

Maximum concentration for cadmium, unfiltered, i.e., 6.60E+02, is suspect, more reliable maximums for 1990-1995 and 1994-1995 are 9.40E+01 and 5.40E+01, respectively.

Table 3-4. Chromium, Aluminum, and Turbidity for Unfiltered Samples from 1994 and 1995, 200-UP-1 Operable Unit. (sheet 1 of 2)

Well Name	Sample Date Time	Chromium µg/L	Aluminum µg/L	Turbidity NTU	Reasons for Exclusion of Chromium Result
299-W18-19	1/3/95 12:16	~~36~~	46000	NA	Al > 2X background (200 ug/L)
299-W18-21	11/28/94 10:45	94	31	1.5	Not excluded
299-W18-25	3/28/94 8:30	85	30	1	Not excluded
299-W18-30	3/28/94 10:30	~~73~~	100	5.2	Turbidity > 5
299-W18-31	3/22/94 10:00	43	19	1.7	Not excluded
299-W18-33	6/7/94 8:31	~~45~~	4100	NA	Al > 2X background (200)
299-W19-1	6/3/94 10:00	~~40~~	4400	NA	Al > 2X background (200)
299-W19-2	9/22/94 0:00	~~804~~	2480	NA	Al > 2X background (200)
299-W19-29	10/3/94 0:00	35.8	24.9	3.99	Not excluded
299-W19-31	3/28/94 10:00	140	100	4.2	Not excluded
299-W19-31	9/29/94 0:00	43.2	30.6	2.48	Not excluded
299-W19-32	3/28/94 9:15	~~490~~	140	15	Turbidity > 5
299-W19-32	7/7/94 0:00	102	27.4	3.93	Not excluded
299-W19-32	9/27/94 0:00	~~39.6~~	27.8	75	Turbidity > 5
299-W19-32	2/11/95 11:20	~~420~~	270	6.8	Turbidity > 5
299-W19-34A	10/3/94 0:00	~~34~~	418	18.8	Al > 2X background (200) and Turbidity > 5
299-W19-91	2/17/94 9:30	~~38~~	890	NA	Al > 2X background (200)
299-W19-91	6/3/94 8:30	~~750~~	53000	NA	Al > 2X background (200)
299-W19-91	6/7/94 10:45	~~1000~~	100000	NA	Al > 2X background (200)
299-W21-1	9/19/94 0:00	~~94.5~~	3050	166	Al > 2X background (200) and Turbidity > 5
299-W22-20	2/8/95 9:25	~~420~~	NA	NA	Turbidity and Aluminum Not Analyzed
299-W22-20	6/6/95 9:15	90	NA	4.93	Not excluded
299-W22-20	8/29/95 11:50	71.1	NA	2.53	Not excluded
299-W22-21	7/19/95 10:00	~~34.5~~	NA	29.6	Turbidity > 5
299-W22-21	9/11/95 11:35	~~144~~	NA	26.6	Turbidity > 5
299-W22-22	9/26/94 10:31	~~190~~	56	6.3	Turbidity > 5
299-W22-23	3/2/94 9:15	~~2100~~	480	36	Al > 2X background (200) and Turbidity > 5
299-W22-23	6/27/94 8:30	~~1200~~	390	49	Al > 2X background (200) and Turbidity > 5
299-W22-23	9/22/94 18:20	~~840~~	520	58	Al > 2X background (200) and Turbidity > 5
299-W22-23	12/15/94 10:00	~~2000~~	4200	290	Al > 2X background (200) and Turbidity > 5
299-W22-39	3/18/94 10:00	200	48	1.7	Not excluded
299-W22-40	3/4/94 9:15	67	25	0.6	Not excluded
299-W22-41	3/4/94 9:45	77	27	0.63	Not excluded
299-W22-41	6/27/94 10:40	59	19	1.1	Not excluded
299-W22-41	9/23/94 9:30	33	26	0.87	Not excluded
299-W22-42	3/2/94 10:15	110	32.5	2.1	Not excluded
299-W22-42	6/28/94 8:20	78	19	1.1	Not excluded
299-W22-42	9/23/94 10:15	60	26	0.89	Not excluded
299-W22-43	3/2/94 10:45	70	32.5	0.95	Not excluded
299-W22-43	6/27/94 9:50	78	19	1.5	Not excluded
299-W22-43	9/22/94 17:15	44	26	1.7	Not excluded
299-W22-43	12/15/94 10:40	89	38	1.2	Not excluded
299-W22-44	3/18/94 9:30	~~160~~	13000	360	Al > 2X background (200) and Turbidity > 5
299-W22-46	3/22/94 10:00	120	40	2.8	Not excluded

Table 3-4. Chromium, Aluminum, and Turbidity for Unfiltered Samples from 1994 and 1995, 200-UP-1 Operable Unit. (sheet 2 of 2)

Well-Name	Sample Date Time	Chromium µg/L	Aluminum µg/L	Turbidity NTU	Reasons for Exclusion of Chromium Result
299-W23-13	3/18/94 8:30	~~120~~	460	20	Al > 2X background (200) and Turbidity > 5
299-W23-14	3/18/94 8:15	~~160~~	2600	100	Al > 2X background (200) and Turbidity > 5
299-W23-15	3/18/94 9:30	~~140~~	710	20	Al > 2X background (200) and Turbidity > 5
299-W26-10	12/7/94 11:00	~~74~~	2600	NA	Al > 2X background (200)
299-W26-12	12/7/94 12:00	~~78~~	460	NA	Al > 2X background (200)
299-W26-6	1/16/95 9:53	~~292~~	NA	NA	Turbidity and Aluminum Not Analyzed
299-W26-6	6/7/95 9:10	~~100~~	NA	34.3	Turbidity > 5
299-W26-7	12/7/94 11:30	250	110	NA	Not excluded
299-W26-7	1/16/95 11:00	~~219~~	NA	NA	Turbidity and Aluminum Not Analyzed
299-W26-8	12/7/94 10:00	340	71	NA	Not excluded
299-W26-9	12/7/94 10:30	58	58	NA	Not excluded
299-W26-9	1/17/95 12:15	~~65.4~~	NA	NA	Turbidity and Aluminum Not Analyzed
299-W27-2	1/20/95 9:25	220	170	NA	Not excluded
699-32-72B	8/3/94 10:40	~~42~~	320	13	Turbidity > 5
699-32-72B	10/25/94 9:01	~~53~~	190	7.5	Turbidity > 5
699-32-72B	1/9/95 9:30	~~36~~	160	6.5	Turbidity > 5
699-34-61	1/27/94 10:05	~~120~~	350	12	Turbidity > 5
699-34-61	5/6/94 8:40	~~220~~	1400	43	Al > 2X background (200) and Turbidity > 5
699-34-61	10/25/94 11:00	~~320~~	1300	52	Al > 2X background (200) and Turbidity > 5
699-34-61	1/10/95 9:30	~~210~~	130	6.2	Turbidity > 5
699-36-70A	9/30/94 10:20	~~2400~~	1400000	NA	Al > 2X background (200)
699-36-70A	10/16/94 13:45	~~54~~	28000	NA	Al > 2X background (200)
699-36-70A	10/21/94 14:30	~~170~~	96000	NA	Al > 2X background (200)
699-36-70A	11/2/94 18:30	~~68~~	35000	NA	Al > 2X background (200)
699-36-70A	1/3/95 11:00	~~58~~	520	20	Al > 2X background (200) and Turbidity > 5
699-38-61	5/6/94 9:45	~~74~~	82	9.8	Turbidity > 5
699-38-61	8/3/94 8:45	~~48~~	99	7.2	Turbidity > 5
699-38-61	10/25/94 9:31	~~40~~	200	14	Turbidity > 5
699-38-68A	8/5/94 11:30	~~37.2~~	4360	219	Al > 2X background (200) and Turbidity > 5
699-38-68A	9/27/94 0:00	~~38.6~~	2160	NA	Al > 2X background (200)

Chromium values with strikeover, e.g., ~~38.6~~, are considered unreliable and are excluded because of high turbidity, high aluminum concentrations, or if turbidity or aluminum data are not available. The EPA recommends that samples with turbidity greater than 5 nephelometric turbidity units (NTUs) not be used for metals analysis (NWWA 1986).

High aluminum and turbidity results indicate poor sample quality (suspended particulate matter in the unfiltered water). Hanford Site background for aluminum is 200 µg/L (DOE-RL 1992).

Well 299-W19-1 was last sampled with a bailer and may not have been purged before sampling.

Well 299-W19-91 also excluded since it monitors perched water. It is now dry.

Well 299-W22-23 is dry. When its pump was removed in June 1995 clay was in the pump intake screen.

NA - turbidity or aluminum results not available

Table 3-5. Summary of Data and Assessment of Plumes for the 26 High-Priority Contaminants, 200-UP-1 Operable Unit.

Constituent	Units	1994 Through 1995 Analyses		Back-ground	Groundwater Standards			Do Plumes Exist?	Rationale
		Sample Filtered	Maximum Concentration		Federal MCL	MTCA-B	MTCA-C		
1,1-Dichloroethene	µg/L	No	3.20E+00	ND	7.00E+00	7.29E-02	7.29E-01	No	No detections in 3 adjacent wells; all detections in 1 well
1,2-Dichloroethane	µg/L	No	5.50E+00	ND	5.00E+00	4.81E-01	4.81E+00	No	No detections in 3 adjacent wells
4,4'-DDD	µg/L	No	8.00E-03	ND	na	3.65E-01	3.65E+00	No	No detections in 1994 through 1995
4,4'-DDT	µg/L	No	ND	ND	na	2.57E-01	2.57E+00	No	No detections in 1994 through 1995
Aldrin	µg/L	No	ND	ND	na	1.50E-03	1.50E-02	No	No detections in 1994 through 1995
Arsenic	µg/L	Yes	1.80E+01	< 1.00E+01	5.00E+01	5.00E-02	5.00E-01	No	No detections greater than background in 3 adjacent wells
Bis(2-ethylhexyl) phthalate	µg/L	No	ND	ND	na	6.25E+00	6.25E+01	No	No detections in 3 adjacent wells
Cadmium	µg/L	Yes	7.20E+00	< 1.00E+01	5.00E+00	8.00E+00	1.75E+01	No	No detections greater than background in 3 adjacent wells
Carbon tetrachloride	µg/L	No	1.80E+03	ND	5.00E+00	3.37E-01	3.37E+00	Yes	Detections in 3 adjacent wells
Chloroform	µg/L	No	2.90E+01	ND	na	7.17E+00	7.17E+01	Yes	Detections in 3 adjacent wells
Chromium	µg/L	Yes	2.50E+02	<3.00E+01	1.00E+02	8.00E+01	1.75E+02	No	No detections greater than background in 3 adjacent wells
Dieldrin	µg/L	No	ND	ND	na	5.47E-03	5.47E-02	No	No detections in 1994 through 1995
Endrin	µg/L	No	ND	ND	2.00E+00	4.80E+00	1.05E+01	No	No detections in 1994 through 1995
Endrin aldehyde	µg/L	No	ND	ND	na	na	na	No	No detections in 1994 through 1995
Fluoride	µg/L	No	2.40E+03	7.75E+02	4.00E+03	9.60E+02	2.10E+03	Yes	Detections greater than background in 3 adjacent wells
Gamma-BHC (Lindane)	µg/L	No	ND	ND	2.00E-01	6.73E-01	6.73E-01	No	No detections in 1994 through 1995
Heptachlor	µg/L	No	ND	ND	4.00E-01	1.94E-02	1.94E-01	No	No detections in 1994 through 1995
Iodine-129	pCi/L	No	8.61E+01	3.12E-05	4.80E-01	na	na	Yes	Detections greater than background in 3 adjacent wells
N-Nitrosodimethylamine	µg/L	No	ND	ND	na	1.72E-03	1.72E-02	No	No detections in 1994 through 1995
Plutonium-238	pCi/L	No	4.15E-03	6.43E-05	1.50E+01	na	na	No	No detections in 3 adjacent wells
Potassium-40	pCi/L	No	1.42E+02	2.47E+00	2.95E+02	na	na	No	No detections greater than MCL
Selenium	µg/L	Yes	1.28E+01	<5.00E+00	5.00E+01	8.00E+01	1.75E+02	No	No detections greater than background in 3 adjacent wells
Strontium-90	pCi/L	No	7.13E+01	3.77E-03	8.00E+00	na	na	No	No detections greater than background in 3 adjacent wells
Technetium-99	pCi/L	No	2.14E+04	na	9.00E+02	na	na	Yes	Detections in 3 adjacent wells - IRM plume
Trichloroethene	µg/L	No	3.30E+01	ND	5.00E+00	3.98E+00	3.98E+01	Yes	Detections in 3 adjacent wells - IRM plume
Uranium	µg/L	No	1.64E+04	3.43E+00	4.40E+01	4.80E+01	na	Yes	Detections greater than background in 3 adjacent wells - IRM plume

Notes:
Federal Maximum Contaminant Levels (MCLs) are from 40 CFR 141.62, except for uranium. Federal MCL for uranium is from 40 CFR 192.02 Table 1.
MTCA-B = Model Toxics Control Act Method B, WAC-173-340 MTCA-C = Model Toxics Control Act Method C, WAC-173-340
ND = Not Detected, background for organic constituents is assumed to be non detect na = not available
IRM = Wells associated with the 200-UP-1 uranium and technetium-99 interim remedial measure (IRM) effort. Trichloroethene, technetium-99, and uranium plumes are not present in other parts of the 200-UP-1 Operable Unit.
Background concentrations for inorganics and uranium are from DOE/RL-92-23 (DOE-RL 1992).
Background concentrations for iodine-129, plutonium-238, potassium-40, and strontium-90 are arithmetic means calculated for 200-UP-1 from 4 upgradient wells. Background concentration for technetium-99 is not available
Chromium maximum concentration for 1994 through 1995 does not include suspect data from well 299-W22-23.
Shaded cells identify contaminants that exceed a groundwater standard(s) or which form plumes

Table 3-6. LFI Filtered Inorganic Constituents Data Summary and Hanford Background Data.

Analyte	Units	200-UP-1 LFI Data[a] 1990 - 1995			Hanford Background[b]
		Minimum	Maximum	Average	
Aluminum	ppb	19	3,300	110	<200
Antimony	ppb	19	87	45	NR
Arsenic	ppb	1	25	5	10[c]
Barium	ppb	6.3	420	57.4	68.5[c]
Beryllium	ppb	0.2	1.5	0.6	<5
Cadmium	ppb	1.1	7.2	3.1	<10
Calcium	ppb	10,000	330,000	56,000	63,600[c]
Chromium	ppb	3.6	2,500	47.8	<30
Cobalt	ppb	4.1	40	12.3	NR
Copper	ppb	2.2	120	14.2	<30
Iron	ppb	7.6	89,000	366.2	86[c,d]
Lead	ppb	0.6	42	3.6	<5
Magnesium	ppb	3,100	110,000	17,900	16,480[e]
Manganese	ppb	0.69	1,900	55.4	24.5[c,d]
Mercury	ppb	0.04	0.21	0.11	<0.1
Nickel	ppb	13	1,200	61.0	<30
Potassium	ppb	830	13,000	4,655	7,975[e]
Selenium	ppb	1.3	12.8	3.7	<5
Silver	ppb	3.0	6.5	4.8	<10
Sodium	ppb	2,000	54,000	23,000	33,500[c]
Vanadium	ppb	4.4	70	25.9	15
Zinc	ppb	0.6	429	27.6	<50[d]

[a] 200-UP-1 LFI data not screened for outliers.

[b] Hanford background values from DOE-RL (1992a).

[c] Based on nonparametric tolerance interval, maximum value reported. As discussed in Appendix B, Section 1.1. of the Hanford Site Groundwater Background (DOE-RL 1992a), a tolerance interval is used in statistical analysis to estimate a reasonable upper or lower limit for an individual data set. A nonparametric tolerance interval is calculated if background concentrations do not follow a normal distribution, if there is insufficient data, or if the proportions of less-than detection limit values are more than 50%. An upper one-sided nonparametric tolerance limit is the largest datum of the observed data (Conover 1980).

[d] Lowest background concentration.

[e] Based on normal distribution.

NR = not reported

Table 3-7. LFI Other Constituent Data Summary and Hanford Background Data.

Analyte	Units	200-UP-1 LFI Data[a] 1990 - 1995			Hanford Background[b]
		Minimum	Maximum	Average	
Alkalinity	mg/L	50	21,000	2,960	210
Ammonia	ppb	40	400	120	120
Chloride	ppb	800	59,000	10,800	88,690
Cyanide	ppb	1.0	30.0	9.6	NR
Specific conductance	μmho/cm	5.88	2,650	511	530
Fluoride	ppb	100	4,000	700	775
Nitrate/nitrite	ppb	60	1,700,000	124,900	12,400
pH		7.2	10.8	8.1	7.25-8.25
Phosphate	ppb	200	2,100	500	<1,000
Sulfate	ppb	1,100	3,500,000	33,900	90,500
Sulfide	ppb	300	600	400	NR
TDS	ppb	110,000	2,100,000	273,000	NR
TOC	ppb	140	4,000	400	2,610
TOX	ppb	5	1,410	99	NR

NR = not reported
TDS = total dissolved solids
TOC = total organic carbon
TOX = total organic halides
[a] 200-UP-1 LFI data not screened for outliers.
[b] Hanford background values from DOE-RL (1992a).

4.0 SITE CONCEPTUAL MODEL

This section summarizes the preceding chapters and describes the 200-UP-1 site conceptual model.

- Wastewater discharges to the sediment column occurred between 1944 and June 1995 in the 200-UP-1 Operable Unit. The increase in vadose zone moisture is the primary driver contributing to vadose and groundwater contamination.

- Stratigraphic units within the vadose zone that are potentially impacted by waste disposal practices are, from youngest to oldest, as follows: Hanford formation Unit 1, Hanford formation Unit 2, Plio-Pleistocene unit, the upper Ringold, and part of Ringold Formation, Unit E. The vadose zone is 59 to 75 m (193 to 247 ft) thick, and the Plio-Pleistocene unit, 0.6 to 15 m thick (2 to 48 ft), is the most significant aquitard above the water table.

- The travel time for wastewater to reach the water table, under saturated or near-saturated conditions, is relatively short (i.e., <2 years). During periods of discharge, effluent migrates vertically downward and spreads laterally along a discontinuous silty layer within Unit 2 of the Hanford formation and on top of the Plio-Pleistocene unit. Perched aquifers several feet thick may develop depending on the amount of effluent discharged. The saturated thickness of the perched water table decreases shortly after periods of high discharge, and perching is of limited lateral extent. Detection of little radiological contamination in boreholes adjacent to waste management facilities also suggests limited lateral spreading of contaminants. Rapid dissipation of the perching horizon may suggest the presence of preferential pathways (e.g., clastic dikes, well seals) through the Plio-Pleistocene unit. Forty-one wells in the operable unit have been identified as having suspect/deficient well seals.

- The high distribution coefficient (K_d) for many of the contaminants released to the sediment column results in their absorption in the vadose zone immediately beneath the point of release, with the exception of highly mobile low K_d contaminants (e.g., tritium). Contaminants are also detected at depth on the caliche layer; however, these concentrations are lower relative to concentrations near release points.

- The water content within the vadose is decreasing because effluent is no longer being discharged to the sediment column. It may take several years after discharge has ceased to restore pre-Hanford moisture conditions.

- Wastewater discharges to the sediment column have produced a groundwater mound in the operable unit. The shape and location of the mound reflect the influence of discharging wastewater across the 200 West Area. The water table occurs within Ringold Formation Unit E and is currently 59 to 79 m (193 to 247 ft) below ground surface. Groundwater flow is towards the east and northeast. The average horizontal gradient in the upper portion of Ringold Unit E is 1.51×10^{-3}. The surface of the water table is dropping at a rate of about 1.5 m/yr (5.0 ft/yr) near the groundwater mound and reflects the lack of wastewater discharge in the 200 West Area since June 1995. The horizontal gradient is expected to decrease and shift to the east as the mound dissipates. The available data suggest that at least seven groundwater monitoring wells are expected to be dry in less than 3 years. Because water-level data were collected from a limited number of wells, the number of dry wells may be larger.

- The saturated thickness of Ringold Unit E is at least 61 m (200 ft). Aquifer tests indicate that hydraulic conductivities range between 0.61 and 18 m/day (2 and 60 ft/day). The Ringold Formation, lower mud unit [6 to 22 m (19 to 72 ft) thick] is the confining unit between Unit E and the confined aquifer (Ringold Unit A). Unit A is 14 to 37 m (45 to 122 ft) thick, and hydraulic conductivities range between 0.8 to 6 m/day (2.5 to 19 ft/day).

- Groundwater flow within the deep unconfined aquifer is to the southeast and the gradient is 2.6×10^{-3}. The horizontal gradient in Unit A is 1×10^{-5}, and flow direction is to the southwest.

- Downward vertical gradients exist between the upper unconfined and deep unconfined aquifers, between Units E and A, and between Unit A and the Rattlesnake Ridge interbed. Gradients may reverse as the mound in the 200 West Area becomes less pronounced.

- Thirteen of twenty-six high-priority groundwater contaminants were detected in the 200-UP-1 Operable Unit that exceed *Safe Drinking Water Act*, MTCA, and *Uranium Mill Tailings Radiation Control Act* groundwater standards. High-priority contaminants exceeding groundwater standards include 1,1-dichloroethene, 1,2-dichloroethane, arsenic, cadmium, carbon tetrachloride, chloroform, chromium, fluoride, iodine-129, strontium-90, technetium-99, trichloroethene, and uranium. The distribution of these contaminants in groundwater occurs as well-defined plumes and sporadic occurrences. The distribution of the remaining 13 contaminants is characterized as undetects, one-time detections, below background, or below applicable groundwater standards.

- The vertical distribution of the technetium-99 and uranium plumes extends no greater than 30 m (100 ft) below the water table. Carbon tetrachloride is distributed similarly in the upper aquifer; however, elevated levels were also detected below the Ringold lower mud unit. The higher concentration of each contaminant correlates strongly with monitoring wells with missing or poor annular seals.

- Groundwater is slightly basic due to calcium carbonate buffering of the system. Redox potential changes from oxidizing to reducing with depth below the water table; this may act as a solubility control and limit vertical migration of redox-sensitive contaminants (e.g., uranium and technetium-99). The fine size fraction in the aquifer matrix shows some tendency to sorb cations.

- There are four general routes (i.e., ingestion, inhalation, direct contact, and external) by which humans and biota can be exposed to contaminated groundwater. Ingestion is assumed to represent the primary exposure route for humans because the risk from ingestion exceeds the risk of other exposure routes. Direct contact and external exposure are assumed to be the primary exposure routes for biota.

4.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA requires that remedial actions attain all applicable or relevant and appropriate requirements (ARARs) embodied in federal or state environmental laws unless a waiver of such standard is invoked. Potential ARARs for the 200-UP-1 Groundwater Operable Unit are identified in the 200 West AAMSR (DOE-RL 1993a) and are incorporated by reference in this LFI. The ARARs provide the standards that potentially may be applied to cleanup. Chemical-specific standards for the refined contaminants of concern are identified in Tables 4-1 and 4-2. Location-specific ARARs are shown in Table 4-3.

Water Quality Standards for Waters of the State of Washington (WAC 173-201A-040) for chromium are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River and salmon. The MCLs and maximum contaminant level goals prescribed in EPA's National Primary Drinking Water Regulations under the *Safe Drinking Water Act* are relevant and appropriate regulations for radioactive and nonradioactive constituents for the 200-UP-1 Operable Unit. Proposed MCLs are not ARARs; however, the progress of the proposed rulemaking should be monitored in the event that these become final standards. An appropriate standard that may be applicable to uranium and drinking water is the *Uranium Mill Tailings Radiation Control Act*. The MTCA (WAC 173-340) defines groundwater and surface water standards and is relevant and appropriate. Location-specific ARARs are identified to address the presence of threatened or endangered species and archaeological resources.

Table 4-1. Ambient Water Quality Criterion.

Chemical	National Ambient Water Quality Criterion (µg/L)	
	Acute	Chronic
Chromium III	1,700	210
Chromium VI	16	11

Table 4-2. Potential Chemical-Specific ARARs.

Refined COPC	Safe Drinking Water Act				MTCA B (groundwater/ surface water)[e]	MTCA C (groundwater)[f]
	Primary MCL[a]	MCLG[b]	Secondary MCL[c]	Proposed MCL[d]		
1, 2-Dichloroethane	5				.481/59.4	4.81
1, 1-Dichloroethylene	7	7			.0729/1.93	.729
Carbon tetrachloride	5				.337/2.66	3.37
Chloroform					7.17/283	71.7
Trichloroethylene	5				3.98/55.6	39.8
Iodine-129	0.48			21		
Potassium-40	295[g]					
Strontium-90	8			42		
Technetium-99	900			3790		
Uranium	44[h]			20 (30 pCi/L)	48/-	
Arsenic	50				0.05/.0842	.500
Cadmium	5	5			8/20.3	17.5
Chromium	100	100			80/810	175
Fluoride	4,000	4,000			960/-	2,100
Selenium	50	50			80/-	175

NOTE: Units for radionuclides in pCi/L; all other units in µg/L.

[a] 40 CFR 141.16 (radionuclides) as amended at 41 FR 28404, July 9, 1976; 40 CFR 141.61(organics) as amended at 59 FR 34324, July 1, 1994; 40 CFR 141.62 (inorganics) as amended at 60 FR 33932, June 29, 1995.

[b] 40 CFR 141.50 as amended at 57 FR 31846 July 17, 1992, and 40 CFR 141.51 as amended at 60 FR 33932, June 29, 1995.

[c] 40 CFR 143.3 as amended at 56 FR 3597 January 30, 1991 - TBC under federal regulations, possible ARAR under MTCA

[d] 56 FR 33050 - 33127 July 18, 1991 - Proposed Rule TBC.

[e] WAC 173-340-720, MTCA, Groundwater Cleanup Standards, Method B, and WAC 173-340-730, Surface Water Cleanup Standards, Method B.

[f] WAC 173-340-720 , MTCA, Groundwater Cleanup Standards, Method C.

[g] Based on Federal Guidance report, EPA 520/1-88-020, September 1988.

[h] 40 CFR 192.02, Uranium Mill Tailings Radiation Control Act.

ARAR = applicable or relevant and appropriate requirement
CFR = *Code of Federal Regulations*
COPC = contaminant of potential concern
EPA = U.S. Environmental Protection Agency
FR = *Federal Register*
MCLG = maximum contaminant level goal
MCL = maximum contaminant level
MTCA = *Model Toxics Control Act*
RCRA = *Resource Conservation and Recovery Act*
WAC = *Washington Administrative Code*

Table 4-3. Location-Specific ARARs.

Description	Citation	Applicable/ Relevant and appropriate	Requirements	Remarks
Archaeological and Historical Preservation Act of 1974	16 USC 469	Applicable	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	Applicable when remedial action threatens significant scientific, prehistorical, historical, or archaeological data.
Endangered Species Act of 1973	16 USC 1531 et seq.		Prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival.	
Fish and Wildlife Services List of Endangered and Threatened Wildlife and Plants	50 CFR 17, 222, 225, 226, 227, 402, 424	Applicable	Requires identification of activities that may affect listed species. Actions must not threaten the continued existence of a listed species or destroy critical habitat.	Requires consultation with the Fish and Wildlife Service to determine if threatened or endangered species could be impacted by activity.
Historic Sites, Buildings, and Antiquities Act	16 USC 461	Applicable	Establishes requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts to such resources must be mitigated.	
National Historic Preservation Act of 1966, as amended	16 USC 470 et seq.	Applicable	Prohibits impacts on cultural resources. Where impacts are unavoidable, requires impact mitigation through design and data recovery.	Applicable to properties listed in the National Register of Historic Places, or eligible for such listing. B Reactor is listed on the Register.
Wild and Scenic Rivers Act	16 USC 1271	Applicable	Prohibits federal agencies from recommending authorization of any water resource project that would have a direct and adverse effect on the values for which a river was designated as a wild and scenic river or included in a study area.	The Hanford Reach of the Columbia River is under study for inclusion as a wild and scenic river.

5.0 SUMMARY OF RISK ASSESSMENT

A risk assessment was performed to quantify human health risks associated with potential exposure to the high-priority groundwater contaminants. This risk assessment was conducted in accordance with the methodology presented in the *Risk-Based Decision Analysis for 200 Area Groundwater Operable Units* (RBDA) (BHI 1995b). The RBDA methodology assesses, through sample-specific risk characterization, the spatial distribution of risk for current and future plume conditions. Analytical fate and transport modeling was used to evaluate the migration of 200-UP-1 high-priority contaminants in groundwater in order to characterize risk at future downgradient exposure locations. The technical approach for the identification of contaminants of potential concern (COPC) based on risk followed the procedure defined in the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1995c). The exposure assessment and calculation of risk also followed the HSRAM methodology.

Although the RI/FS work plan (DOE-RL 1994c) specifies the use of the risk assessment methodology for performing the risk assessment, the RBDA, which has been developed since the work plan was written, provides a more realistic depiction of risk distribution within a plume and also provides analytical tools for estimating future risks as the plume migrates downgradient. Whereas the risk assessment methodology represents an entire plume by a single risk value based on the historical maximum contaminant concentrations, the RBDA preserves the spatial distribution of contaminants throughout the risk analysis, allowing risk contours to be plotted for both current conditions and for projected future conditions as the plume migrates. Thus, the RBDA provides more accurate information from which to base IRM decisions.

This section summarizes the results of the risk assessment, which is provided in Appendix A.

5.1 RISK ASSESSMENT OBJECTIVES

The purpose of this effort was to quantify risk from potential exposure to high-priority contaminants in groundwater as a factor in establishing the need for interim actions. The following are the objectives of the 200-UP-1 risk assessment:

- Quantify current and future human health risks due to exposure to high-priority contaminants
- Identify which of the high-priority groundwater contaminants are the primary contributors to current and future risk
- Identify the current location and extent of groundwater containing chemicals or radionuclides that contribute to elevated levels of current or future risk.

5.2 OVERVIEW OF RISK ASSESSMENT PROCESS

The principal groundwater chemistry data set used in the risk assessment included data collected during 1994 and 1995 that are considered representative of current conditions in the 200-UP-1 Groundwater Operable Unit. The initial step in the risk assessment was a screening process to focus the risk assessment on the significant risk contributors following the HSRAM (DOE-RL 1995c). High-priority groundwater contaminants were eliminated from further assessment if one of the following criteria were met:

- Contaminants with one-time detections that were subsequently confirmed as nondetections
- Contaminants with concentrations less than or equal to background threshold values
- Carcinogenic contaminants with maximum concentrations that do not exceed 1×10^7 incremental lifetime cancer risk (ILCR) and noncarcinogenic contaminants with maximum concentrations that do not exceed a hazard quotient of 0.1 using a residential groundwater ingestion scenario.

Contaminants retained after the screening process as COPCs were further assessed consistent with boundaries and exposure scenarios recommended by the Future Site Uses Working Group (FSUWG). Exposure scenarios include the following:

- A commercial/industrial groundwater ingestion scenario for current conditions at the 200-UP-1 Operable Unit[1]
- A commercial/industrial groundwater ingestion scenario at the FSUWG boundary for the Central Plateau referred to as the "hypothetical future-use boundary"[1]
- A residential groundwater ingestion scenario at the hypothetical future-use boundary as recommended by the FSUWG.[1]

Future COPC concentrations at the Columbia River were also predicted. The contaminant fate and transport modeling method used to estimate contaminant concentrations at the hypothetical future-use boundary and Columbia River is described in Appendix A.

Predicted concentrations at the Columbia River were also used to assess potential ecological impacts on the aquatic ecosystem. The ecological assessment was made by comparing the predicted maximum COPC concentration at the river to established freshwater quality

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[1] The commercial/industrial ingestion scenario is assumed for illustrative purposes only and provides a basis for evaluating remediation potential.

benchmarks. Benchmarks consist of surface water standards (i.e., ARARs) and advisory concentrations that were derived to be indicators of ecological risk.

5.3 SUMMARY OF HUMAN HEALTH RISKS

Results of the risk assessment are summarized in Tables 5-1 through 5-4. For current conditions (Table 5-1) only carbon tetrachloride is present in concentrations that correspond to a hazard quotient (noncarcinogenic risk) greater than 1. Carbon tetrachloride concentrations also result in the highest current-condition ILCR ($>1 \text{ x } 10^4$), which suggests significant risk.

Table 5-2 shows the predicted maximum COPC concentrations and corresponding risks at the hypothetical future-use boundary. Based on the shorter (northern) of two flow paths to the hypothetical future-use boundary, contaminant travel times were predicted to be between 100 and 11,900 years. Only carbon tetrachloride reaches the hypothetical future-use boundary at concentrations that correspond to significant noncarcinogenic risk (hazard quotient >1). Carbon tetrachloride is also the only contaminant that reaches the hypothetical future-use boundary at concentrations indicative of significant carcinogenic risk. The maximum concentrations of carbon tetrachloride, chloroform, arsenic, and iodine-129 at the hypothetical future-use boundary are predicted to exceed drinking water MCLs, MTCA B, or both standards. However, arsenic is not a COPC because its concentration does not exceed background.

Predicted maximum concentrations at the Columbia River are provided in Table 5-3. Table 5-4 summarizes risk assessment results for COPCs.

5.4 SUMMARY OF ECOLOGICAL RISKS

The ecological risk evaluation uses the maximum concentrations of COPC predicted to reach the Columbia River to conservatively assess risk. Risks were identified by comparing concentration at the river to established benchmarks for protection of aquatic life.

Table 5-5 shows the predicted maximum COPC concentration at the Columbia River and compares those values to water quality advisory standards. Unretarded travel times to the river are predicted to be between 410 and 47,600 years. Only carbon tetrachloride is predicted to reach the river at concentrations that may pose significant ecological risk. However, a comparison of concentration at the river with the National Ambient Water Quality Criterion (see Table 4-1) also identified chromium VI as a contributor to significant ecological risk. Chromium VI was eliminated as a potential contributor to risk based on investigations in the 100 Areas that suggest that dilution occurs within aquifer sediments near the river. Attenuation near the river in aquifer sediments would reduce the predicted concentration of chromium at the river below the established benchmark. A complete discussion of ecological risk is provided in Appendix A.

Table 5-1. Current-Condition Maximum Concentrations and Estimated Maximum Commercial/Industrial Groundwater Ingestion Risks[a].

Contaminant of Potential Concern	Current Maximum Concentration (µg/L, unless noted)[b]	Maximum Contaminant Level[c] (µg/L, unless noted)	Monitoring Well where Maximum Concentration is Observed	Hazard Quotient	Incremental Lifetime Cancer Risk
1,2-Dichloroethane	5.5	5	299-W22-20	NC[d]	1E-06
1,1-Dichloroethylene	3.2	7	299-W22-20	Not a COPC[e]	5E-06
Arsenic	18	50	299-W18-29	6E-01	8E-05
Cadmium	22	5	299-W19-91	4E-01	NC
Carbon tetrachloride	1,800	5	299-W18-21	3E+01	7E-04
Chloroform	29	7.17 or 71.7[f]	299-W19-18	3E-02	5E-07
Chromium VI	250	100	299-W22-20	0.5	NC
Fluoride	2,400	4,000	299-W19-30	4E-01	NC
Iodine-129	86.1[g]	0.48[g]	299-W22-9	ND[h]	8E-05
Potassium-40	142[g]	295	699-36-70A	ND	8E-06
Selenium	12.8	50	299-W19-19	3E-02	NA[i]
Strontium-90	71.3[g]	8[g]	299-W22-1	ND	1E-05
Technetium-99	2,260[g]	900[g]	299-W23-2	ND	1E-05
Trichloroethylene	33	5	299-W22-20	5E-02	1E-06
Uranium	118	44[j]	299-W22-21	ND	4E-06

[a] The individual contaminant risks presented in this table should not be summed to estimate total risk. This is because the risks are based on maximum concentrations that do not all occur at the same monitoring well location.

[b] Units are micrograms per liter, unless noted.

[c] Maximum contaminant levels (MCLs) for strontium-90 and nonradioactive contaminants of potential concern (COPCs) are from 40 CFR 141, Subparts B and G. The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127.

[d] Risk is not calculated because a toxicity value is not available for the chemical.

[e] Based on risk-based screening, 1,1-dichloroethylene is not a noncarcinogenic COPC.

[f] The MCL for chloroform is a risk-based standard derived from the WAC 173-340, Model Toxics Control Act–Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards. The first value given is for residential exposure and the second is for nonresidential exposure.

[g] Concentration units are picocuries per liter.

[h] As per the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995c), radionuclides are not noncarcinogenic COPCs.

[i] The U.S. Environmental Protection Agency has determined that selenium is not classifiable as to human carcinogenicity.

[j] 40 CFR 192.02, Uranium Mill Tailings Radiation Control Act.

Table 5-2. Predicted Analytical Model of Maximum Concentrations and Groundwater Ingestion Risk at the Hypothetical Future-Use Boundary Using the Northern Flow Path.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)	Maximum Contaminant Level[a] (µg/L, unless noted)	Travel Time (years)	Commercial/ Industrial Exposure Scenario		Residential Exposure Scenario	
				Hazard Quotient	ILCR	Hazard Quotient	ILCR
1,2-Dichloroethane	0.051	5	115	NC[b]	1E-08	NC	6E-08
1,1-Dichloroethylene	0.046	7	145	Not a COPC[c]	8E-08	Not a COPC	3E-07
Arsenic	3.3	50	105	1E-01	1E-05	7E-01	6E-05
Cadmium	0.12	5	8,830	2E-03	NC	2E-02	NC
Carbon tetrachloride	670	5	160	9E+00	2E-04	6E+01	1E-03
Chloroform	18	7.17 or 71.7[d]	105	2E-02	3E-07	1E-01	1E-06
Chromium VI	25	100	95	0.05	NC	0.3	NC
Fluoride	290	4,000	100	5E-02	NC	3E-01	NC
Iodine-129	24[e]	0.48[e]	100	ND[f]	2E-05	ND	1E-04
Potassium-40	39[e]	295	100	ND	2E-06	ND	9E-06
Selenium	0.11	50	105	2E-04	NA[g]	1E-03	NA
Strontium-90	0[e]	8[e]	11,700	ND	0E+00	ND	0E+00
Technetium-99	100[e]	900[e]	105	ND	7E-07	ND	3E-06
Trichloroethylene	2.2	5	175	4E-03	7E-08	2E-02	3E-07
Uranium	5.1	44[h]	635	ND	2E-07	ND	7E-07

ILCR = incremental lifetime cancer risk
NA = not available
ND = not detected

[a] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from 40 CFR, Subparts B and G. The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127.

[b] Risk is not calculated because a toxicity value is not available for the chemical.

[c] Based on risk-based screening, 1,1-dichloroethylene is not a noncarcinogenic COPC.

[d] The MCL for chloroform is a risk-based standard derived from WAC 173-340, Model Toxics Control Act-Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards). The first value given is for residential exposure and the second is for nonresidential exposure.

[e] Concentration units are picocuries per liter.

[f] As per the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995c), radionuclides are not noncarcinogenic COPCs.

[g] The U.S. Environmental Protection Agency has determined that selenium is not classifiable as to human carcinogenicity.

[h] 40 CFR 192.02, Uranium Mill Tailings Radiation Control Act.

Table 5-3. Predicted Analytical Model of Maximum Concentrations at the Columbia River Using the Northern Flow Path.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)[a]	Maximum Contaminant Level[b] (µg/L, unless noted)	Travel Time (years)
1,2-Dichloroethane	0.024	5	465
1,1-Dichloroethylene	0.022	7	585
Arsenic	1.6	50	425
Cadmium	0.058	5	35,900
Carbon tetrachloride	370	5	680
Chloroform	11	7.17 or 71.7[c]	465
Chromium VI	13	100	410
Fluoride	140	4,000	420
Iodine-129	12[d]	21[d]	420
Potassium-40	20[d]	295	420
Selenium	0.049	50	430
Strontium-90	0[d]	8[d]	47,600
Technetium-99	46[d]	3,790[d]	430
Trichloroethylene	1.1	5	705
Uranium	2.5	44[e]	2,700

[a] No mixing or river dilution is taken into account.
[b] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from 40 CFR, Subparts B and G. The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127.
[c] The MCL for chloroform is a risk-based standard derived from WAC 173-340, *Model Toxics Control Act—Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards*. The first value given is for residential exposure and the second is for nonresidential exposure.
[d] Concentration units are picocuries per liter.
[e] 40 CFR 192.102, Uranium Mill Tailings Radiation Control Act.

Table 5-4. Summary of Risk Assessment for the 200-UP-1 Limited Field Investigation.

Contaminant of Potential Concern	Risk Assessment Results
1,2-Dichloroethane	Detected at only one monitoring well; not a significant contributor to risk.
1,1-Dichloroethylene	Detected at only one monitoring well; not a significant contributor to risk.
Arsenic	Very few detections above the background threshold value; not a significant contributor to risk.
Cadmium	Detected above the background threshold value at only one monitoring well; not a significant contributor to risk.
Carbon tetrachloride	Detected in relatively high concentrations; predominant contributor to current- and future-condition carcinogenic and noncarcinogenic risk.
Chloroform	Widespread detections; not a major contributor to risk.
Chromium	Many detections; if present predominantly as hexavalent chromium; not a significant contributor to risk.
Fluoride	Widespread detections; not a significant contributor to risk.
Iodine-129	Present as well-defined plume; where present, iodine-129 is a contributor to current- and future-condition carcinogenic risk, second only to carbon tetrachloride.
Potassium-40	Widespread detections, very consistent concentrations; not a significant contributor to total carcinogenic risk.
Selenium	Very few detections above the background threshold value; not a significant contributor to risk.
Strontium-90	A few detections contribute to current-condition carcinogenic risk; due to strong sorption and relatively rapid radioactive decay, should not reach the hypothetical future-use boundary.
Technetium-99	A few detections contribute to current-condition carcinogenic risk; not a significant contributor to total future-condition carcinogenic risk.
Trichloroethylene	Not a significant contributor to total current-condition risk; not a significant contributor to future-condition risk.
Uranium	Not a significant contributor to total current-condition carcinogenic risk; not a significant contributor to future-condition risk.

Table 5-5. Ecological Risk-Based Screening Ambient Water Quality Advisory Values.

Chemical	Predicted Maximum Concentration at Columbia River[a] (µg/L unless otherwise noted)	National Ambient Water Quality Criterion Advisory Values[b] - Acute (µg/L unless otherwise noted)	National Ambient Water Quality Criterion Advisory Values[b] - Chronic (µg/L unless otherwise noted)	Tier 2 Secondary Acute Value[c] (µg/L)	Tier 2 Secondary Chronic Value[c] (µg/L)	Estimated Dose to Small Insects and Larvae at Max. Conc. (µGy/h)[d]	DOE Order 5400.5 DCG (pCi/L)	Ecological Criteria/ Advisory Exceeded?
Carbon tetrachloride	370	690	63	4,090	229			Yes
Chloroform	11	570	14	3,360	188			No
1,2-Dichloroethane	0.024	2,300	144	13,500	1,100			No
1,1-Dichloroethylene	0.022	590	15	3,520	196			No
Iodine-129	12 pCi/L	NA	NA			6.7E-4	500	No
Potassium-40	20 pCi/L	NA	NA			1.2	7,000	No
Technetium-99	46 pCi/L	NA	NA			2E-3	100,000	No
Trichloroethylene	1.1	880	55	43,50	465			No

[a] Predicted concentrations assume no mixing or dilution from the river.
[b] National Ambient Water Quality Criterion Advisory Values based on Sutter et al. (1992)--No promulgated values.
[c] Concentrations that would be expected to be higher than the NAWQC in no more than 20% of the cases. Values are based upon the method described in EPA's Proposed Water Quality Guidance for the Great Lakes System.
[d] DOE Aquatic Biota Guideline Dose Limit = 400 µGy/h.
DCG = Derived Concentration Guideline.

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

Waste disposal practices in the 200 West Area impact the groundwater in the 200-UP-1 Operable Unit. Thirteen of twenty-six high-priority groundwater contaminants were detected in the 200-UP-1 Operable Unit that exceed *Safe Drinking Water Act*, MTCA, and *Uranium Mill Tailings Radiation Control Act* groundwater standards. High-priority contaminants exceeding groundwater standards include 1,1-dichloroethene, 1,2-dichloroethane, arsenic, cadmium, carbon tetrachloride, chloroform, chromium, fluoride, iodine-129, strontium-90, technetium-99, trichloroethene, and uranium. The distribution of these contaminants in groundwater occurs as well-defined plumes and sporadic occurrences. The distribution of the remaining 13 contaminants is characterized as undetects, one-time detections, below background, or below applicable groundwater standards. Impact is reflected by water-table elevation, flow direction, and gradient changes. The vertical extent of contamination is generally less than 30 m (100 ft) below the water-table surface and correlative to unsealed monitoring wells. Only carbon tetrachloride was detected in the confined aquifer at elevated levels.

The risk assessment addresses current and future risk associated with exposure to chemical and radionuclides in the groundwater. The commercial/industrial and residential ingestion scenarios were employed to estimate risks. Application of the risk assessment suggests that the predominant current and future risks are attributed to carbon tetrachloride. Current conditions suggest there is significant noncarcinogenic risk due to carbon tetrachloride (i.e., HQ is 30). There is also significant carcinogenic risk because the ILCR is greater than 1×10^{-4}. Only carbon tetrachloride will reach the hypothetical future-use boundary at concentrations indicative of significant noncarcinogenic and carcinogenic risk. The maximum concentration of carbon tetrachloride predicted to reach the hypothetical future-use boundary will exceed the MCL and the MTCA groundwater standards for residential and industrial exposure scenarios. The maximum concentration of iodine-129 predicted to reach the hypothetical future-use boundary will exceed the MCL. The maximum concentration of chloroform and arsenic predicted to reach the hypothetical future-use boundary will exceed MTCA standards.

A qualitative evaluation of ecological risk was performed using a benchmarking method to assess potential ecological effects on aquatic life. The analysis suggests that carbon tetrachloride may present a future unacceptable ecological risk to aquatic life when the plume eventually reaches the river. The evaluation also suggests that the concentration of chromium at the river also indicates significant risk to aquatic life. However, chromium was eliminated as a COPC because dilution within near-shore aquifer sediments was not considered in the analysis. Investigation in the 100 Areas of the Hanford Site suggests that dilution in near-shore aquifer sediments would reduce chromium concentrations to below the established benchmark.

6.2 RECOMMENDATIONS

6.2.1 Carbon Tetrachloride

Carbon tetrachloride is the primary contributor to future human health (ILCR 1 x 10^{-3}) and ecological risk associated with 200-UP-1 Operable Unit groundwater. Simplified analytical modeling suggests that this contaminant will exceed the MCL and MTCA groundwater standards at the hypothetical future-use boundary and the ambient water quality criterion at the Columbia River. More comprehensive numerical modeling is being performed to predict migration of sitewide plumes, including carbon tetrachloride, and is being documented separately.

An IRM should be initiated in the 200-UP-1 Operable Unit for remediation of carbon tetrachloride based on the LFI investigation. However, because the carbon tetrachloride plume is part of a larger and more contaminated plume in the adjacent 200-ZP-1 Operable Unit, it is recommended that carbon tetrachloride be addressed as part of a 200 West Area-wide problem. Specifically, carbon tetrachloride is deferred to 200-ZP-1 remedial efforts.

6.2.2 Other Contaminants of Potential Concern

Excluding carbon tetrachloride, 12 COPCs (1,1-dichloroethene, 1,2-dichloroethane, arsenic, cadmium, chloroform, chromium, fluoride, iodine-129, strontium-90, technetium-99, trichloroethene, and uranium) were identified in the 200-UP-1 Operable Unit that exceed applicable ARARS. In addition, an evaluation of future conditions suggests that three of these contaminants (chloroform, arsenic, and iodine-129) may reach the hypothetical future-use boundary at concentrations that exceed ARARS. As indicated previously, human health and ecological risks associated with these contaminants, based on the exposure scenarios and boundaries presented in this report, are not significant. Therefore, they will not continue along the IRM pathway. However, discontinuance along the IRM pathway does not terminate the requirement to clean up these contaminants in the groundwater. Cleanup actions applicable to the subject 12 COPCs are deferred to the final remedy selection phase for the operable unit. Deferment of these contaminants to final remedy selection is consistent with the *Hanford Past-Practice Strategy* (DOE-RL 1991).

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APPENDIX A

200 NATIONAL PRIORITIES LIST AGREEMENT/ CHANGE CONTROL FORM

Control Number:

200 NPL Agreement/Change Control Form

__ Change _X Agreement __ Information

Operable Unit(s): 200-UP-1

Date Submitted:

Sept. 01, 1994

Date Approved:

Document Number/Title:

200-UP-1 Characterization Drilling Description of Work.

Date Document Last Issued:
3/31/94

Originator:
CD Wittreich

Phone: 376-1862

SUBJECT: COMPLETION OF 200-UP-1 OPERABLE UNIT WELLS UP1-3 AND UP1-4

As identified in the 200-UP-1 Characterization Drilling Description of Work, WHC-SD-EN-AP-151, planned Well 299-W19-34C (UP1-4) may not be constructed if uranium, technetium and nitrate contamination is not encountered in Well 299-W19-34B (UP1-3). Criteria were developed on which to base the decision to proceed with or not to proceed with the construction of Well UP1-4. This decision criteria and a revised well construction/sampling program for UP1-3 (Attachment A) was agreed to by Ecology, EPA and DOE Unit Managers during a 6/28/94 meeting and subsequently presented at the July Unit Managers Meeting. In summary, Well UP1-3 was to be extended into the confined aquifer to basalt. Based on field and lab analyses of groundwater samples above and below the Ringold Lower Mud, a decision would be made on the need to have a permanent monitoring well in the confined aquifer.

Ecology, EPA and DOE Unit Managers for Groundwater Operable Unit 200-UP-1 agree that Well UP1-3 should be backpulled and screened above the Lower Mud and that Well UP1-4 will not be installed based on data collected to date from Well UP1-3.

In addition, Ecology, EPA, and DOE Unit Managers agree that one final groundwater sample will be collected for CLP analysis and slug test will be conducted near the top of basalt (~553 ft) prior to backpulling Well UP1-3.

Justification and Impact of Change:

Ecology, EPA and DOE Unit Managers for Groundwater Operable Unit 200-UP-1 agree that Well UP1-3 should be backpulled and screened above the Lower Mud and that Well UP1-4 is not required for the following reasons:

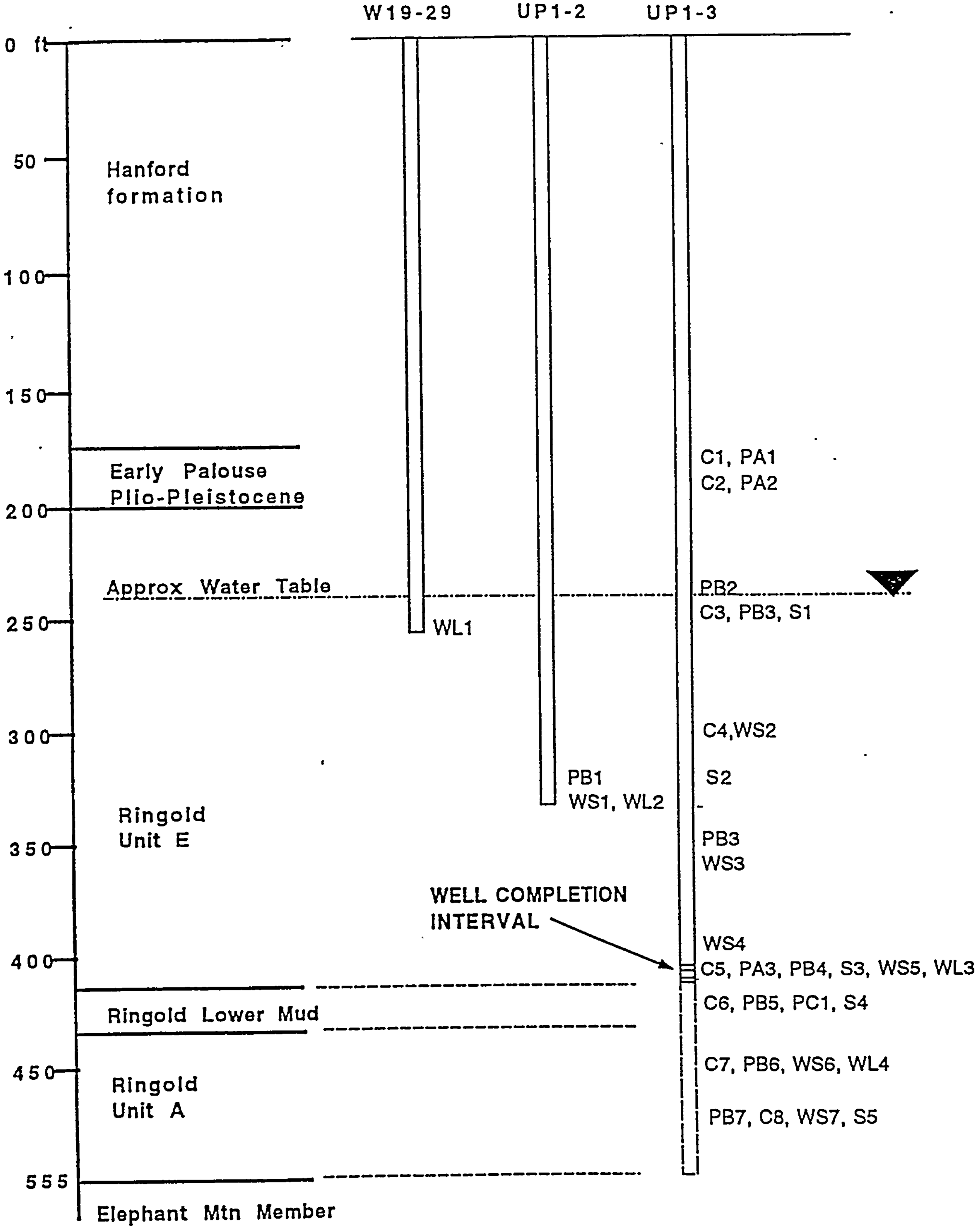
- Groundwater analyses within the confined aquifer (WS6, WL4, & WS7 of Attachment A) indicate no IRM contamination for which the well was drilled. However, very low levels of carbon tetrachloride and chloroform were detected. Based on laboratory analyses (WL4), carbon tetrachloride and chloroform levels were observed at 5 ppb at the upper portion of the confined aquifer (461 ft). Subsequent field analyses on groundwater samples taken at 517 ft (WS7) did not detect carbon tetrachloride or chloroform.

- The well cannot be completed at the bottom of the confined aquifer due to technical problems. Heaving sands are encountered in this zone.

- The data quality objectives (aquifer properties and soil chemistry) identified in the work plan have been meet with the characterization data collected to date.

WHC Operable Unit Coordinator	Date 10/5/94
DOE Unit Manager	Date 10/5/94
Ecology Unit Manager	Date 10/10/94
Amp for Dave Einan per Telecon Env. Protection Agency Unit Manager	Date 10/5/94

Per Action Plan for Implementation of the Hanford Consent Order and Compliance Agreement Section 9.3.



PA = Physical A
PB = Physical B
PC = Physical C
C = Chemical

WS = Groundwater Screening
WL = Groundwater Lab
S = Slug Test

Control Number: BHI-00419	200 NPL Agreement/Change Control Form __ Change _X Agreement __ Information Operable Unit: 200-UP-1 Groundwater	Date Submitted: May 23, 1995 Date Approved:

Document Number/Title: 200-UP-1 Groundwater Operable Unit IRM	Date Document Last Issued: N/A
Originator: C. D. Wittreich	Phone: 372-9315

Agreement:

Ecology, EPA, and DOE Unit Managers agree to defer the installation of 5 characterization wells from the FY 95 work scope. This scope will be replaced with installation of up to six new injection/extraction/monitoring wells in support of the 200-UP-1 pump and treat interim remedail measure.

Justification and Impact of Change:

The installation of new IRM wells will be used to validate the conceptual IRM designs (e.g., capture zone and aquifer response), and focus 200-UP-1 resources on activities identified in the IRM Proposed Plan with a bias for action per the Hanford Past Practice Strategy. This action is consistent with TPA change number M-13-93-03 which identifies that the pump and treat system will be modified during treatability and remediation phases to optimize cleanup activities.

Accelerating the IRM would require that characterization activities of the non-IRM plumes, within 200-UP-1, be deferred. The three parties will work together to revise the schedule for completion of the Limited Field Investigation as established within the RI/FS Work Plan for the 200-UP-1 Groundwater Operable Unit.

ERC Project Manager	Date 5/31/95
DOE Unit Manager Donna Wanek	Date 5/31/95
Ecology Unit Manager	Date 5/31/95
Env. Protection Agency Unit Manager	Date 31 May 95

Per Action Plan for Implementation of the Hanford Consent Order and Compliance Agreement Section 9.3.

Control Number: BHI-00166	200 NPL Agreement/Change Control Form __ Change _X Agreement __ Information Operable Unit: 200-UP-1 Groundwater	Date Submitted: Novenber 17, 1994; Revised January 23, 1995 Date Approved: January 24, 1995
Document Number/Title: 200-UP-1 Operable Unit Groundwater Monitoring		Date Document Last Issued: N/A
Originator: C. D. Wittreich		Phone: 376-1862

Agreement:

Only three quarters of data will be required to prepare the IRM Proposed Plan. The new wells installed in 1994 will continue to be sampled/monitored in 1995.

Justification and Impact of Change:

There will be no impact to the project. Ecology, EPA, and DOE Unit Managers agree that three quarters of groundwater monitoring data is sufficient to support the IRM Proposed Plan.

ERC Project Manager	Date 1/24/95
DOE Unit Manager Donna Wanek	Date 1/23/95
Ecology Unit Manager	Date 1/23/95
Env. Protection Agency Unit Manager	Date 23 Jan 95

Per Action Plan for Implementation of the Hanford Consent Order and Compliance Agreement Section 9.3.

APPENDIX B

RISK ASSESSMENT

APPENDIX B

RISK ASSESSMENT

1.0 INTRODUCTION

This appendix presents the results of a risk assessment conducted to estimate potential human health and ecological risks associated with exposure to chemicals and radionuclides in groundwater in the 200-UP-1 Groundwater Operable Unit. The 200-UP-1 Groundwater Operable Unit Remedial Investigation/Feasibility Study (RI/FS) addresses potential groundwater contamination underlying the 200 West Area U Plant and S Plant Aggregate Areas (southern half of the 200 West Area) at the U.S. Department of Energy (DOE) Hanford Site. The general location of the 200-UP-1 Groundwater Operable Unit is shown in Figure B-1.

Within the 200-UP-1 Groundwater Operable Unit, portions of groundwater contaminant plumes with high concentrations of uranium and technetium-99 have been designated for an Interim Remedial Measure (IRM), and peripheral, lower concentration plumes have been identified for a Limited Field Investigation (LFI). This risk assessment addresses the LFI plumes and does not address the IRM plumes. A risk assessment for the IRM portions of the uranium and technetium-99 plumes has been performed previously (Appendix B of BHI 1996) and is not discussed in this appendix.

This risk assessment was conducted in accordance with the methodologies presented in the *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1995) and the *Risk-Based Decision Analysis for Groundwater Operable Units* (RBDA) (BHI 1995). The technical approach for the identification of contaminants of potential concern (COPC) follows the procedure defined in the HSRAM. The exposure assessment and calculation of risk also follows the HSRAM methodology. The RBDA methodology assesses, through sample-specific risk characterization, the spatial distribution of risk for current and future plume conditions. Analytical fate and transport modeling is used to evaluate the migration of 26 high-priority groundwater contaminants in order to characterize risk at future downgradient exposure locations. For estimation of both current and future risk, this risk assessment assumes no remediation of the high-priority groundwater contaminants. Thus, risks presented are baseline risks; however, as discussed above, this risk assessment does not include the IRM portions of the uranium and technetium-99 plumes in the 200-UP-1 Groundwater Operable Unit.

This appendix is organized as follows: Chapter 2.0 presents the purpose, scope, and objectives of the risk assessment. Chapter 3.0 identifies the COPCs. The exposure assessment methodology and human toxicity data are given in Chapter 4.0, and Chapter 5.0 presents the human-health risk characterization. Chapter 6.0 presents the results of the ecological risk screening. Chapter 7.0 summarizes the risk assessment and provides pertinent conclusions.

2.0 PURPOSE, SCOPE, AND OBJECTIVES

The purpose of this work is to calculate potential risk due to exposure to 26 high-priority groundwater contaminants in groundwater and to support the identification and implementation of IRMs for the COPCs, if needed.

This risk assessment is limited to 26 chemicals and radionuclides that have been detected in groundwater samples collected from the uppermost portion of the unconfined aquifer beneath the southern half of the 200 West Area. The 26 high-priority groundwater contaminants identified in the RI/FS Work Plan for the 200-UP-1 Groundwater Operable Unit (DOE-RL 1994) are as follows:

- 1,2-dichloroethane
- 1,1-dichloroethylene
- 4,4'-DDD
- 4,4'-DDT
- aldrin
- arsenic
- bis(2-ethylhexyl)phthalate
- cadmium
- carbon tetrachloride
- chloroform
- chromium
- dieldrin
- endrin
- endrin aldehyde
- fluoride
- gamma-BHC
- heptachlor
- iodine-129
- n-Nitrosodimethylamine
- plutonium-238
- potassium-40
- selenium
- strontium-90
- technetium-99
- trichloroethylene
- uranium.

As discussed in Chapter 1.0, the portions of the uranium and technetium-99 plumes that are addressed by an IRM are not considered in this risk assessment. However, areas of uranium and technetium-99 contamination within the 200-UP-1 Groundwater Operable Unit that are not addressed by the IRM are included in this risk assessment. The groundwater chemistry data used in the risk assessment are maximum concentrations collected during 1994 and 1995. This data set provided enough groundwater chemistry information to perform the risk assessment, i.e., the number of monitoring wells sampled, the number of samples collected, and the list of analytes were sufficient to estimate the spatial distribution and magnitude of potential current and future risk for exposure to the high-priority groundwater contaminants. In addition, the data were collected recently and are therefore representative of current conditions in the 200-UP-1 Groundwater Operable Unit.

The objectives of the risk assessment are as follows:

- To calculate potential current and future human health risks due to exposure to LFI contaminants in 200-UP-1 Operable Unit groundwater assuming that no remediation occurs
- To screen for potential future ecological effects at the Columbia River due to natural discharge into the river of groundwater containing high-priority contaminants
- To identify which of the high-priority groundwater contaminants are the primary contributors to current and future risk
- To identify the current location and extent, within the 200-UP-1 Groundwater Operable Unit, of groundwater containing chemicals or radionuclides that contribute to elevated-levels of current or future risk.

3.0 IDENTIFICATION OF CONTAMINANTS OF POTENTIAL CONCERN

As discussed in Chapter 2.0, 26 chemicals and radionuclides were detected in groundwater from the 200-UP-1 Groundwater Operable Unit. All 26 high-priority groundwater contaminants may not be detrimental to human health or the environment. To expedite the risk assessment, contaminants that are not detrimental to human health or the environment at the levels observed in 200-UP-1 Operable Unit groundwater are eliminated from further consideration in the risk assessment process. This chapter documents the identification of COPCs for the high-priority contaminant risk assessment.

3.1 METHODOLOGY

The COPC screening process used in this risk assessment follows methodology defined in the HSRAM (DOE-RL 1995). The process is as follows:

- **Elimination of One-Time Detections.** If a contaminant was detected only once in groundwater samples collected during 1994 and 1995 from a given monitoring well, the contaminant was eliminated as a COPC at that well. For this step in the screening process, in addition to 1994 and 1995 data, 1990 through 1993 groundwater chemistry data were included. Including the 1990 through 1993 data is conservative, because more data were retained than would have otherwise been possible if only the 1994/1995 data set was used. A one-time detection was not eliminated if that detection was obtained from the only time the analysis was performed on a groundwater sample from a given monitoring well. Thus, to qualify for elimination, one-time detections had to be confirmed by nondetections of the same contaminant in samples collected at other times from the same monitoring well.

- **Elimination of Nondetections and Retention of Maximum Concentrations.** In addition to eliminating one-time detections, all nondetections were removed from the data set. Also, where a contaminant was detected repeatedly at a given monitoring well during 1994 and 1995, only the maximum concentration was retained for the risk assessment.

- **Comparison to Background.** Concentrations of inorganic and radioactive contaminants that were less than or equal to background threshold values were eliminated from further consideration in the risk assessment. The background threshold values for inorganic compounds and uranium used in the comparison are from the *Hanford Site Groundwater Background* report (DOE-RL 1992a). The background threshold values for radionuclides other than uranium were arithmetic mean concentrations calculated for samples collected from monitoring wells located hydrologically upgradient of the 200-UP-1 Groundwater Operable Unit and upgradient of any suspected sources of contamination. The background for organic compounds was assumed to be zero. Although concentrations less than or equal to background threshold values were removed from the data set, some of these data were still used to support the delineation of plumes and sources for fate and transport modeling.

- **Risk-Based Screening.** Using the residential groundwater ingestion scenario defined in the HSRAM (DOE-RL 1995), a screening risk was computed for the maximum concentration of each contaminant in the remaining 200-UP-1 Groundwater Operable Unit data set. Residential intake and risk were computed with the same equations used in the risk assessment; the exposure factors and toxicity values for the calculations are presented in Chapter 4.0. Carcinogenic contaminants with maximum concentrations that do not exceed 1 x 10^{-7} incremental lifetime cancer risk (ILCR) were eliminated, and noncarcinogenic contaminants with maximum concentrations that do not exceed a hazard quotient of 0.1 were eliminated.

3.2 CONTAMINANTS OF POTENTIAL CONCERN

Table B-1 presents the results of the COPC screening process. Of the 26 high-priority groundwater contaminants, 15 qualified as COPCs for this risk assessment. Of the contaminants removed from further consideration in the risk assessment, most were eliminated because they were detected only once at a monitoring well (Table B-1). No contaminant was entirely removed from the risk assessment by comparison with background, although some individual detections of arsenic, cadmium, chromium, fluoride, selenium, and uranium were removed during the background comparison step (Table B-1). Only 1,1-dichloroethylene was eliminated as a noncarcinogenic COPC by risk-based screening (Table B-1). Current-condition concentration maps are presented in Attachment B.1 of this appendix for 11 of the 15 COPCs. Maps were not prepared for 1,2-dichloroethane, 1,1-dichloroethylene, cadmium, or selenium because these COPCs were detected at only one or very few monitoring wells.

4.0 EXPOSURE AND TOXICITY ASSESSMENT

This chapter presents the groundwater exposure scenarios for the risk assessment and the data used to calculate COPC intake. The toxicity values used to convert human receptor intake to risk are also presented.

4.1 CURRENT-CONDITION EXPOSURE

The commercial/industrial groundwater ingestion scenario defined in the HSRAM (DOE-RL 1995) was used to estimate current-condition risks for the 200-UP-1 Groundwater Operable Unit. This scenario assumes that a human receptor working in the 200 West Area receives 1 L of water per day from the portion of the underlying aquifer contaminated with LFI COPCs. Using the HSRAM methodology, intake of COPCs was calculated at each monitoring well location. Table B-2 presents the exposure factors used to calculate intake of COPCs via the commercial/industrial ingestion scenario, and Figure B-2 shows the location of the monitoring wells at which current-condition risks were estimated.

To simplify the risk assessment, groundwater ingestion was assumed to represent the primary exposure route, because for most of the COPCs, the risk due to direct ingestion greatly exceeds the risks from other exposure routes. There is no current or planned use of groundwater from the 200-UP-1 Operable Unit for human consumption. The commercial/industrial ingestion scenario is hypothetical and is assumed for illustrative purposes only; it provides a basis for evaluating remediation potential. Use of this scenario does not imply that the DOE is advocating human consumption of groundwater from the 200-UP-1 Groundwater Operable Unit.

4.2 FUTURE-CONDITION EXPOSURE

Both the commercial/industrial and residential groundwater ingestion scenarios defined in the HSRAM (DOE-RL 1995) were used to estimate future condition risks for the 200-UP-1 Groundwater Operable Unit. Exposure factors used to calculate commercial/industrial and residential intake of LFI COPCs are listed in Table B-2. The receptors are assumed to be located at the boundary for the Central Plateau as recommended by the Future Site Uses Working Group (FSUWG). This boundary will be referred to as the "hypothetical future-use boundary." For the purposes of this risk assessment, the hypothetical future-use boundary is considered to be the dividing line between commercial/industrial land use and unrestricted use (recommended by the FSUWG). The commercial/industrial ingestion scenario was employed to provide direct comparison between current-condition and future-condition risk. The residential ingestion scenario was selected to provide conservative estimates of unrestricted land-use risk for exposure to COPCs migrating in groundwater from the 200 West Area. As with current-condition exposure, groundwater ingestion was assumed to represent the primary future exposure route, because for most of the COPCs, the risk due to direct ingestion greatly exceeds the risks from other exposure routes. Again, use of ingestion scenarios does not imply that the DOE is advocating human consumption of groundwater from the 200-UP-1 Groundwater Operable Unit.

To estimate risk at the hypothetical future-use boundary and to perform ecological risk screening at the Columbia River, COPC migration was simulated using the CONMIG[1] contaminant fate and transport model (Walton 1989). This two-dimensional analytical model simulated the transport of COPCs from the 200-UP-1 Groundwater Operable Unit to the hypothetical future-use boundary and the Columbia River. The hydrogeological and geochemical processes simulated by CONMIG were advection, dispersion, adsorption, and radiological decay. It was assumed that organic COPCs do not undergo degradation. Contaminant plumes were represented in the model as a group of point sources. The number, size (contaminant mass), strength (contaminant concentration), and location of the point sources were unique to each COPC and were based on the plume maps presented in Attachment 1 of this appendix. For the contaminants that were observed in only one or very few monitoring wells, professional judgment was used in developing the modeled point sources.

Transport directions for contaminants in the 200-UP-1 Operable Unit are uncertain because of the impact of dissipating groundwater mounds from artificial recharge centered in the 216-B-3 Pond System and other areas (DOE-RL 1992b, 1993). For this reason, the transport of COPCs was simulated for two separate flow directions, an eastern and a northern flow path.

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[1] CONMIG is not an approved Hanford Site Code per DOE-RL (1995).

Figure B-3 shows that the eastern flow path is approximately due east to the Columbia River. The northern groundwater flow path starts to the east and bends to the north, flowing through the gap between Gable Butte and Gable Mountain (Figure B-3). Along the eastern flow path, the distances to the hypothetical future-use boundary and the Columbia River are approximately 11,720 m (38,450 ft) and 26,840 m (88,050 ft), respectively. Along the northern flow path, the distances are approximately 8,640 m (28,360 ft) and 18,350 m (60,190 ft), respectively.

The assumptions inherent in the analytical fate and transport modeling are as follows.

- Groundwater flow is uniform and steady-state in one direction through an aquifer of infinite extent that is homogeneous and isotropic. Hydrogeological and geochemical properties are constant in time and space.
- There are no sources supplying contaminants to the aquifer and, therefore, the existing mass of COPCs in the aquifer (i.e., dissolved in groundwater and adsorbed) is the source for modeling.
- Contaminants are assumed to mix quickly in the vertical direction so that the concentration is essentially uniform with depth.

In the 200-UP-1 Groundwater Operable Unit, the aquifer containing COPCs is primarily within the fluvial gravel deposits of the Ringold Formation Unit E (DOE-RL 1994). The physical, hydrogeological, and geochemical data used in the fate and transport modeling are listed in Attachment B.2 of this appendix. Also presented in Attachment B.2 is a summary table for the COPC fate and transport modeling. Attachment B.3 of this appendix contains the predicted maximum concentrations of LFI COPCs at the Columbia River for both the eastern and northern groundwater flow paths.

4.3 TOXICITY DATA

Table B-3 presents the toxicity values used in this risk assessment to convert human receptor intake to risk. Consistent with the HSRAM methodology (DOE-RL 1995), the source of toxicity data for most COPCs is the U.S. Environmental Protection Agency's (EPA) *Integrated Risk Information System* (EPA 1996). The *Health Effects Assessment Summary Tables* (HEAST) (EPA 1994a) were the sources of radionuclide slope factors. The oral reference dose for trichloroethylene was obtained from the EPA Region IX Preliminary Remediation Goals Tables (EPA 1994b), and the slope factor for trichloroethylene was obtained from a communication with the EPA Superfund Health Risk Technical Support Center (EPA 1995a). Because all chromium data used in this risk assessment were from filtered groundwater samples, it was assumed that the chromium was hexavalent. For uranium, the slope factor for uranium-238 plus daughter products was used. This is conservative, because it is the largest of the uranium-isotope slope factors listed in the HEAST.

For carcinogenic COPCs, it is assumed that the probability of an additional cancer incidence as a result of exposure is linearly proportional to the intake. Thus, for an individual COPC, intake is multiplied by the slope factor to estimate the ILCR. Individual chemical ILCRs are summed at an exposure location to estimate the total ILCR at that location.

It is assumed that a threshold exists for noncarcinogenic health effects, and thus, for an individual COPC, intake is divided by the reference dose to estimate the hazard quotient. As this quotient increases toward unity, concern for the potential noncarcinogenic hazard of the contaminant increases. A value above unity is an indication of risk, although a direct correlation to the magnitude of the risk cannot be drawn. Similar to carcinogenic risk, individual chemical hazard quotients are summed at an exposure location to estimate the total hazard index at that location.

5.0 HUMAN-HEALTH RISK ASSESSMENT

This chapter presents the results of the human-health risk assessment. Both current-condition and future-condition risks are presented for the COPCs. In the following discussion, estimated risks are compared to specific values (e.g., hazard quotient of 1 or ILCR of 1 x 10^{-5}). These values are for comparison purposes only; they are not necessarily benchmarks or regulatory drivers.

5.1 CURRENT-CONDITION RISKS

Table B-4 presents maximum COPC concentrations in 200-UP-1 groundwater observed in 1994/1995 data and the current-condition risks derived from these concentrations. For comparison, maximum contaminant levels (MCL) for drinking water are also shown. A maximum hazard quotient of 30 is predicted for commercial/industrial ingestion of groundwater containing carbon tetrachloride (Table B-4). This is the highest chemical-specific hazard quotient (noncarcinogenic risk) predicted for the hypothetical current-condition exposure scenario. By contrast, current-condition hazard quotients predicted for maximum concentrations of the other COPCs are no greater than 0.6 (Table B-4). Carbon tetrachloride concentrations also result in the highest current-condition ILCR (greater than 1 x 10^{-4}). Maximum ILCRs for arsenic and iodine-129 are 8 x 10^{-5} (Table B-4). Maximum current-condition ILCRs for other COPCs are no greater than 1 x 10^{-5}.

Although Table B-4 presents maximum risks, it does not adequately characterize the current-condition risks for the 200-UP-1 Groundwater OU. This is because many of the COPCs occur in groundwater only at a single monitoring well, or sporadically, and these COPCs are not present in groundwater as "plumes." Thus, the RBDA methodology (BHI 1995) was employed to estimate total current-condition risks at each monitoring well, and the risks were plotted on maps and contoured. The results are shown in Figures B-4 and B-5 for total noncarcinogenic and total carcinogenic risk, respectively.

Figure B-4 shows that hazard indices greater than 1 are found in the northern portions of the 200-UP-1 Operable Unit (the U Plant Aggregate Area). Attachment 4 of this appendix presents tabulated current-condition commercial/industrial exposure risks for each 200-UP-1 Operable Unit monitoring well; both individual-chemical and total risks are shown. Review of the information in Attachment 4 and comparison of Figure B-4 with the carbon tetrachloride concentration map presented in Attachment 1 indicates that hazard indices greater than 1 are due almost entirely to carbon tetrachloride in groundwater. The carbon tetrachloride appears to be a southern extension of the large plume in the 200-ZP-1 Groundwater Operable Unit (DOE-RL 1992b).

Figure B-5 shows a large area of the 200-UP-1 Groundwater Operable Unit with ILCRs greater than 1×10^{-5} and several smaller areas greater than 1×10^{-4}. Evaluation of the risk data listed in Attachment 4 indicates that the ILCRs are primarily due to carbon tetrachloride, iodine-129, and several other radionuclides. Carbon tetrachloride is the predominant contributor to total cancer risk in the northern portion of the 200-UP-1 Groundwater Operable Unit; however, the iodine-129 plume (see Attachment 1, iodine-129 map) is the predominant contributor in the area immediately south and west of the U and S Plant Aggregate Areas (Figure B-5). Small areas of ILCR greater than 1×10^{-5} are also present beneath the 241-S Tank Farms (Figure B-5), due to the presence of strontium-90 and technetium-99 in groundwater. As discussed in Chapter 2.0, portions of the uranium and technetium-99 plumes that have been designated for an IRM are not included in this risk assessment. If these IRM plumes were included, current-condition ILCRs would be higher in the area beneath and east of the U Plant.

5.2 FUTURE-CONDITION RISKS

Tables B-5 and B-6 present the predicted maximum COPC concentrations and maximum risks at the hypothetical future-use boundary for the eastern and northern groundwater flow paths, respectively. The flow paths and hypothetical future-use boundary are shown in Figure B-3. Unretarded travel times to the hypothetical future-use boundary are predicted to be approximately 200 years via the eastern flow path and approximately 100 years via the northern flow path. For both flow paths, only carbon tetrachloride reaches the hypothetical future-use boundary at concentrations corresponding to a hazard quotient (noncarcinogenic risk) of greater than 1. The highest chemical-specific residential ILCRs predicted for COPCs at the hypothetical future-use boundary are due to arsenic, carbon tetrachloride, and iodine-129 (Tables B-5 and B-6). Transport modeling predicts that strontium-90 will not reach the hypothetical future-use boundary because of the relatively long travel time (greater than 10,000 years) and short half -life (28.5 years). Comparison to drinking water MCLs indicates that for the eastern groundwater flow path, predicted maximum concentrations of carbon tetrachloride and chloroform exceed MCLs (Table B-5). For the northern flow path, carbon tetrachloride, chloroform, and iodine-129 predicted concentrations exceed MCLs (Table B-6).

Total future-condition risk at the hypothetical future-use boundary as a function of time is shown in Figures B-6 through B-9. The future-condition risk due to carbon tetrachloride is also plotted on these figures for comparison. These plots assume that the centerline of all plumes (maximum concentrations) will cross the hypothetical future-use boundary at the same location. This is a conservative assumption.

Figures B-6 through B-9 show that the total predicted noncarcinogenic risk is almost completely due to carbon tetrachloride, and that after 250 and 150 years in the future for the eastern and northern flow paths, respectively, the predicted total ILCR is also completely due to carbon tetrachloride. For both groundwater flow paths, the influence of unretarded carcinogenic COPCs is reflected in the future total ILCRs. This influence is indicated in Figures B-6 through B-9 as the separation between the total and carbon tetrachloride ILCR curves at early travel times. Figure B-7 indicates that the predicted total residential ILCR for the eastern groundwater flow path will be greater than 1 x 10^{-5} at the hypothetical future-use boundary for a period of approximately 250 years, and the predicted noncarcinogenic risk will be greater than 1 at the boundary for the same length of time. Similarly, Figure B-9 shows that the predicted total residential ILCR for the northern groundwater flow path will be greater than 1 x 10^{-5} at the hypothetical future-use boundary for a period of approximately 150 years, and the predicted noncarcinogenic risk will be greater than 1 at the boundary for approximately 200 years. Figures B-6 through B-9 and Tables B-5 and B-6 show that, for a given COPC, the magnitude of the predicted future-condition risks is similar, regardless of the groundwater flow path selected for transport modeling. However, because of higher groundwater velocities to the north, predicted travel times to the hypothetical future-use boundary are shorter via the northern flow path, and the COPC plumes also pass through the boundary more rapidly.

6.0 ECOLOGICAL RISK SCREENING

Both ecological and human-health risk assessments require definition of a risk evaluation framework. Without a complete exposure pathway, the risk to potential receptors is zero. The primary route by which high-priority groundwater contaminants from the 200-UP-1 Groundwater Operable Unit could pose an ecological risk is via migration in groundwater to the Columbia River, where dissolved contaminants may be ecologically available (see Figure B-3). The conceptual model for this ecological risk screening considers protection of Columbia River biota to be a primary goal. Contamination in groundwater migrating to exposed areas along or in the Columbia River are of concern. Potential exposure of this important resource to significant levels of dissolved contaminants may be unacceptable.

6.1 METHODOLOGY

This ecological evaluation uses the maximum concentrations of COPCs predicted to reach the Columbia River to conservatively assess the potential ecological impact that the COPCs may have on an aquatic ecosystem. The predicted maximum concentrations were obtained from the fate and transport modeling conducted for the human-health risk assessment (Section 4.2). Predicted maximum concentrations used were from the northern groundwater flow path to the river, because these concentrations were greater than those predicted for the eastern flow path (Attachment B.3). This screening-level assessment is not intended to estimate doses and potential impacts to a particular species. It does conservatively identify the COPCS that offer the potential for an ecological effect, if any, using benchmarks for protection of aquatic life. Benchmarks consists of water quality standards or advisory values that were derived to be indicative of ecological risk. Benchmarks provide a tool to gauge potential ecological risk from identified groundwater contaminants.

For the ecological risk evaluation, each of the 26 high-priority groundwater contaminants was first evaluated by a COPC screening process similar to that applied to the human-health risk assessment. Contaminants were eliminated from further consideration based upon the one-time detections previously shown in Table B-1. The chemicals eliminated by this first step in the screening process were aldrin, gamma-BHC, bis(2-ethylhexyl)phthalate, 4,4'-DDD, 4,4'-DDT, dieldrin, endrin, endrin aldehyde, heptachlor, n-nitrosodimethylamine and plutonium-238 (Table B-7).

For some high-priority groundwater contaminants, background threshold values were available in the *Hanford Site Groundwater Background* (DOE-RL 1992a). Contaminants with maximum predicted concentrations below background thresholds were also eliminated from further consideration. Arsenic, cadmium, chromium, fluoride, selenium, and uranium were eliminated on this basis. Strontium-90 was eliminated, because the maximum modeled concentration predicted to intersect the river was 0 pCi/L.

The high-priority groundwater contaminants remaining after the above screening process were COPCs for the ecological risk analysis, and the maximum predicted concentrations of these contaminants were compared to freshwater benchmark concentrations. Table B-8 shows that the ecological COPCs were carbon tetrachloride; chloroform; 1,2-dichloroethane; 1,1-dichloroethylene; iodine-129; potassium-40; technetium-99; and trichloroethylene. Also shown in Table B-8 are aquatic freshwater quality criteria for comparison to the predicted maximum concentrations at the Columbia River. The derivation and interpretation of aquatic freshwater quality criteria are discussed below.

Benchmark concentrations for a given contaminant vary, depending upon the water quality criterion used for comparison. Therefore, for most of the ecological COPCs, a range of benchmark concentrations is available for comparison. Exceeding a benchmark concentration that is at the low end of the range suggests that a contaminant is of ecological concern, unless other information indicates that the data are unreliable or the comparison is inappropriate.

Chemicals with concentrations below the lower end of the benchmark concentration range are not of concern if the ambient data are judged to be adequate. Concentrations exceeding the upper end of the benchmark range suggest a high likelihood of significant effects and indicate that the chemical in question is clearly of concern in a surface-water environment.

Aquatic freshwater quality benchmarks used in this risk screening were compiled from a variety of sources. These include Sutter et al. (1992), DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1990), and the Oak Ridge National Laboratory database *Screening Benchmarks for Ecological Risk Assessment* (Version 1.5, January 1996) (ORNL 1996). Radiological dose estimates were calculated using the "Point Source Dose Distribution" approach as described in Blaylock et al. (1993). Iodine-129 did not have an average energy of decay or biological concentration factor listed in Blaylock et al. (1993). Estimates of dose contribution for iodine-129 were based upon a 6.38×10^{-2} mega-electron volts per decay average beta energy, a 2.46×10^{-2} mega-electron volts per decay average gamma energy (EPA 1989), and a biological concentration factor of 40.

National Ambient Water Quality Criteria (NAWQC) are applicable or relevant and appropriate requirements (ARAR) for the protection of aquatic life. These values have been developed to protect most aquatic species with a reasonable level of confidence. Chronic and acute values have been developed for some contaminants. The acute NAWQC values correspond to concentrations that would be expected to cause less than 50% mortality in the most susceptible 5% of a population after a brief exposure. NAWQC are not designed for contaminant screening, but are ARARs for site cleanup. Most contaminants do not have promulgated NAWQC; none of the 200-UP-1 Groundwater Operable Unit ecological COPCs have a promulgated NAWQC. Sutter et al. (1992) have produced an extensive compilation of NAWQC "advisory" values. These values are concentrations that are expected to be higher than NAWQC values (if they were promulgated) in no more than 5% of the cases. The Sutter et al. (1992) values shown in Table B-8 were derived from acute toxicity data.

The Tier 2 secondary acute and chronic values shown in Table B-8 were developed based on the method described in the EPA Proposed Water Quality Guidance for the Great Lakes System. This method allows for derivation of benchmarks with fewer data points than the number required for NAWQC. Benchmark concentration values are from the Oak Ridge National Laboratory database *Screening Benchmarks for Ecological Risk Assessment* (Version 1.5, January 1996) (ORNL 1996). These concentrations are expected to be higher than the NAWQC in no more than 20% of the cases.

Estimated dose rates to small insects and larvae from water contaminated with iodine-129, potassium-40, and technetium-99 are included in Table B-8. These estimates were made considering bioconcentration factors, external exposure, and internal dose contributions (Blaylock et al. 1993). Small organisms were selected for the radionuclide evaluation because they would be the most likely aquatic organisms to have average exposure concentrations approaching the predicted groundwater values. Conversely, organisms with large sizes and/or ranges would have exposures averaged over large areas of surface water, rather than exposures at highly localized groundwater discharge areas such as seeps or river springs. Due to self-shielding, larger organisms would also have lower proportions of their total dose from external exposure. However, the primary dose contributor in each case is internal, not an external dose. Internal dose estimates are a function of radionuclide concentration in water times the previous-discussed bioconcentration factor. Bioconcentration factors listed in Blaylock et al. (1993) are generic, fish-derived factors, so the internal dose estimates to fish will not exceed those made for small aquatic organisms.

The DOE recommends limiting dose rates to aquatic biota to less than 400 micrograys per hour (1 rad/day), based on reviews summarized in the National Council on Radiation Protection and Measurements Report No. 109 (NCRP 1991). Dose rates below this level are expected to have no detrimental population effects. When results of dose estimates show dose rates of 100 microgray per hour or more to aquatic biota, NCRP (1991) recommends a detailed ecological evaluation.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE 1990), specifies concentrations in water to protect public health and the environment from radionuclide exposure. The order provides Derived Concentration Guide (DCG) values as reference values for conducting radiological environmental protection programs at operational DOE facilities. Standards for liquid effluent discharges are driven by the DOE as-low-as-reasonably-achievable policy and the objective to minimize contamination in the environment to the extent practicable. Based on cost/benefit considerations, radioactive waste streams that contain radionuclide concentrations of not more than the DCG reference values at the point of discharge to a surface waterway normally will not require treatment to further reduce the radionuclide concentration. For water, DCGs are based upon ingestion of a radioactive isotope that would result in an effective dose equivalent of 1 millisievert (100 millirem). The DCGs for the radioactive ecological COPCs are listed in Table B-8.

6.2 RESULTS

The ecological risk-based screening process employed suggests that only one COPC, carbon tetrachloride, may pose significant ecological risk at the river. This suggests that carbon tetrachloride, if present in surface water at the maximum concentration predicted to intercept the Columbia River, may pose an ecological risk. However, a comparison of modeled chromium VI concentrations at the river and the ambient water quality criterion shows that chromium VI exceeds the surface water standard of 11 μg/L by 2 μg/L. This concentration of 13 μg/L would suggest significant ecological risk if chromium VI had not been eliminated during the screening process as a COPC assuming background is <30 μg/L. Additionally, it may also have been reasonable to retain this contaminant for IRM consideration based on a concentration of 13 μg/L. However, groundwater investigations in the 100 Areas suggest there are other factors that should be considered that are not accounted for in the model.

The Declaration of Record of Decision for the 100 Areas suggests that chromium VI concentrations near the river in aquifer sediments are attenuated by half before reaching the aquatic receptor exposure point. Because dilution within aquifer sediment (not the river) was not considered in the contaminant and fate transport analysis, a modeled concentration of 13 μg/L at the river is overly conservative. Based on the modeled concentration of chromium VI and a 1:1 attenuation close to, but not in the river, a conservative concentration for assessment of risk is likely <1 μg/L. This concentration is not indicative of significant ecological risk and does not suggest a remedial action is needed. Therefore, chromium VI is not recommended for IRM consideration.

As discussed in Section 6.1, maximum predicted concentrations for the modeled northern groundwater flow path to the river were used in the risk screening because these concentrations are greater than those predicted for the eastern flow path. However, the ecological risk results also apply to the eastern flow path; the maximum predicted concentration of carbon tetrachloride via the eastern flow path also exceeds some of the ecological benchmark criteria presented in Table B-8. Table B-8 shows that chloroform; 1,2-dichloroethane; 1,1-dichloroethylene; trichloroethylene; iodine-129; potassium-40; and technetium-99 maximum predicted concentrations at the Columbia River are below the ecological benchmark values. Based on fate and transport modeling and the ecological risk-based screening process, these COPCs will not reach the Columbia River at concentrations that would adversely affect aquatic receptors.

Additional considerations will be necessary to decide the significance of any potential threat to surface water. The modeled groundwater plumes discussed in this appendix will make extremely small contributions to surface water. Mixing of discharging groundwater with Columbia River water will greatly reduce the concentration of COPCs in the river water downstream of the discharge area. This is particularly true for contaminants that are not naturally occurring, e.g., carbon tetrachloride, because background concentrations of these contaminants in river water should be very low.

This screening-level assessment helped identify which of the 200-UP-1 Groundwater Operable Unit contaminants would be expected to have potential ecological impact at the maximum concentrations predicted to intersect the Columbia River. Although this process does not provide a species-specific exposure assessment based upon a biologically relevant dose, it does provide a tool to conservatively identify potential ecological contaminants of concern.

Certain assumptions and uncertainties inherent in the ecological risk evaluation warrant mention. Further evaluation may be required to assess whether predicted maximum groundwater concentrations at the river would be, in their entirety, biologically available. In order for contaminants to pose an ecological threat, bioavailable concentrations must be present. However, this issue is beyond the scope of the screening process. An additional uncertainty is that groundwater contaminants may mix with surface water, lowering concentrations significantly before the contaminants can be intercepted by significant ecological receptors. Other important assumptions include an adequate conceptual model for long-term fate and transport predictions and sufficient comparison criteria for contaminant screening.

All comparisons to aquatic water quality benchmarks depend on appropriate water concentrations. Although total recoverable concentrations are often used in human-health-risk assessments, aquatic water quality assessments should be based upon dissolved concentrations. Benchmarks are established based upon dissolved concentrations, not total recoverable concentrations, which will include particle-bound material. This is particularly relevant given consideration of the conceptual transport model upon which this assessment is based, i.e., flow through miles of geologic sediments. Use of total recoverable concentrations will overestimate risk; this effect is probably most significant for inorganic COPCs.

7.0 SUMMARY AND CONCLUSIONS

Sample-specific risk characterization as defined in the RBDA (BHI 1995) was used to assess the potential human health risks due to ingestion of high-priority contaminants in 200-UP-1 Operable Unit groundwater. The COPC screening process, calculation of chemical and radionuclide intakes, and computation of risk followed the methodology presented in the HSRAM (DOE-RL 1995). Current-condition risk was estimated using a commercial/industrial groundwater ingestion scenario. Future-condition risk was estimated for both commercial/industrial and residential ingestion exposure at the hypothetical future-use boundary for the 200 Areas. An analytical fate and transport model simulating advection, dispersion, sorption, and radiological decay was used to simulate the transport of COPCs from the 200-UP-1 Groundwater Operable Unit to the hypothetical future-use boundary and the Columbia River.

Some LFI COPCs are present in relatively large plumes in the 200-UP-1 Groundwater Operable Unit (e.g., carbon tetrachloride and iodine-129). Other COPCs are detected at only one monitoring well (e.g., 1,1-dichloroethylene) or are observed in above-background concentrations at very few locations (e.g., arsenic). Table B-9 summarizes the results for each of the LFI COPCs evaluated in this risk assessment. As discussed in Chapter 1.0, the risk assessment for the IRM portions of the uranium and technetium-99 plumes was performed previously and was not included in this risk assessment.

Results of the risk assessment indicate that for both current and future conditions, carbon tetrachloride in groundwater is the predominant contributor to both carcinogenic and noncarcinogenic risk. Over a large portion of the aquifer in the 200-UP-1 Operable Unit, the current-condition hazard index (noncarcinogenic risk) is greater than 1, due almost entirely to carbon tetrachloride in groundwater. Similarly, current-condition ILCRs $>1 \times 10^{-5}$ are estimated for a large portion of the aquifer, due primarily to carbon tetrachloride, but also to a lesser degree due to the presence of iodine-129. In addition, small areas of groundwater with current-condition ILCRs $>1 \times 10^{-5}$ are found beneath the 241-S Tank Farms area, due to technetium-99 and strontium-90.

Because of uncertainty in future groundwater flow directions, transport of COPCs from the 200 West Area to the hypothetical future-use boundary was simulated for two separate flow paths. Future-condition risks are relatively similar for both paths. Carbon tetrachloride was the predominant contributor to future-condition carcinogenic and noncarcinogenic risk. In addition to carbon tetrachloride, arsenic and iodine-129 are predicted to reach the hypothetical future-use boundary at concentrations corresponding to residential ILCRs $>1 \times 10^{-5}$.

Ecological risk screening was conducted to estimate the future ecological risk posed by LFI contaminants in groundwater discharging to the Columbia River. The ecological risk screening process indicated that only carbon tetrachloride is predicted to reach the Columbia River at concentrations that exceed aquatic freshwater quality criteria.

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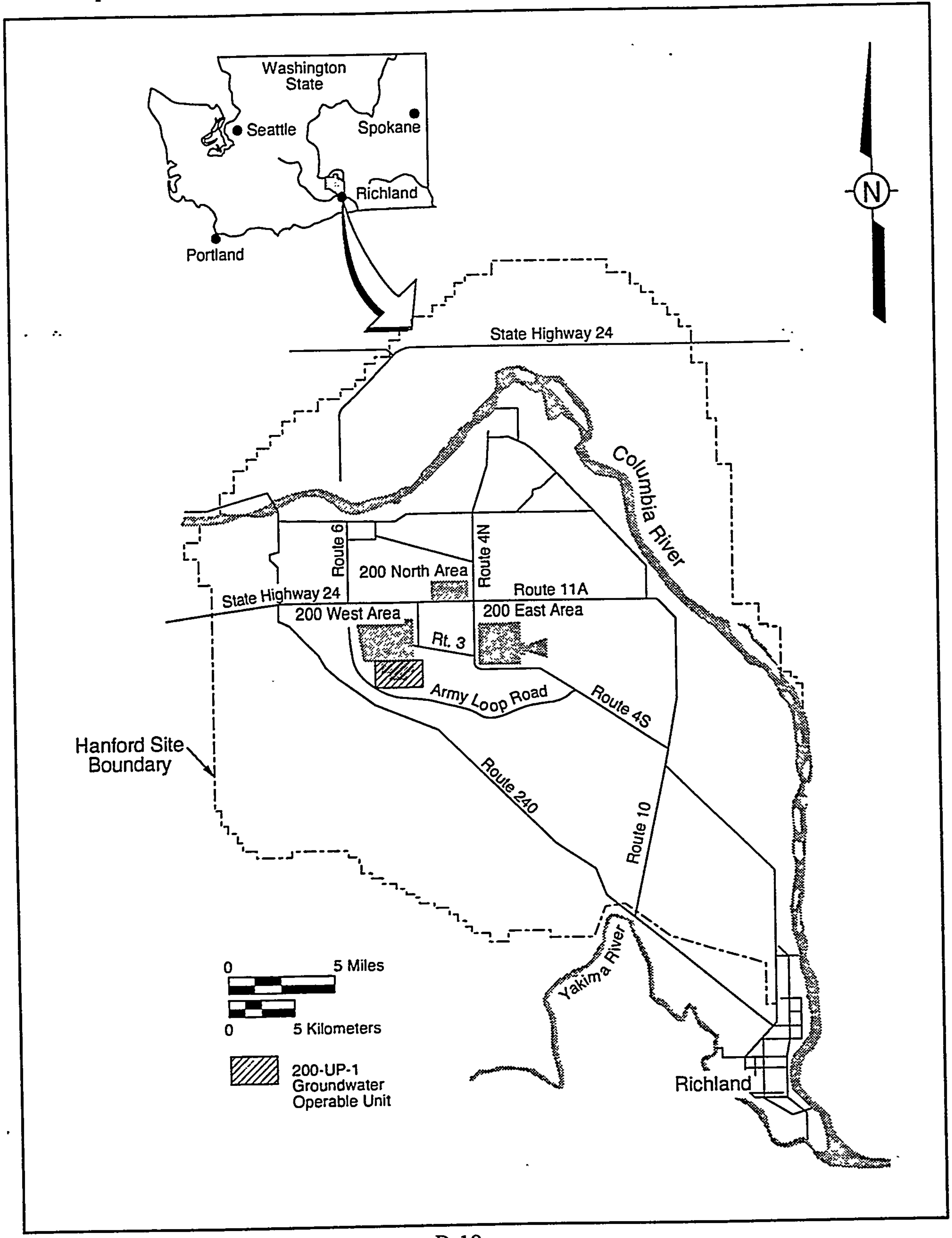
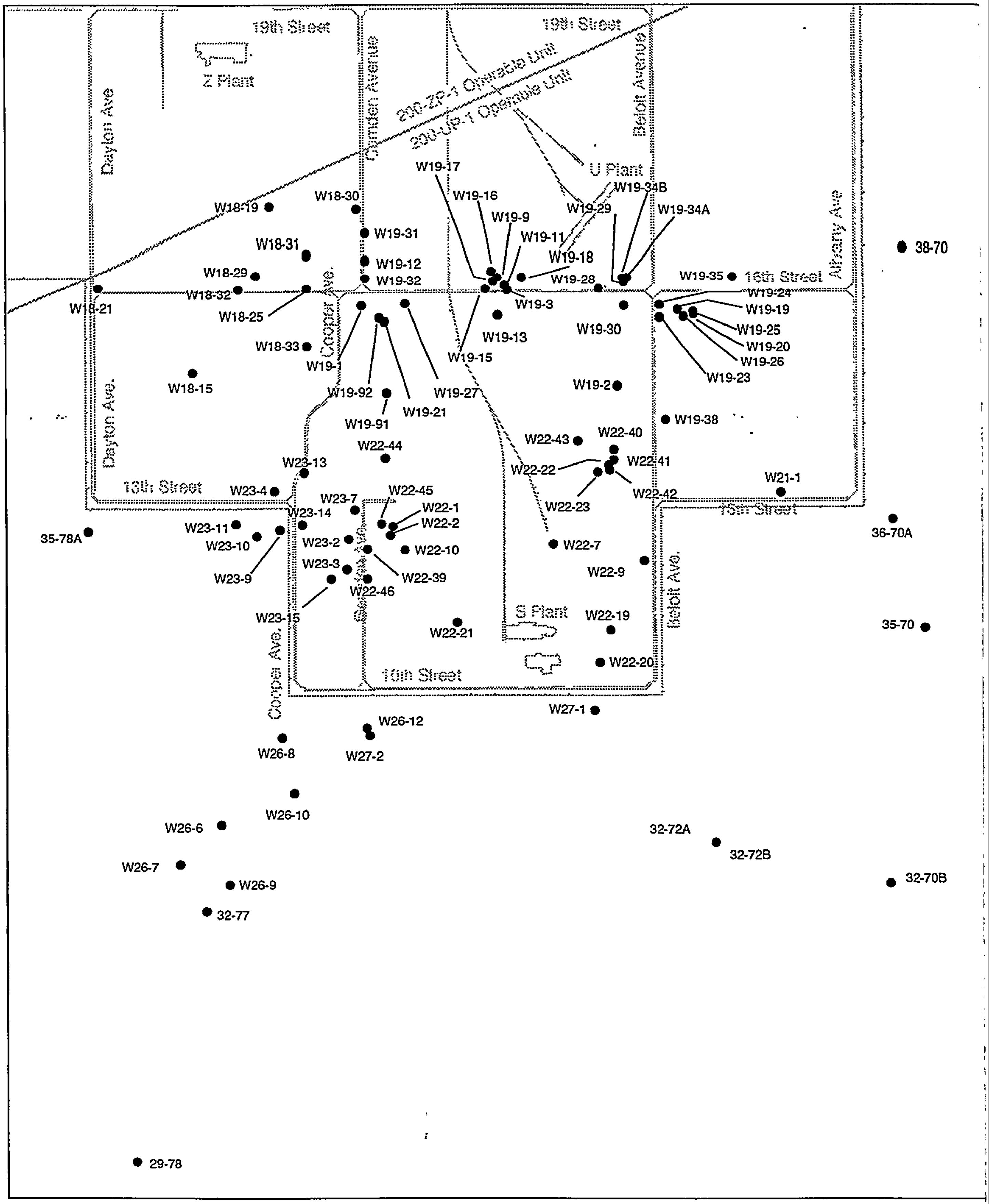
Sutter, G. W., M. A. Futrel, and G. A. Kerchner, 1992, *Toxicological Benchmarks for Screening of Potential Contaminants of Concern for Effects on Aquatic Biota on the Oak Ridge Reservation, Oak Ridge, Tennessee*, ORNL/ER-139, ES/ER/TM-96, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Walton, W. C., 1989, *Analytical Groundwater Modeling, Flow and Contaminant Migration*, Lewis Publishers, Inc., Chelsea, Michigan.

Figure B-1. 200-UP-1 Groundwater Operable Unit Location Map, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



76212.201.PT.RA4/zc B2



2/8/96

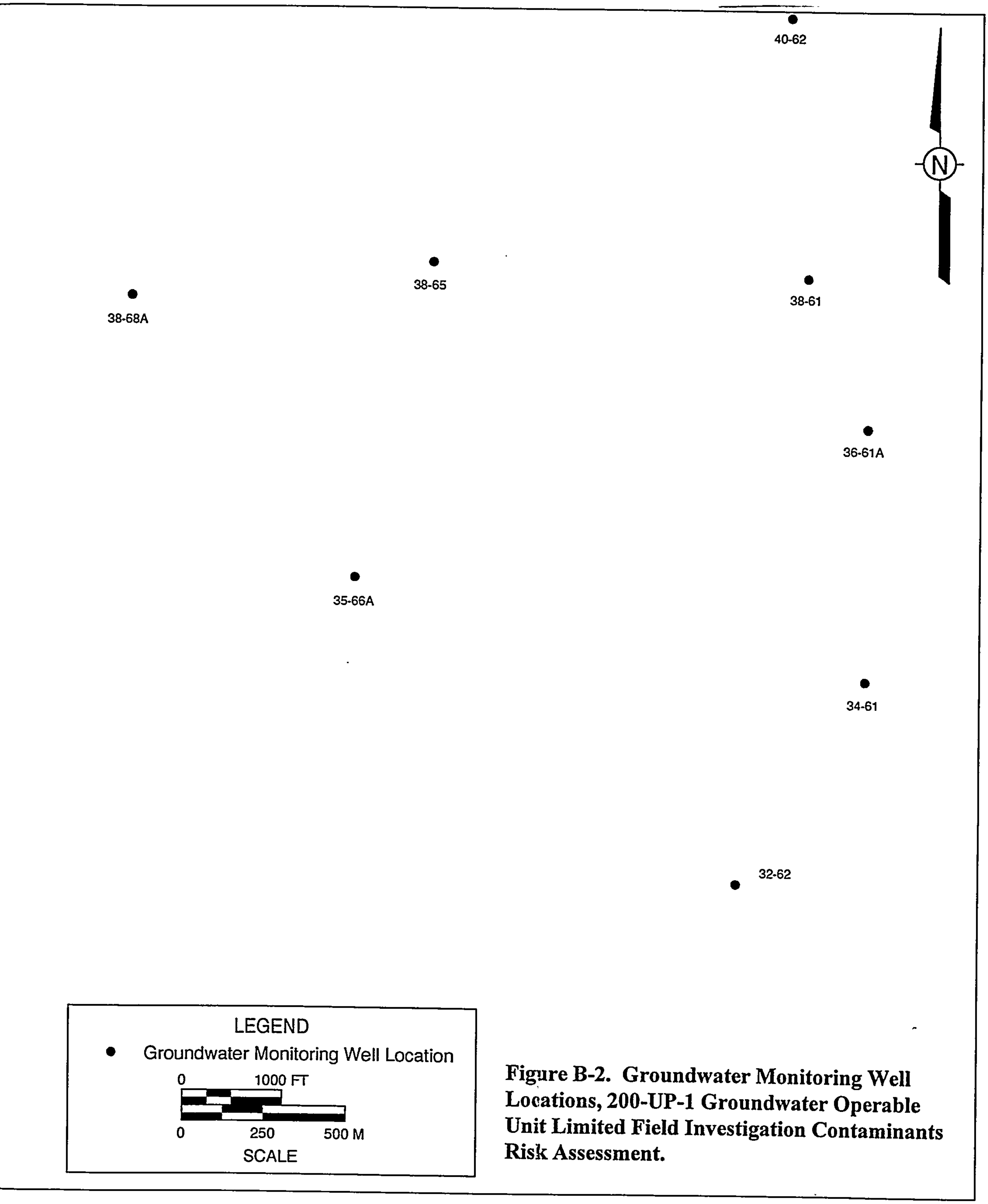
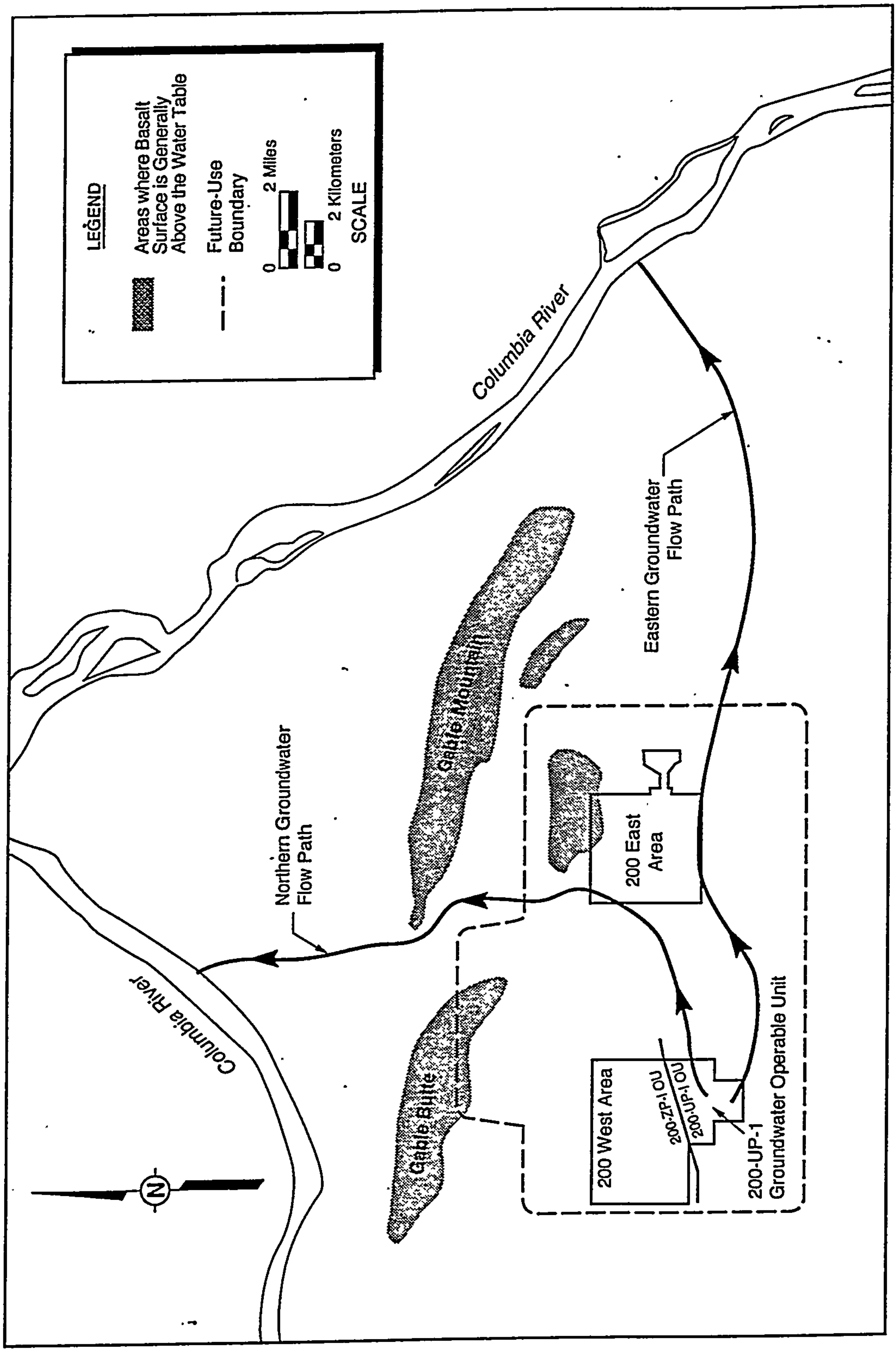
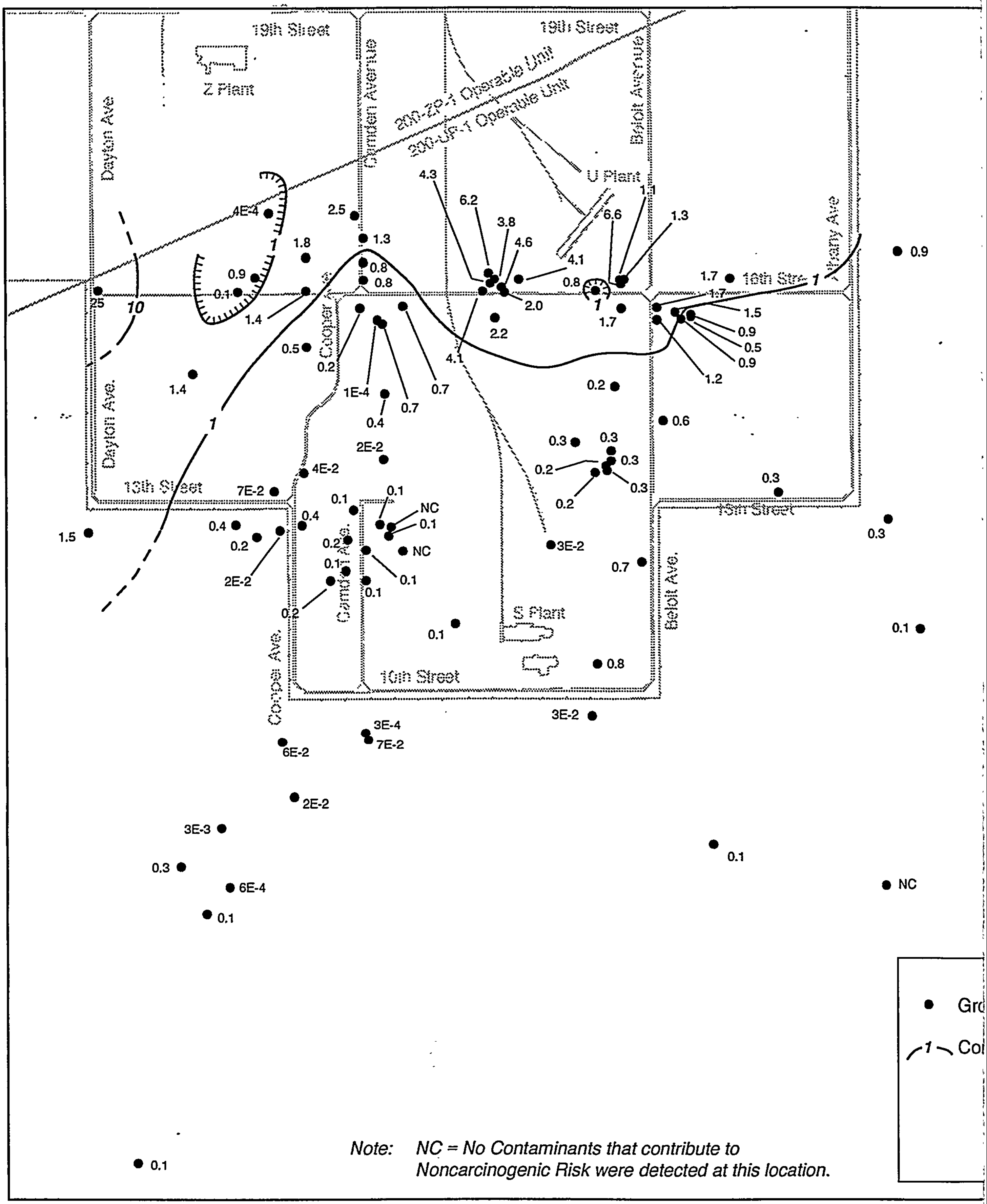


Figure B-2. Groundwater Monitoring Well Locations, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminants Risk Assessment.

Figure B-3. Groundwater Flow Paths to Hypothetical Future-Use Boundary and Columbia River, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



762121.2O1.PT.RA4/zc B14



Note: *NC = No Contaminants that contribute to Noncarcinogenic Risk were detected at this location.*

2/27/96

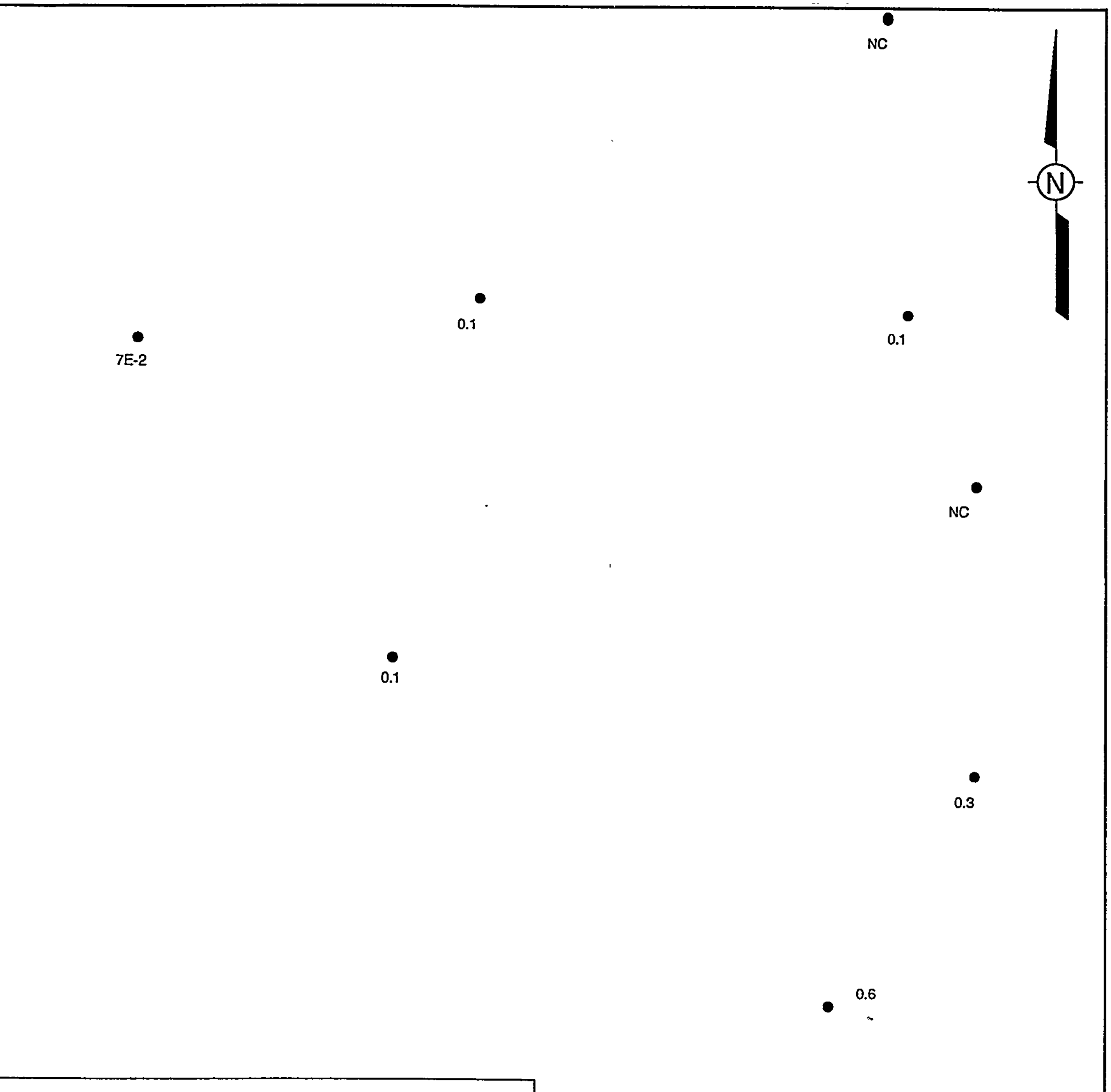
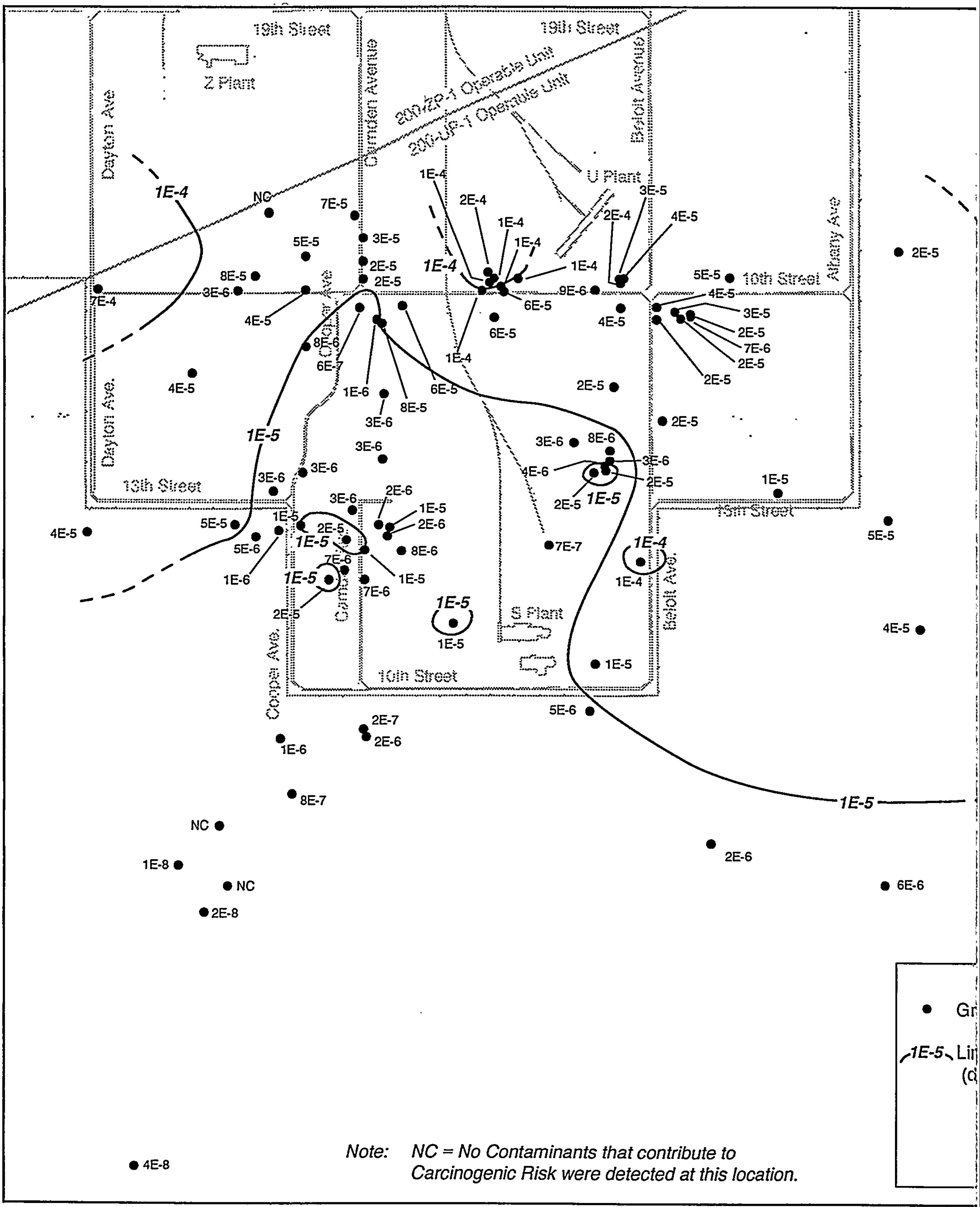


Figure B-4. Hazard Index for Exposure to Contaminants in Groundwater, Current Conditions, Commercial/Industrial Ingestion Scenario, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

762121.201.PT.RA4/zc B15



Note: NC = No Contaminants that contribute to Carcinogenic Risk were detected at this location.

2/27/96

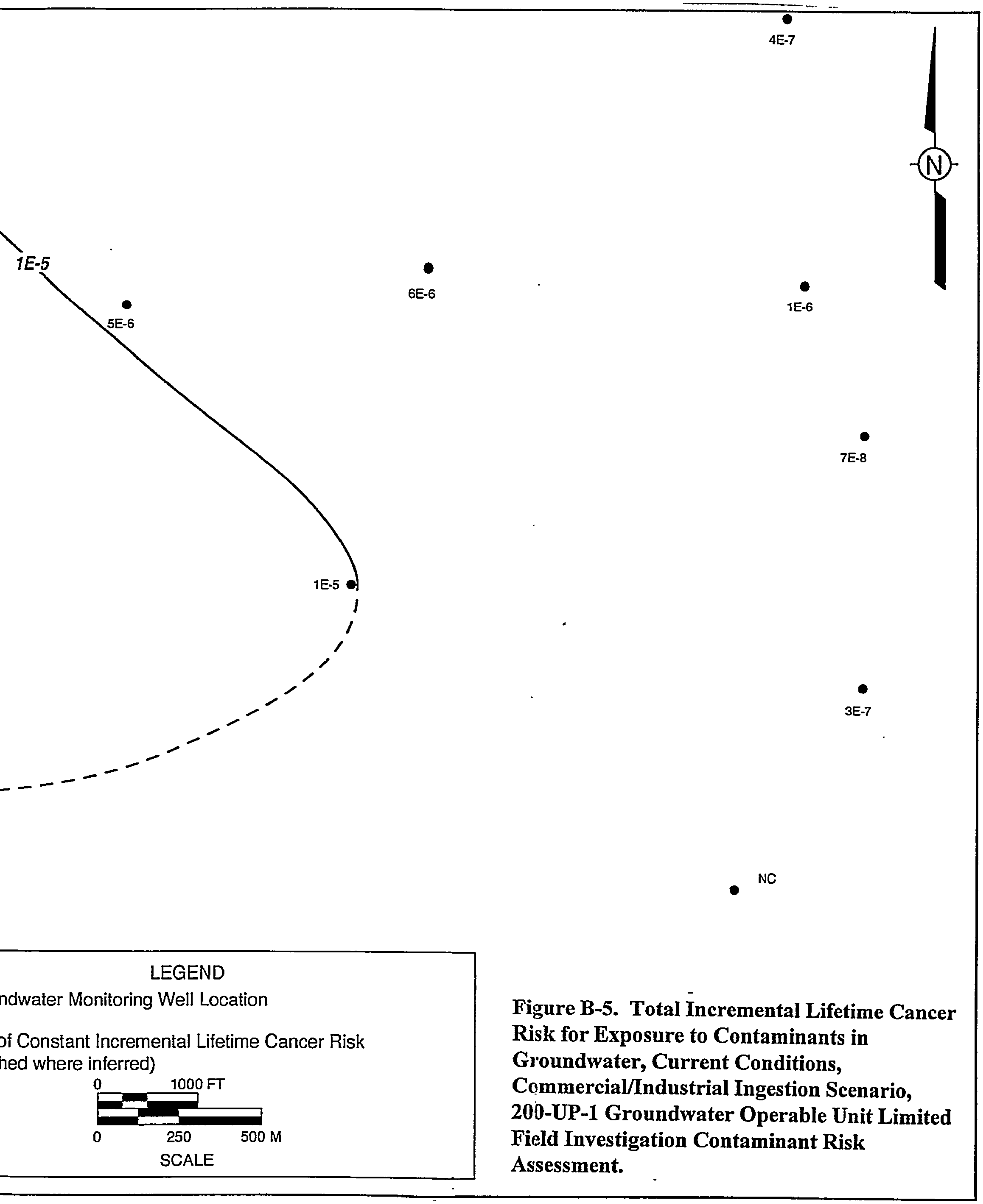


Figure B-5. Total Incremental Lifetime Cancer Risk for Exposure to Contaminants in Groundwater, Current Conditions, Commercial/Industrial Ingestion Scenario, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Figure B-6. Future Condition Commercial/Industrial Groundwater Risk versus Time at Hypothetical Future-Use Boundary, Eastern Flow Path, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

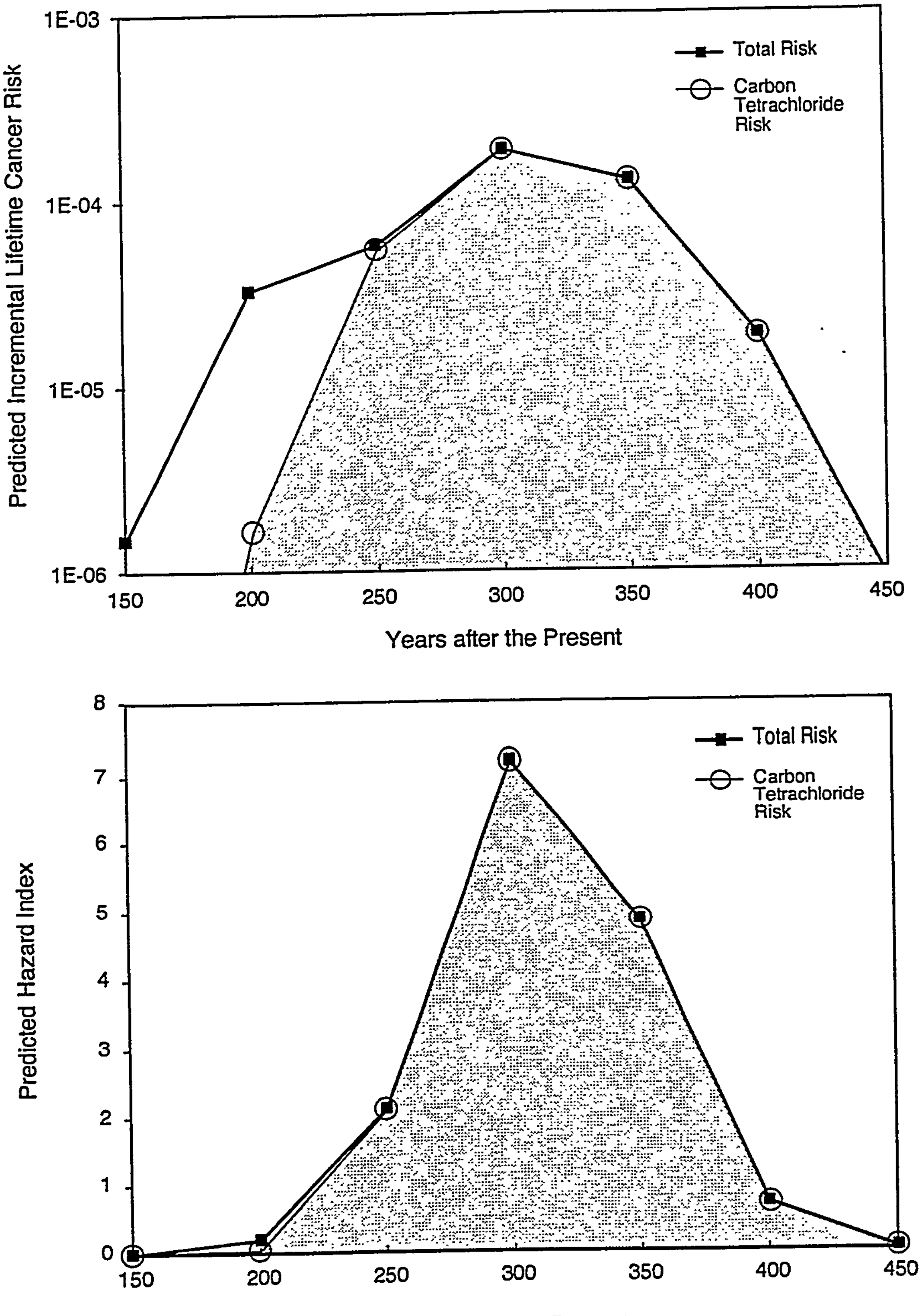
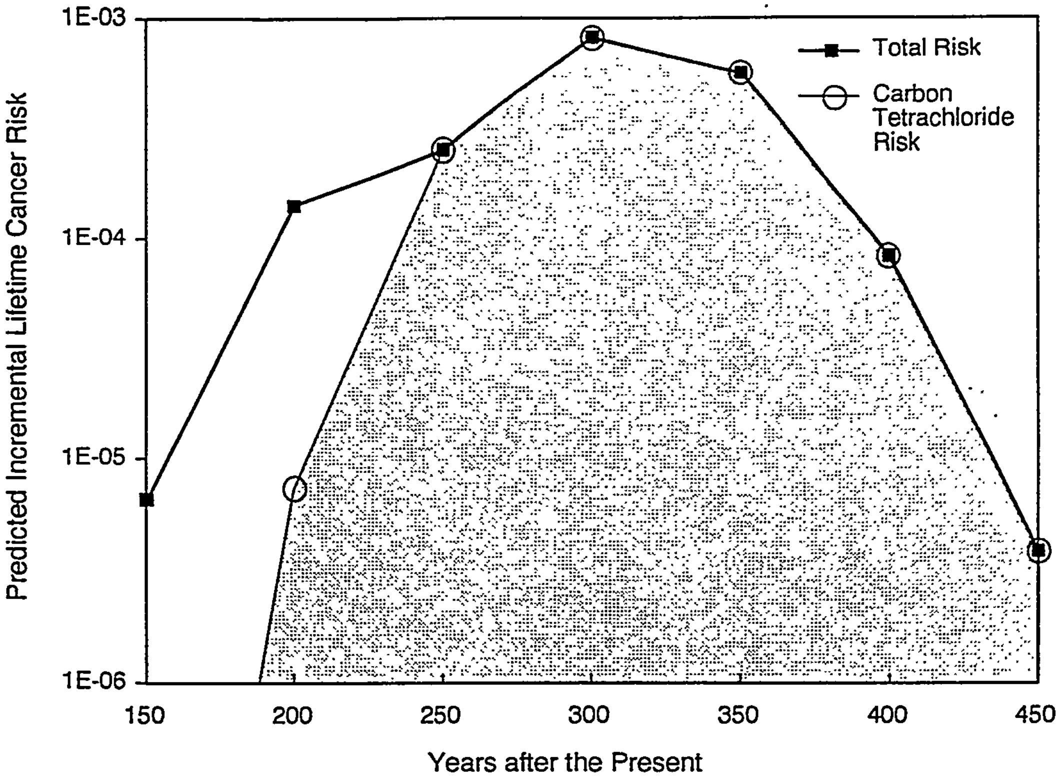


Figure B-7. Future Condition Residential Groundwater Risk versus Time at Hypothetical Future-Use Boundary, Eastern Flow Path, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



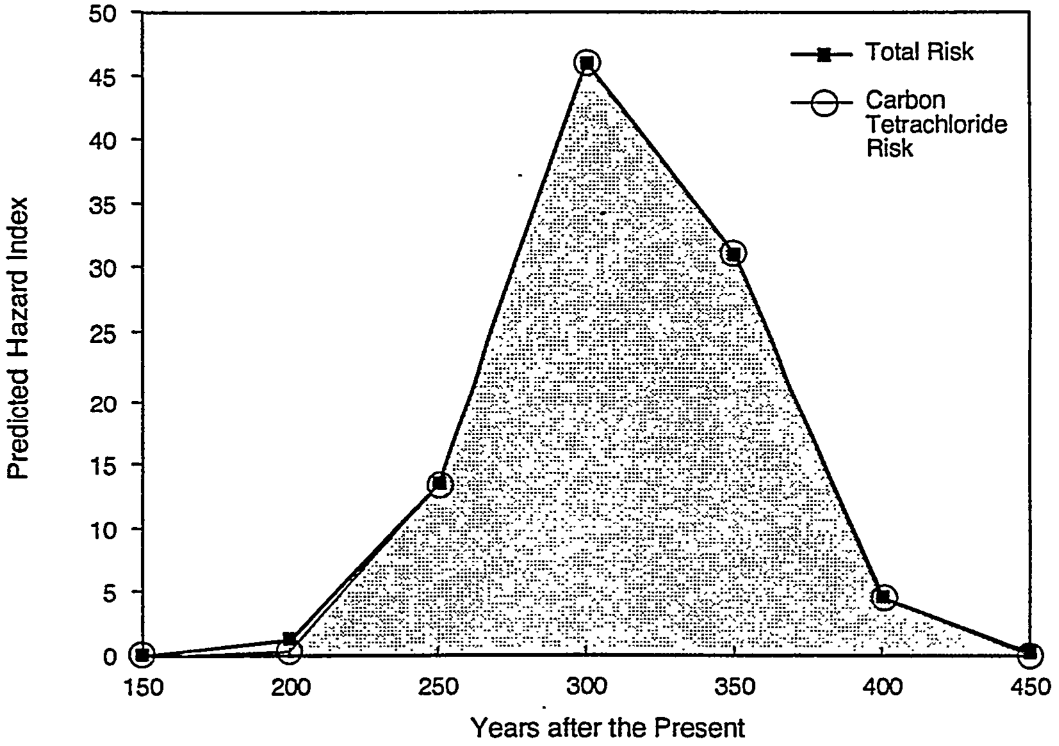


Figure B-8. Future Condition Commercial/Industrial Groundwater Risk versus Time at Hypothetical Future-Use Boundary, Northern Flow Path, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

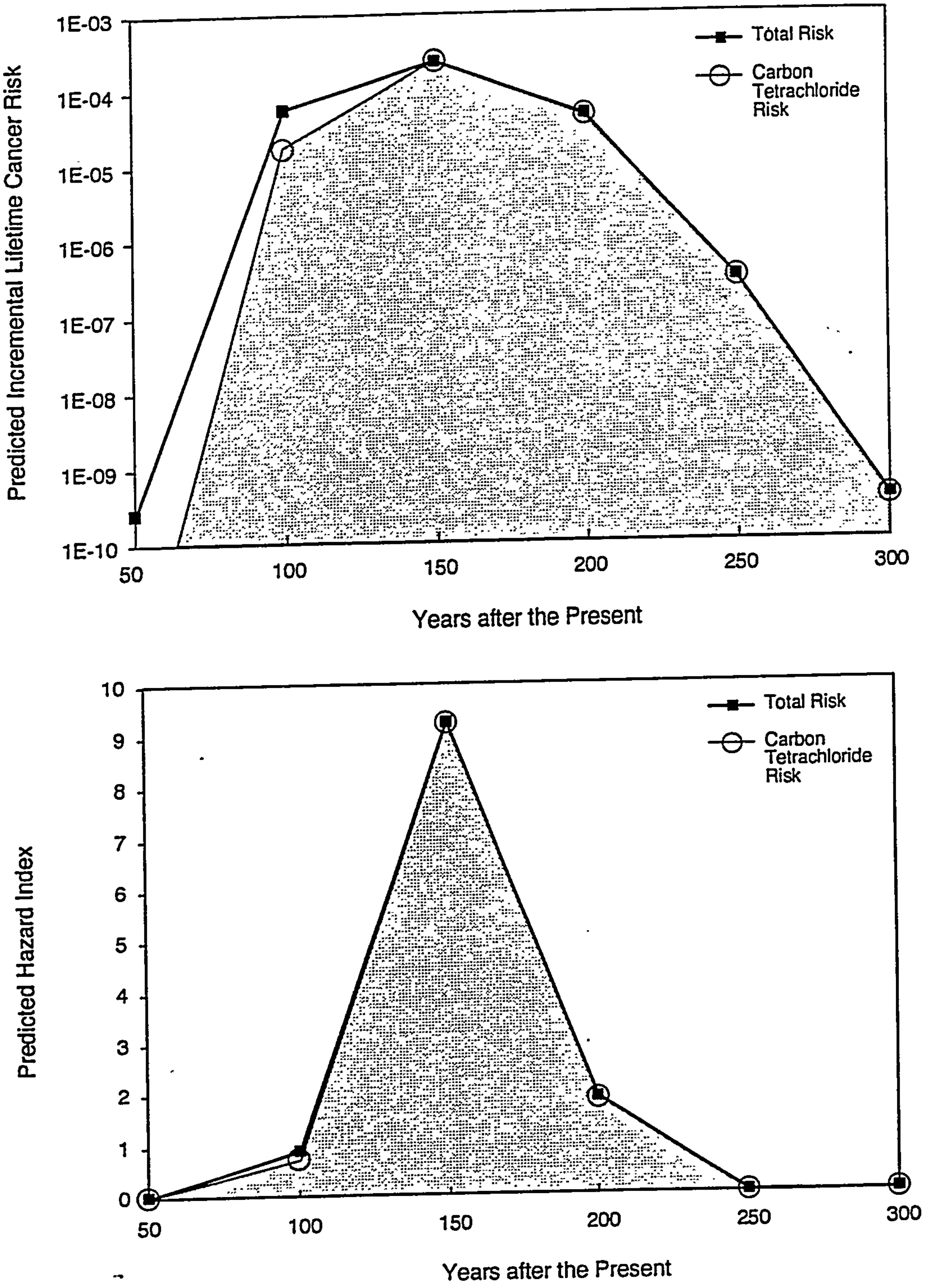
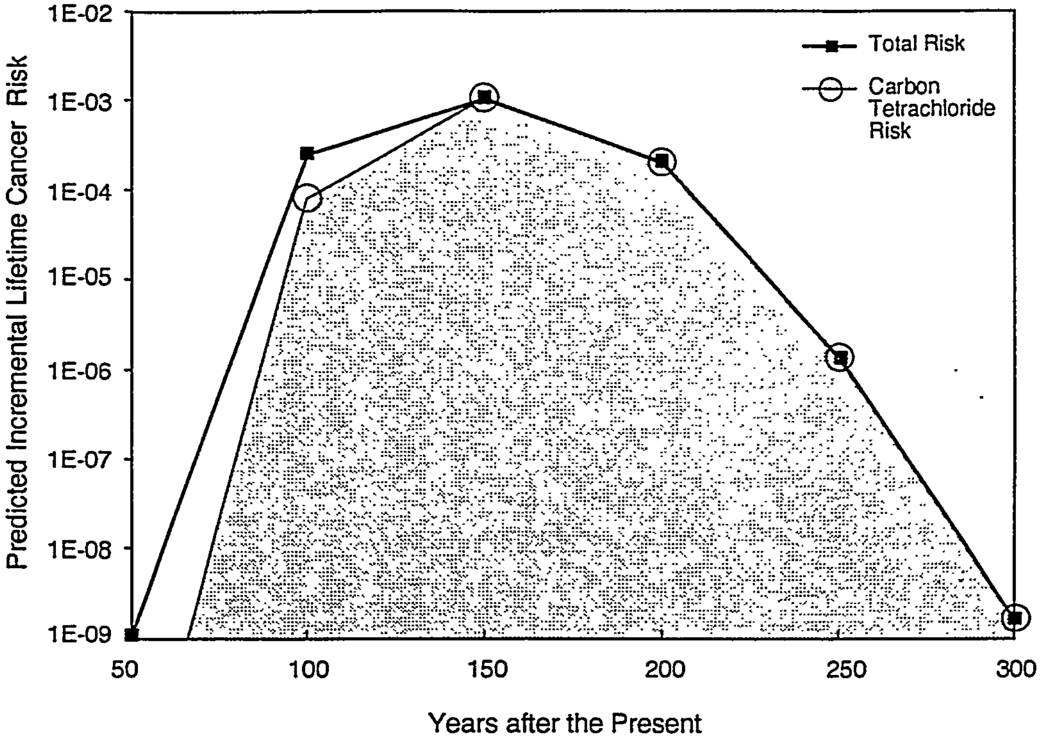


Figure B-9. Future Condition Residential Groundwater Risk versus Time at Hypothetical Future-Use Boundary, Northern Flow Path, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



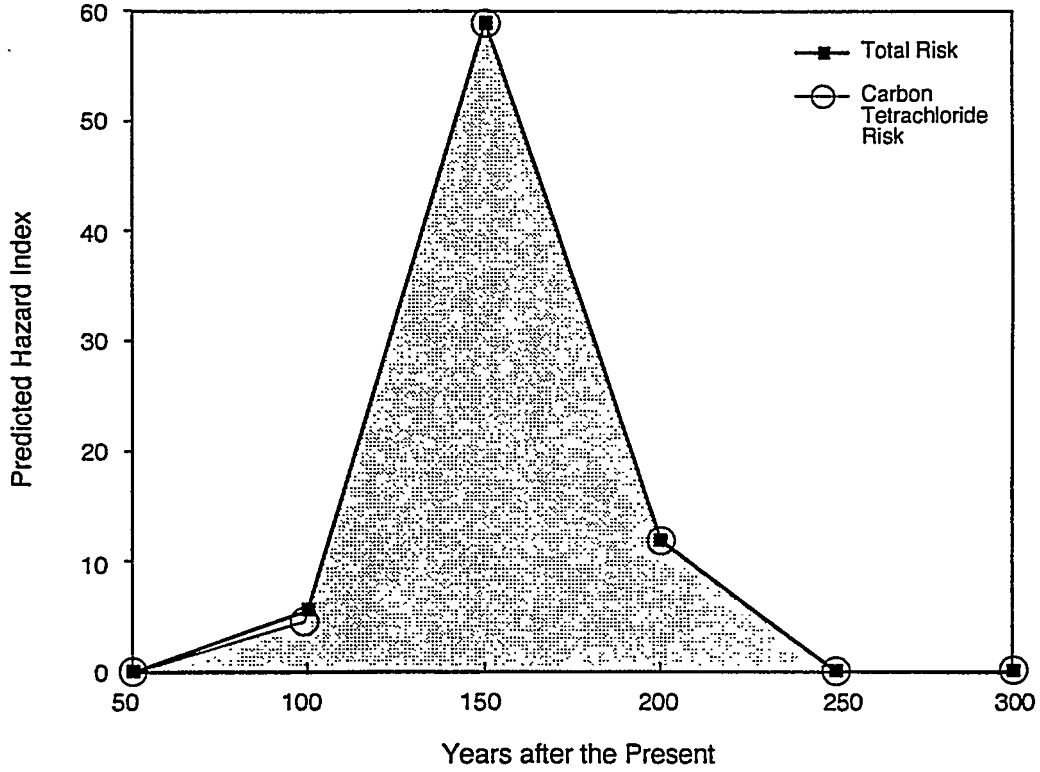


Table B-1. Contaminants of Potential Concern, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 1 of 2)

Contaminant	Eliminated by Screening Process?	Carcinogenic COPC	Noncarcinogenic COPC	Comment
1,2-Dichloroethane	No	Yes	No	
1,1-Dichloroethylene	No	Yes	No	Eliminated as a noncarcinogenic contaminant of potential concern due to risk-based screening, hazard quotient <0.1
Aldrin	Yes	No	No	One-time detection
Bis(2-ethylhexyl)phthalate	Yes	No	No	No detections in 1994/1995 data
Carbon tetrachloride	No	Yes	Yes	
Chloroform	No	Yes	Yes	
4,4'-DDD	Yes	No	No	One-time detection
4,4'-DDT	Yes	No	No	One-time detection
Dieldrin	Yes	No	No	One-time detection
Endrin	Yes	No	No	One-time detection
Endrin aldehyde	Yes	No	No	One-time detection
Gamma-BHC	Yes	No	No	One-time detection
Heptachlor	Yes	No	No	One-time detection
n-Nitrosodimethylamine	Yes	No	No	No detections in 1994/1995 data
Trichloroethylene	No	Yes	Yes	
Arsenic	No	Yes	Yes	Some detections not considered because less than background threshold of 10 µg/L[a]
Cadmium	No	No	Yes	Some detections not considered because less than background threshold of 10 µg/L[a]
Chromium	No	No	Yes	Some detections not considered because less than background threshold of <30 µg/L[a]
Fluoride	No	No	Yes	Some detections not considered because less than background threshold of 775 µg/L[a]

Table B-1. Contaminants of Potential Concern, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 2 of 2)

Contaminant	Eliminated by Screening Process?	Carcinogenic COPC	Noncarcinogenic COPC	Comment
Selenium	No	No	Yes	Some detections not considered because less than background threshold of 5 µg/L[a]
Iodine-129	No	Yes	No	
Plutonium-238	Yes	No	No	One-time detection
Potassium-40	No	Yes	No	
Strontium-90	No	Yes	No	
Technetium-99	No	Yes	No	
Uranium	No	Yes	No	Some detections not considered because less than background threshold of 3.43 pCi/L[a]

[a] Background threshold values from *Hanford Site Groundwater Background* (DOE-RL 1992a).
COPC = contaminant of potential concern

Table B-2. Human-Health Exposure Factors for the 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Exposure Factor	Commercial/Industrial Groundwater Ingestion Scenario			Residential Groundwater Ingestion Scenario		
	Noncarcinogenic	Carcinogenic (Nonradioactive)	Carcinogenic (Radioactive)	Noncarcinogenic	Carcinogenic (Nonradioactive)	Carcinogenic (Radioactive)
Intake rate (L/day)	1	1	1	1	2	2
Exposure frequency (days/year)	250	250	250	365	365	365
Exposure duration (years)	20	20	20	6	30	30
Body weight (kg)	70	70	NA[a]	16 (child)	70	NA
Averaging time (days)	7,300	25,550	NA	2,190	25,550	NA

NOTE: Exposure factors from the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995).

[a] Does not apply to exposure to radioactive carcinogens.

Table B-3. Human Toxicity Values for the 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Chronic Oral Reference Dose (mg/kg-d)	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$ [a]
1,2-Dichloroethane	NA[b]	9.1E-02
1,1-Dichloroethylene	9.0E-03	6.0E-01
Arsenic	3.0E-04	1.5E+00
Cadmium	5.0E-04	NA
Carbon tetrachloride	7.0E-04	1.3E-01
Chloroform	1.0E-02	6.1E-03
Chromium VI	5.0E-03	NA[b]
Fluoride	6.0E-02	NA[c]
Iodine-129	NA[d]	1.9E-10[e]
Potassium-40	NA[d]	1.1E-11[e]
Selenium	5.0E-03	NA[f]
Strontium-90	NA[d]	3.6E-11[e]
Technetium-99	NA[d]	1.3E-12[e]
Trichloroethylene	6.0E-03	1.1E-02
Uranium	NA[d]	2.0E-11[e]

[a] Units are inverse milligrams per kilogram-day, except where noted.
[b] Not available; oral exposure data are not available at this time.
[c] Not available; the contaminant of potential concern has not been evaluated by the U.S. Environmental Protection Agency for evidence of human carcinogenic potential.
[d] Not applicable; the chemical toxicity of radioactive contaminants of potential concern does not generally need to be evaluated pursuant to the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995).
[e] Units are inverse picocuries.
[f] Not available; the weight-of-evidence classification for selenium is Class D—not classifiable as to carcinogenicity in humans.

Table B-4. Current-Condition Maximum Concentrations and Estimated Maximum Commercial/Industrial Groundwater Ingestion Risks[a], 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Current Maximum Concentration (µg/L, unless noted)	Maximum Contaminant Level[b] (µg/L, unless noted)	Monitoring Well where Maximum Concentration is Observed	Hazard Quotient	Incremental Lifetime Cancer Risk
1,2-Dichloroethane	5.5	5	299-W22-20	NC[c]	1E-06
1,1-Dichloroethylene	3.2	7	299-W22-20	not a COPC[d]	5E-06
Arsenic	18	50	299-W18-29	6E-01	8E-05
Cadmium	22	5	299-W19-91	4E-01	NC[c]
Carbon tetrachloride	1,800	5	299-W18-21	3E+01	7E-04
Chloroform	29	7.17 or 71.7[e]	299-W19-18	3E-02	5E-07
Chromium VI	250	100	299-W22-20	5E-01	NC[c]
Fluoride	2,400	4,000	299-W19-30	4E-01	NC[c]
Iodine-129	86.1 pCi/L	21 pCi/L	299-W22-9	ND[f]	8E-05
Potassium-40	142 pCi/L	295	699-36-70A	ND[f]	8E-06
Selenium	12.8	50	299-W19-19	3E-02	NA[g]
Strontium-90	71.3 pCi/L	8 pCi/L	299-W22-1	ND[f]	1E-05
Technetium-99	2,260 pCi/L	900 pCi/L	299-W23-2	ND[f]	1E-05
Trichloroethylene	33	5	299-W22-20	5E-02	1E-06
Uranium	118	20	299-W22-21	ND[f]	4E-06

[a] The individual contaminant risks presented in this table should not be summed to estimate total risk. This is because the risks are based on maximum concentrations that do not all occur at the same monitoring well location.

[b] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from *Title 40, Code of Federal Regulations, Part 141, Subparts B and G* (EPA 1995b). The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127 (EPA 1991).

[c] Risk is not calculated because a toxicity value is not available for the chemical.

[d] Based on risk-based screening, 1,1-dichloroethylene is not a noncarcinogenic COPC.

[e] The MCL for chloroform is a risk-based standard derived from the Washington Administrative Code (WAC), Chapter 173-340, Model Toxics Control Act–Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards (Ecology 1991). The first value given is for residential exposure and the second is for nonresidential exposure.

[f] As per the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995), radionuclides are not noncarcinogenic COPCs.

[g] The U.S. Environmental Protection Agency has determined that selenium is not classifiable as to human carcinogenicity.

Table B-5. Predicted Maximum Concentrations and Groundwater Ingestion Risk at Hypothetical Future-Use Boundary Using the Eastern Flow Path, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)	Maximum Contaminant Level[a] (µg/L, unless noted)	Travel Time (years)	Commercial/Industrial Exposure Scenario		Residential Exposure Scenario	
				Hazard Quotient	Incremental Lifetime Cancer Risk	Hazard Quotient	Incremental Lifetime Cancer Risk
1,2-Dichloroethane	0.037	5	225	NC[b]	9E-09	NC[b]	4E-08
1,1-Dichloroethylene	0.034	7	285	not a COPC[c]	6E-08	not a COPC	2E-07
Arsenic	2.7	50	205	9E-02	1E-05	6E-01	5E-05
Cadmium	0.091	5	17,400	2E-03	NC[b]	1E-02	NC[b]
Carbon tetrachloride	550	5	315	8E+00	2E-04	5E+01	9E-04
Chloroform	15	7.17 or 71.7[d]	220	1E-02	3E-07	9E-02	1E-06
Chromium VI	19	100	190	4E-02	NC[b]	2E-01	NC[b]
Fluoride	220	4,000	200	4E-02	NC[b]	2E-01	NC[b]
Iodine-129	19 pCi/L	21 pCi/L	195	ND[e]	2E-05	ND[g]	8E-05
Potassium-40	30 pCi/L	295	200	ND[e]	2E-06	ND[g]	7E-06
Selenium	0.077	50	210	2E-04	NA[f]	1E-03	NA
Strontium-90	0 pCi/L	8 pCi/L	23,000	ND[e]	0	ND[e]	0
Technetium-99	73 pCi/L	900 pCi/L	205	ND[e]	5E-07	ND[e]	2E-06
Trichloroethylene	1.6	5	350	3E-03	5E-08	2E-02	2E-07
Uranium	3.8	20	1,280	ND	1E-07	ND	6E-07

[a] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from *Title 40, Code of Federal Regulations, Part 141, Subparts B and G* (EPA 1995b). The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127 (EPA 1991).

[b] Risk is not calculated because a toxicity value is not available for the chemical.

[c] Based on risk-based screening, 1,1-dichloroethylene is not a noncarcinogenic COPC.

[d] The MCL for chloroform is a risk-based standard derived from the WAC 173-340, *Model Toxics Control Act–Cleanup, Part VII—Cleanup Standards*, WAC 173-340-720, *Groundwater Cleanup Standards* (Ecology 1991). The first value given is for residential exposure, and the second is for nonresidential exposure.

[e] As per the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995), radionuclides are not noncarcinogenic COPCs.

[f] The U.S. Environmental Protection Agency has determined that selenium is not classifiable as to human carcinogenicity.

Table B-6. Predicted Analytical Model of Maximum Concentrations and Groundwater Ingestion Risk at the Hypothetical Future-Use Boundary Using the Northern Flow Path.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)	Maximum Contaminant Level[a] (µg/L, unless noted)	Travel Time (years)	Commercial/ Industrial Exposure Scenario		Residential Exposure Scenario	
				Hazard Quotient	ILCR	Hazard Quotient	ILCR
1,2-Dichloroethane	0.051	5	115	NC[b]	1E-08	NC[b]	6E-08
1,1-Dichloroethylene	0.046	7	145	Not a COPC[c]	8E-08	Not a COPC	3E-07
Arsenic	3.3	50	105	1E-01	1E-05	7E-01	6E-05
Cadmium	0.12	5	8,830	2E-03	NC	2E-02	NC
Carbon tetrachloride	670	5	160	9E+00	2E-04	6E+01	1E-03
Chloroform	18	7.17 or 71.7[d]	105	2E-02	3E-07	1E-01	1E-06
Chromium VI	25	100	95	0.05	NC	0.3	NC
Fluoride	290	4,000	100	5E-02	NC	3E-01	NC
Iodine-129	24 pCi/L	0.48 pCi/L	100	ND[e]	2E-05	ND	1E-04
Potassium-40	39 pCi/L	295	100	ND	2E-06	ND	9E-06
Selenium	0.11	50	105	2E-04	NA[f]	1E-03	NA
Strontium-90	0 pCi/L	8 pCi/L	11,700	ND	0E+00	ND	0E+00
Technetium-99	100 pCi/L	900 pCi/L	105	ND	7E-07	ND	3E-06
Trichloroethylene	2.2	5	175	4E-03	7E-08	2E-02	3E-07
Uranium	5.1	44[g]	635	ND	2E-07	ND	7E-07

ILCR = incremental lifetime cancer risk
NA = not available
ND = not detected

[a] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from 40 CFR, Subparts B and G. The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127.

[b] Risk is not calculated because a toxicity value is not available for the chemical.

[c] Based on risk-based screening, 1,1-dichloroethylene is not a noncarcinogenic COPC.

[d] The MCL for chloroform is a risk-based standard derived from WAC 173-340, Model Toxics Control Act-Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards). The first value given is for residential exposure and the second is for nonresidential exposure.

[e] As per the *Hanford Site Risk Assessment Methodology* (DOE-RL 1995c), radionuclides are not noncarcinogenic COPCs.

[f] The U.S. Environmental Protection Agency has determined that selenium is not classifiable as to human carcinogenicity.

[g] 40 CFR 192.02, Uranium Mill Tailings Radiation Control Act.

Table B-7. Definition of Ecological Contaminants of Potential Concern, 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Chemical Abstracts Service Number	Chemical	One-Time Detection	Background Threshold Value[a] (µg/L, unless noted)	Predicted Maximum Concentration at Columbia River[b] (µg/L, unless noted)	Environmental Risk-Based Screening Needed?
000309-00-2	Aldrin	Yes			No
022541-54-4	Arsenic III		10[c]	1.6[c]	No
017428-41-0	Arsenic V		10[c]	1.6[c]	No
000058-89-9	BHC, gamma-	Yes			No
000117-81-7	Bis(2-ethylhexyl)phthalate	Yes			No
007440-43-9	Cadmium		10	0.058	No
000056-23-5	Carbon tetrachloride			370	Yes
000067-66-3	Chloroform			11	Yes
018540-29-9	Chromium VI		<30[c]	13[c]	No
000072-54-8	4,4'-DDD	Yes			No
000050-29-3	DDT	Yes			No
000107-06-2	1,2-dichloroethane			0.024	Yes
000075-35-4	1,1-dichloroethylene			0.022	Yes
000060-57-1	Dieldrin	Yes			No
000072-20-8	Endrin	Yes			No
007421-93-4	Endrin aldehyde	Yes			No
007782-41-4	Fluoride		775	140	No
000076-44-8	Heptachlor	Yes			No
015046-84-1	Iodine-129			12 pCi/L	Yes
000062-75-9	n-Nitrosodimethylamine	Yes			No
007440-07-5	Plutonium-238	Yes			No
None	Potassium-40			20 pCi/L	Yes
007782-49-2	Selenium		5	0.049	No
010098-97-2	Strontium-90			0 pCi/L	No
014133-76-7	Technetium-99			46 pCi/L	Yes
000079-01-6	Trichloroethylene			1.1	Yes
007440-61-1	Uranium		4.87	2.5	No

[a] Background threshold values from the *Hanford Site Groundwater Background* (DOE-RL 1992a).
[b] Predicted maximum concentrations using the northern groundwater flow path results (Attachment B.3).
[c] All reported chromium is assumed to be +6 valence in the risk assessment.

Table B-8. Ecological Risk-Based Screening Aquatic Freshwater Quality Criteria for the 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Chemical	Predicted Maximum Concentration at Columbia River[a] (µg/L unless otherwise noted)	National Ambient Water Quality Criterion Advisory Values[b] - Acute (µg/L unless otherwise noted)	National Ambient Water Quality Criterion Advisory Values[b] - Chronic (µg/L unless otherwise noted)	Tier 2 Secondary Acute Value[c] (µg/L)	Tier 2 Secondary Chronic Value[c] (µg/L)	Estimated Dose to Small Insects and Larvae at Max. Conc. (µGy/h)[d]	DOE Order 5400.5 DCG (pCi/L)	Ecological Criteria/ Advisory Exceeded?
Carbon tetrachloride	370	690	63	4,090	229			Yes
Chloroform	11	570	14	3,360	188			No
1,2-Dichloroethane	0.024	2,300	144	13,500	1,100			No
1,1-Dichloroethylene	0.022	590	15	3,520	196			No
Iodine-129	12 pCi/L	NA	NA			6.7E-4	500	No
Potassium-40	20 pCi/L	NA	NA			1.2	7,000	No
Technetium-99	46 pCi/L	NA	NA			2E-3	100,000	No
Trichloroethylene	1.1	880	55	43,50	465			No

[a] Predicted concentrations assume no mixing or dilution from the river.

[b] National Ambient Water Quality Criterion Advisory Values based on Sutter et al. (1992)--No promulgated values.

[c] Concentrations that would be expected to be higher than the NAWQC in no more than 20% of the cases. Values are based upon the method described in EPA's Proposed Water Quality Guidance for the Great Lakes System.

[d] DOE Aquatic Biota Guideline Dose Limit = 400 µGy/h.

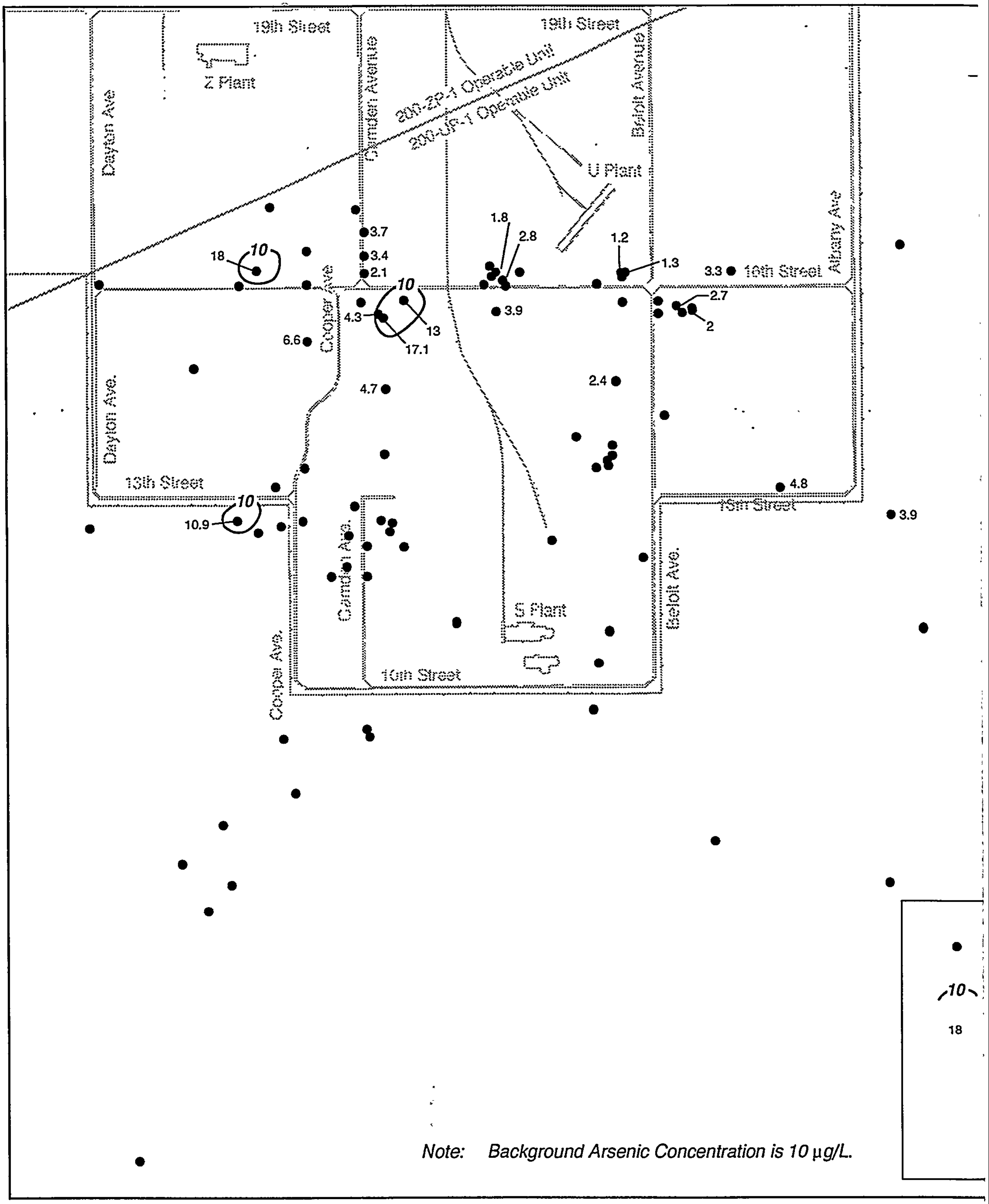
DCG = Derived Concentration Guideline.

Table B-9. Summary of Human-Health Risk Assessment for the 200-UP-1 Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Risk Assessment Results
1,2-Dichloroethane	Detected at only one monitoring well; not a significant contributor to risk.
1,1-Dichloroethylene	Detected at only one monitoring well; not a significant contributor to risk.
Arsenic	Very few detections above the background threshold value; not a significant contributor to risk.
Cadmium	Detected above the background threshold value at only one monitoring well; not a significant contributor to risk.
Carbon tetrachloride	Detected in relatively high concentrations; predominant contributor to current- and future-condition carcinogenic and noncarcinogenic risk.
Chloroform	Widespread detections; not a major contributor to risk.
Chromium	Many detections; if present predominantly as hexavalent chromium; not a significant contributor to risk.
Fluoride	Widespread detections; not a significant contributor to risk.
Iodine-129	Present as well-defined plume; where present, iodine-129 is a contributor to current- and future-condition carcinogenic risk, second only to carbon tetrachloride.
Potassium-40	Widespread detections, very consistent concentrations; not a significant contributor to total carcinogenic risk.
Selenium	Very few detections above the background threshold value; not a significant contributor to risk.
Strontium-90	A few detections contribute to current-condition carcinogenic risk; due to strong sorption and relatively rapid radioactive decay, should not reach the hypothetical future-use boundary.
Technetium-99	A few detections contribute to current-condition carcinogenic risk; not a significant contributor to total future-condition carcinogenic risk.
Trichloroethylene	This contaminant is not a significant contributor to total current-condition risk; not a significant contributor to future-condition risk.
Uranium	Not a significant contributor to total current-condition carcinogenic risk; not a significant contributor to future-condition risk.

ATTACHMENT B.1

CONCENTRATION CONTOUR MAPS FOR 200-UP-1 GROUNDWATER OPERABLE UNIT RISK ASSESSMENT CONTAMINANTS OF POTENTIAL CONCERN



Note: *Background Arsenic Concentration is 10 µg/L.*

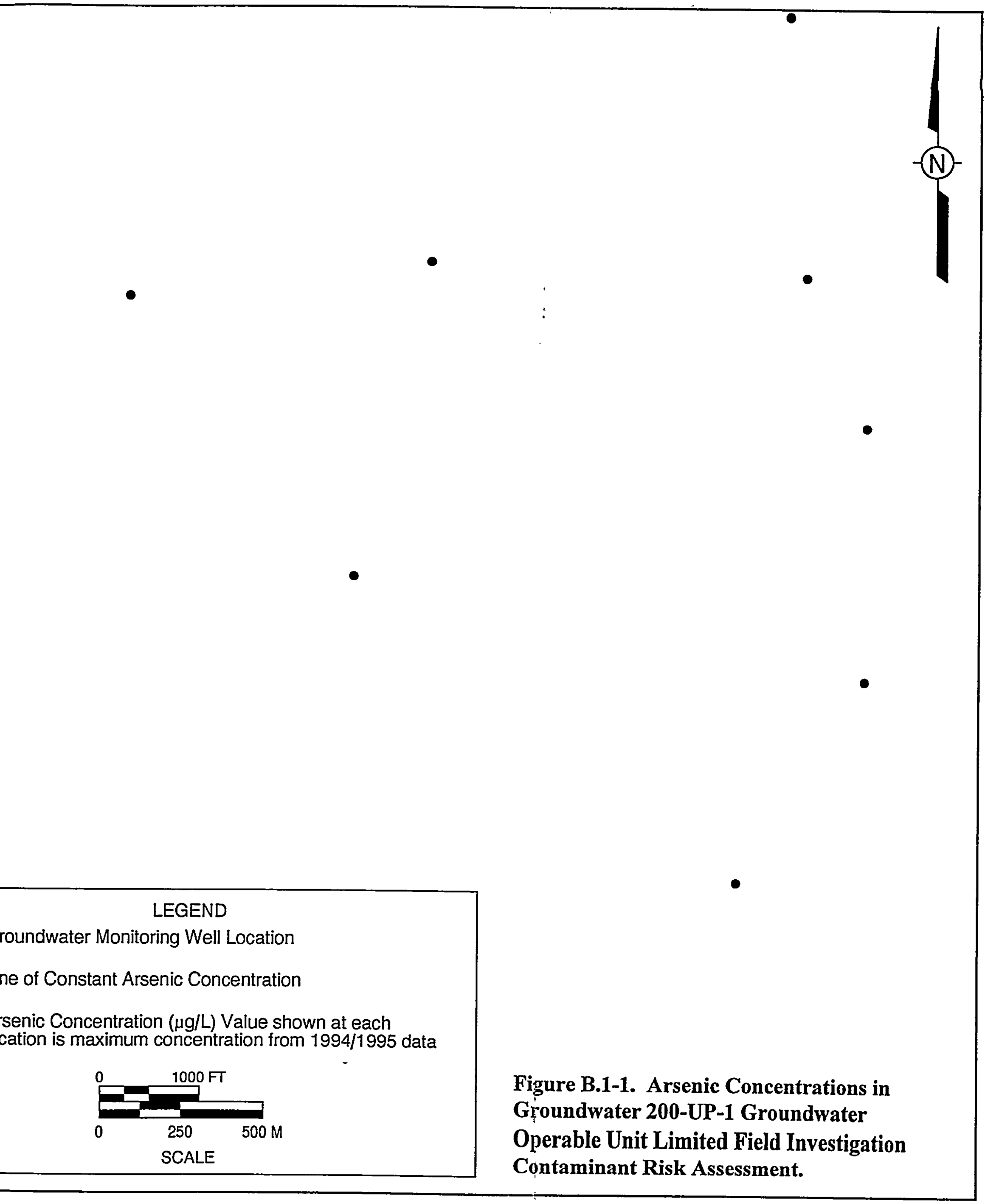
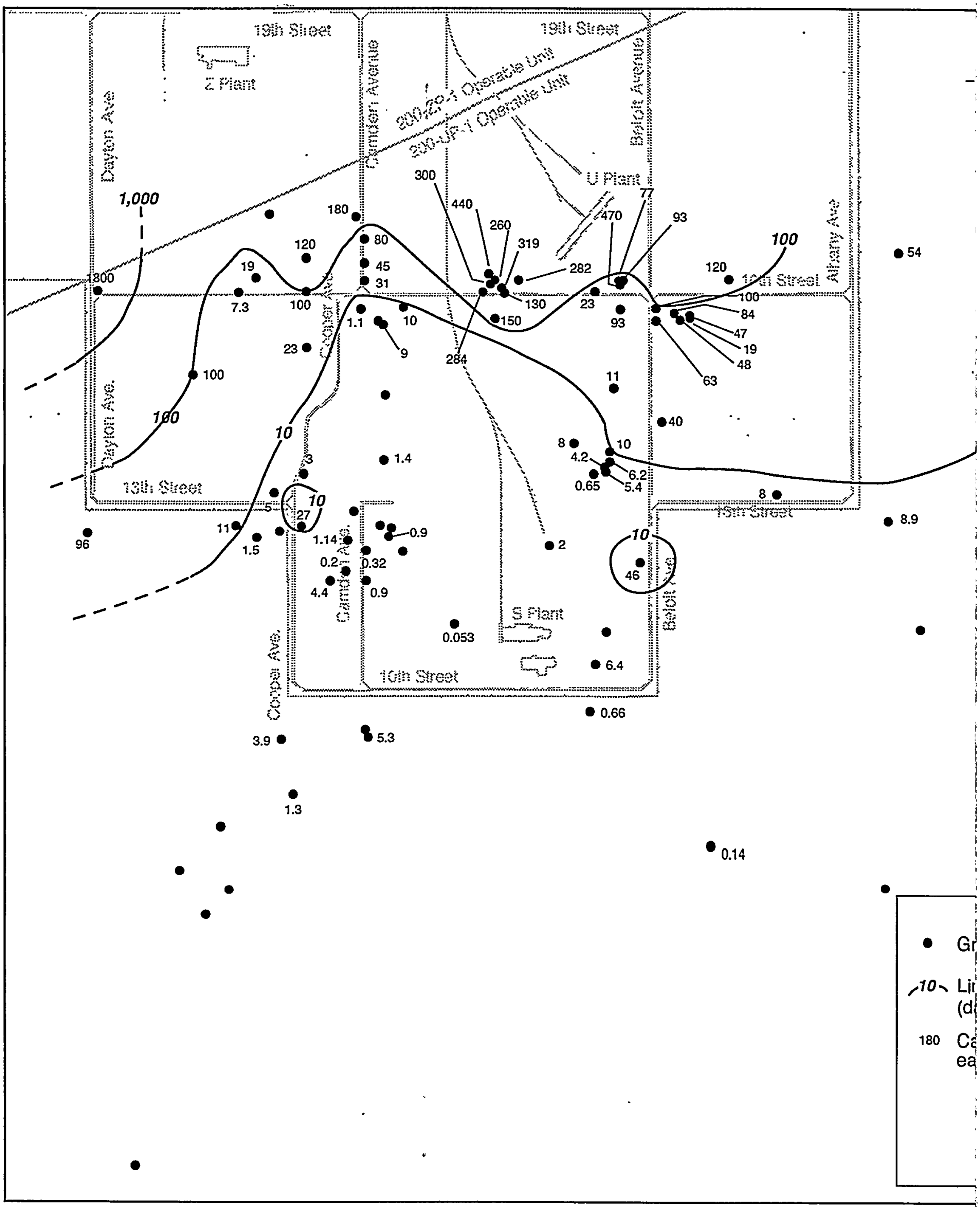


Figure B.1-1. Arsenic Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

762121.201.PT.RA4/zc B4



2/26/96

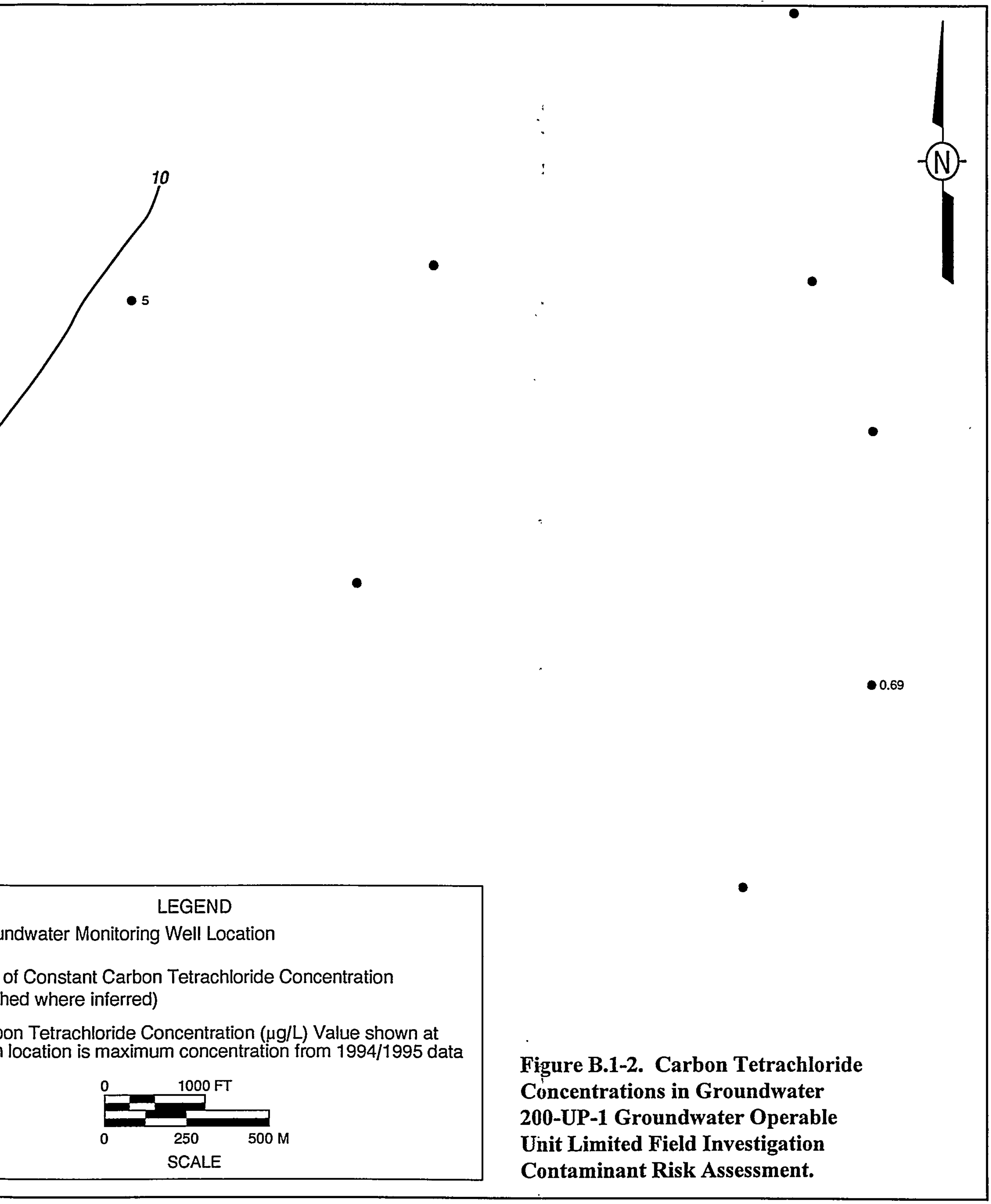
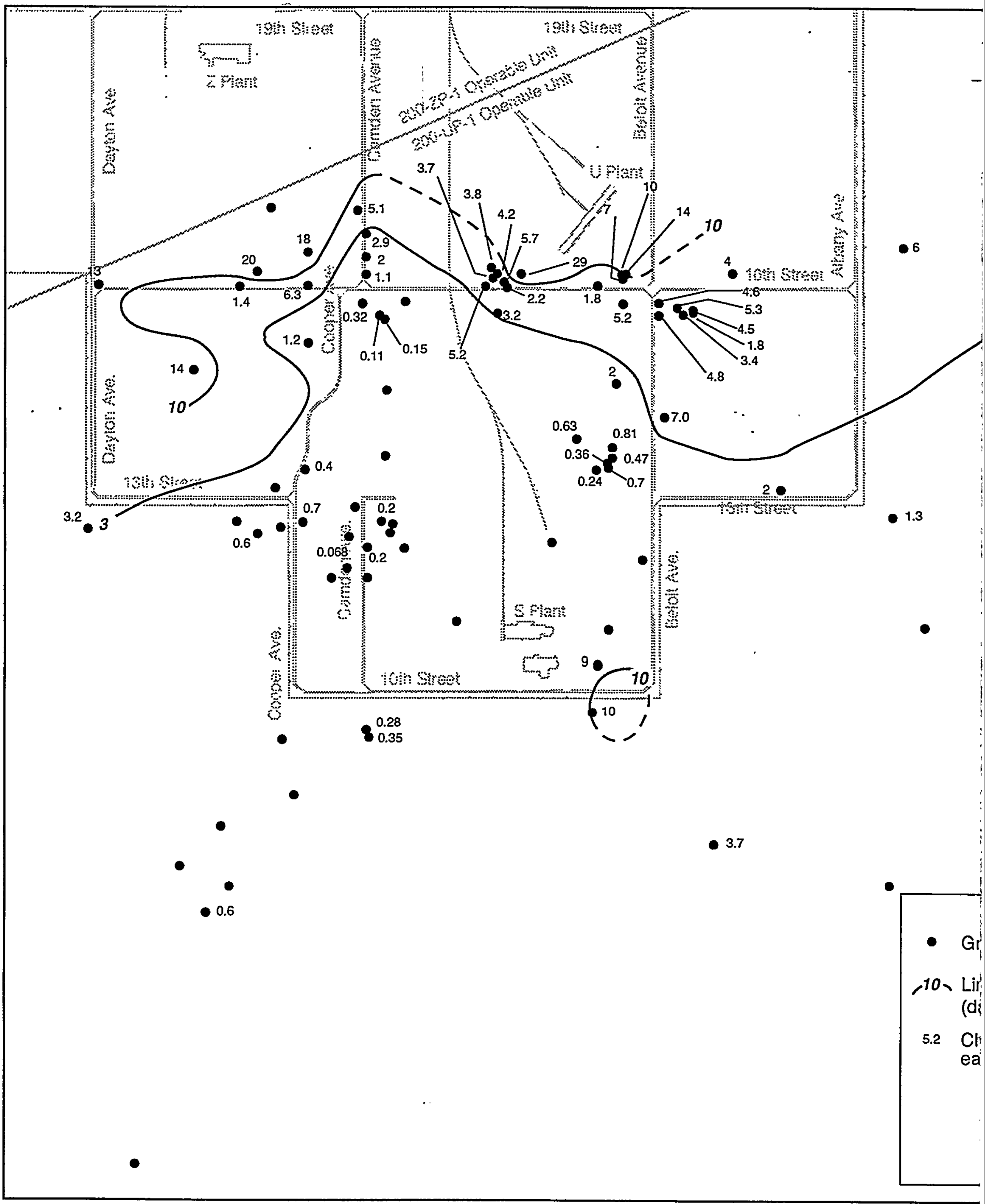


Figure B.1-2. Carbon Tetrachloride Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

762121.201.PT.RA4/zc B5



2/26/96

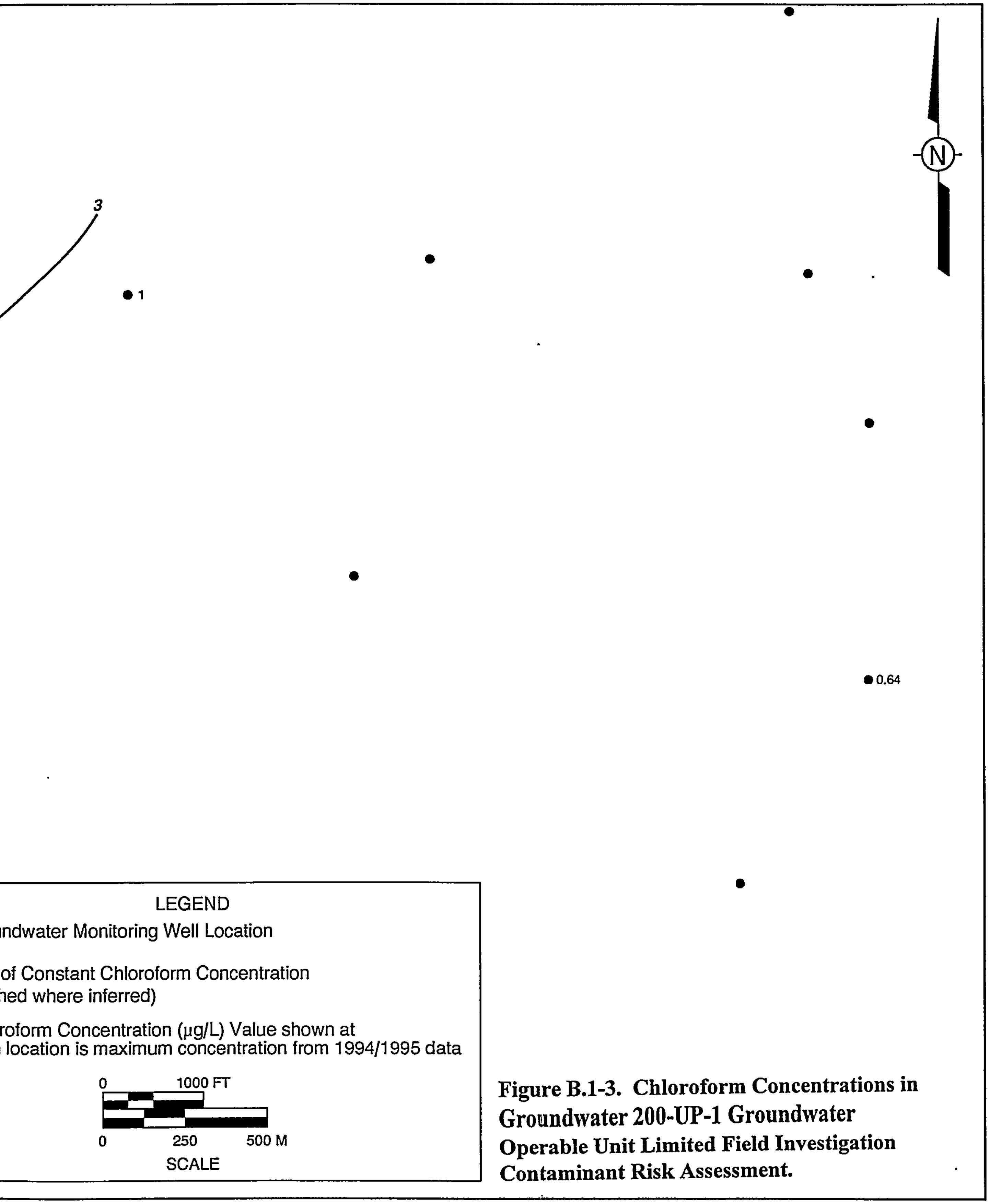
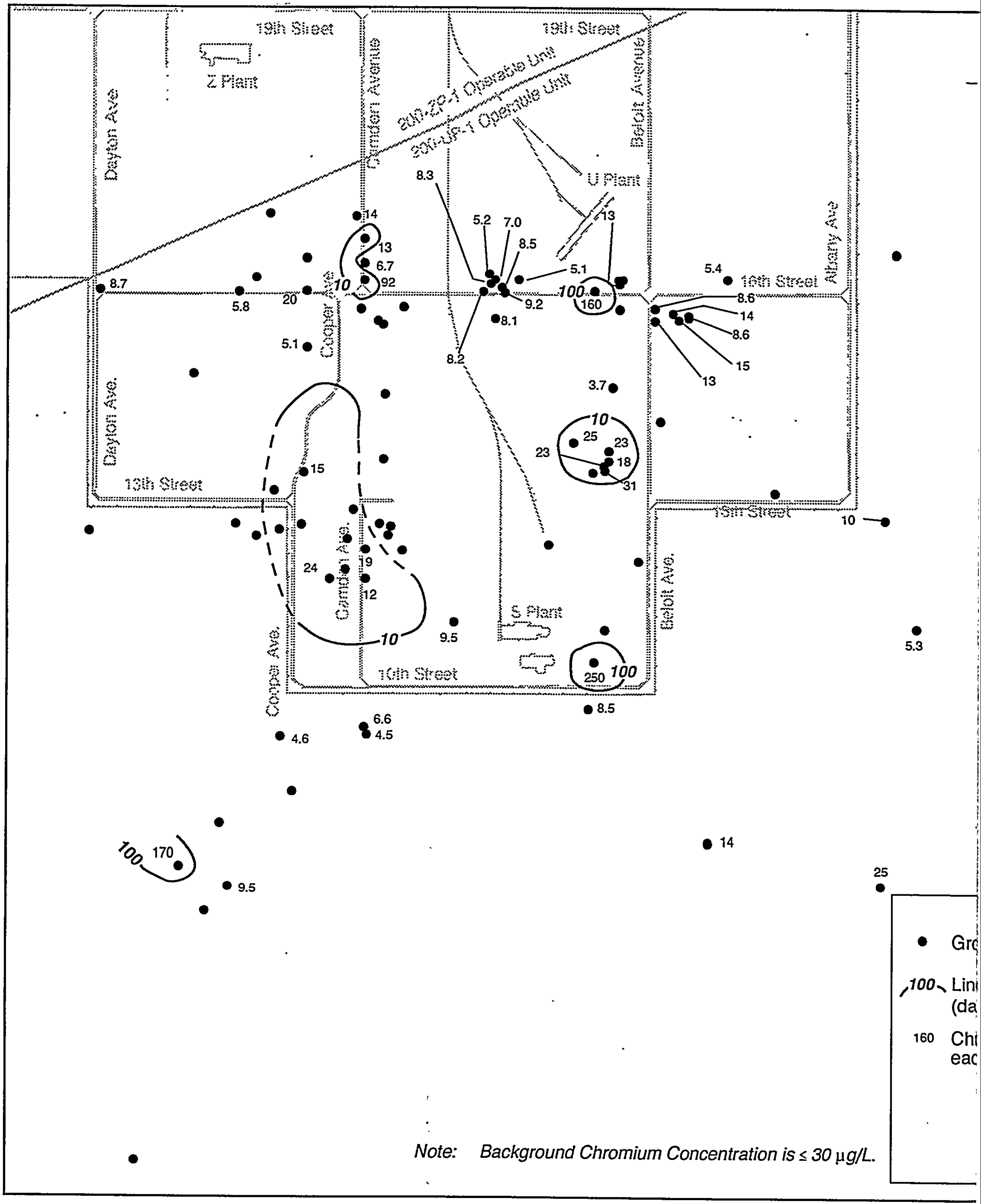


Figure B.1-3. Chloroform Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: Background Chromium Concentration is ≤ 30 µg/L.

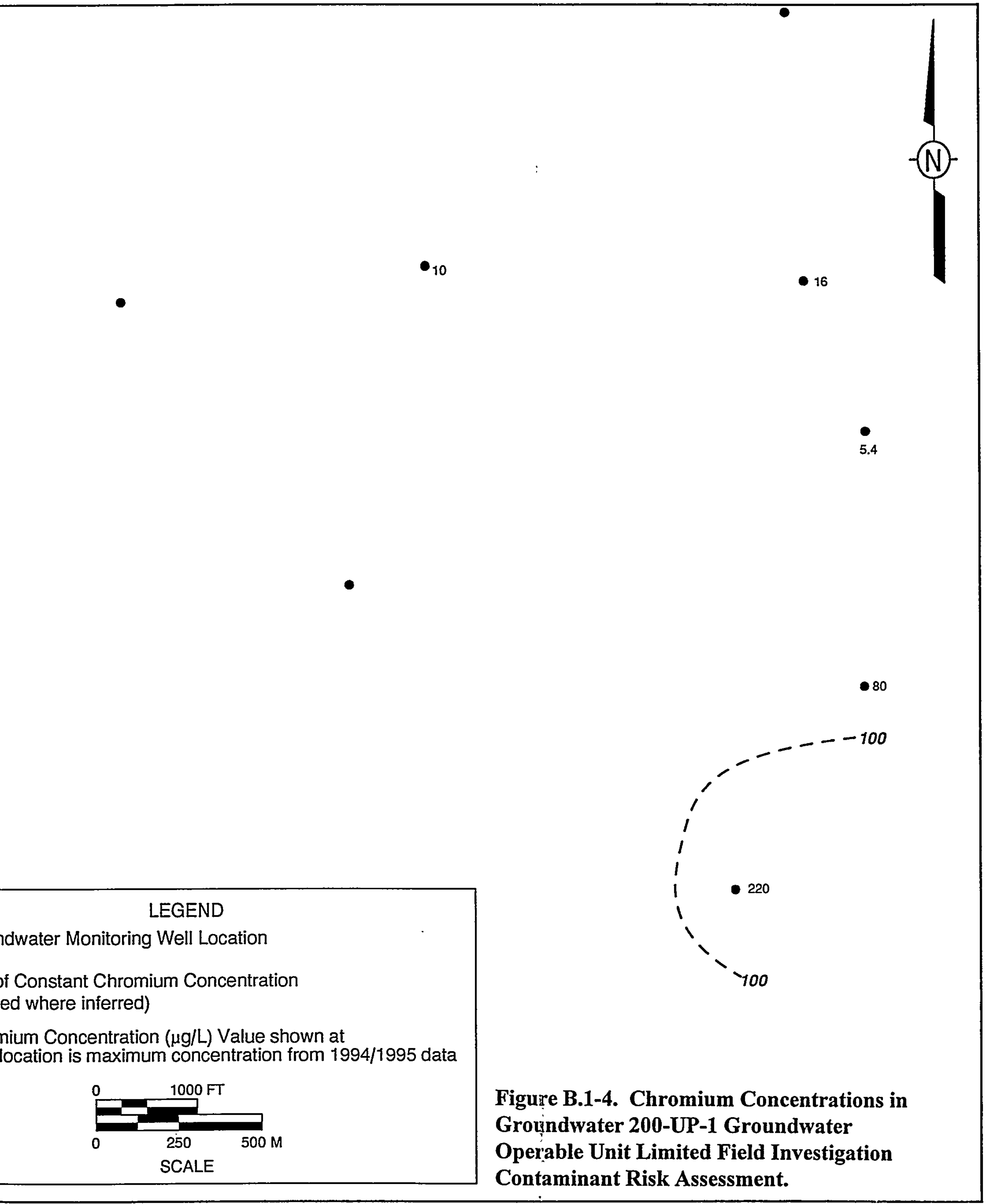
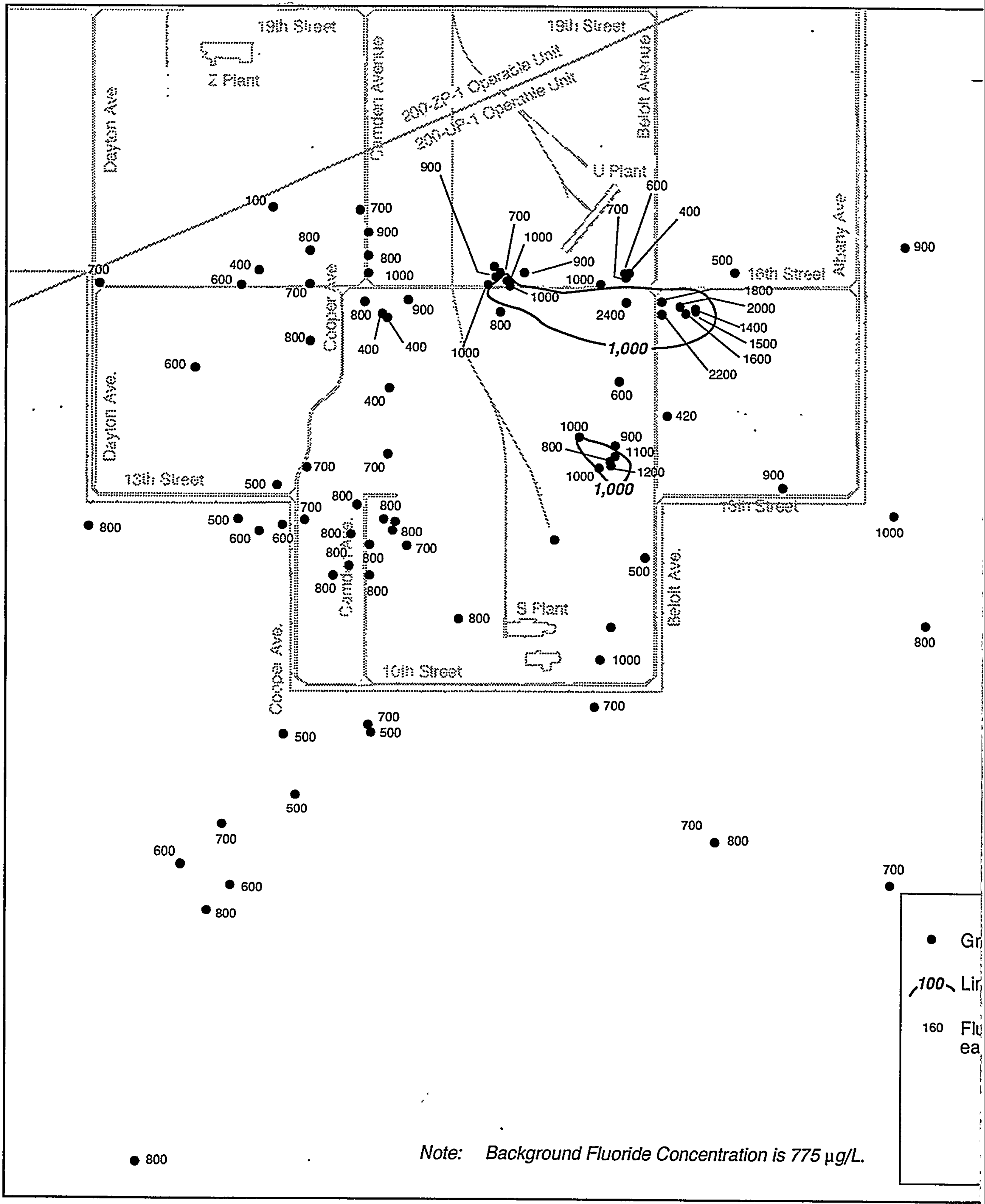


Figure B.1-4. Chromium Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: *Background Fluoride Concentration is 775 µg/L.*

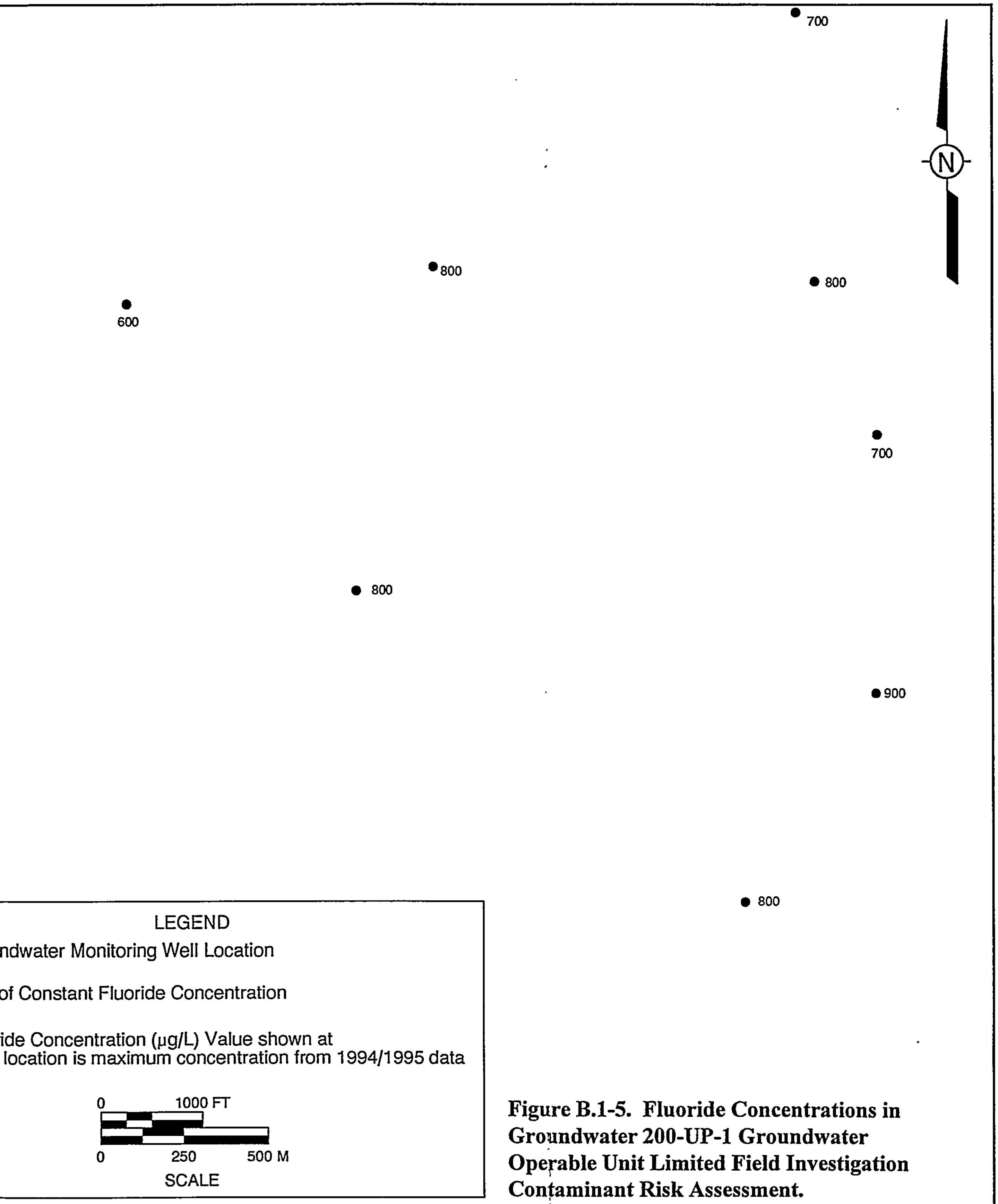
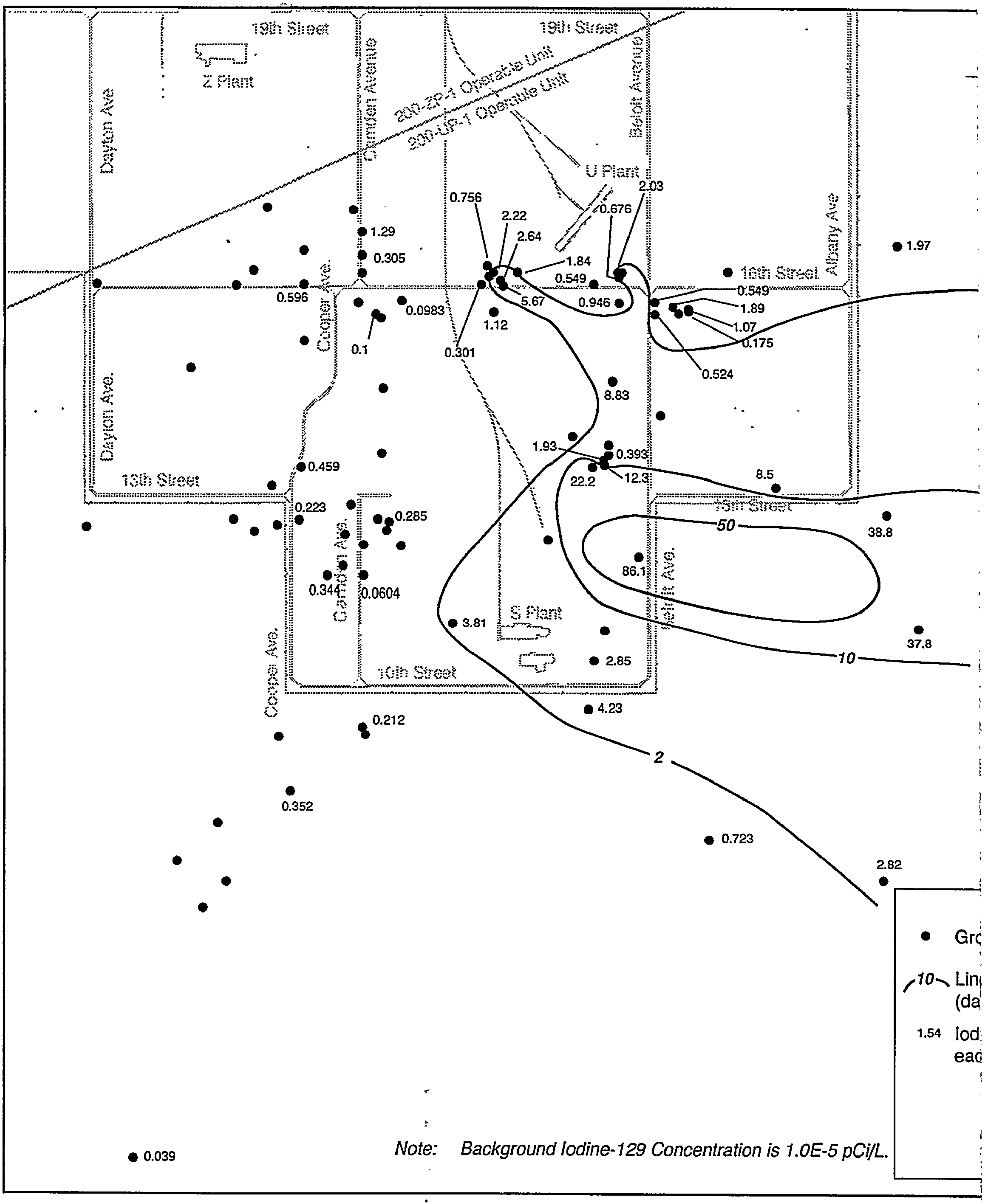


Figure B.1-5. Fluoride Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

762121.201.PT.RA4/zc B8



Note: Background Iodine-129 Concentration is 1.0E-5 pCi/L.

2/26/96

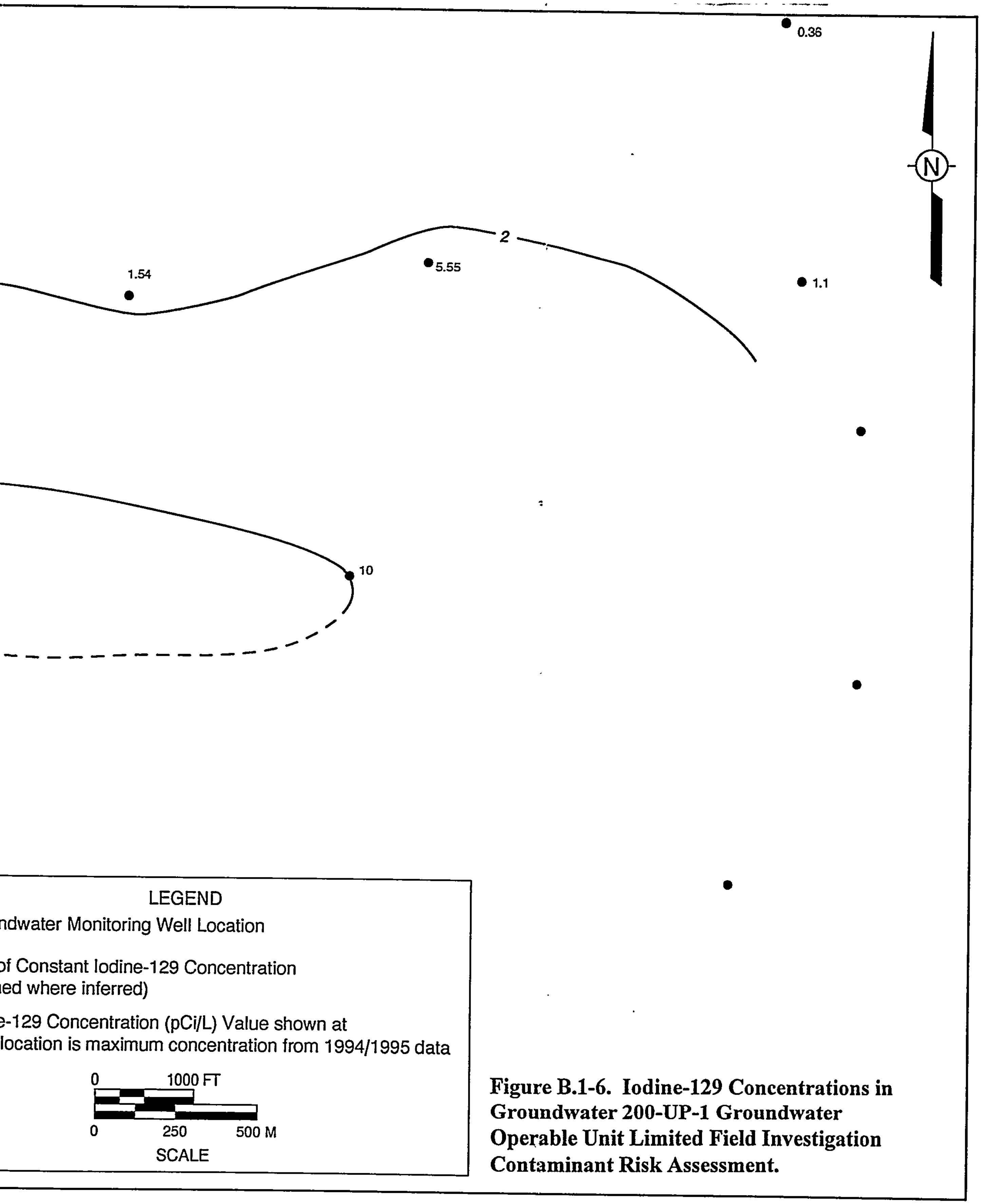
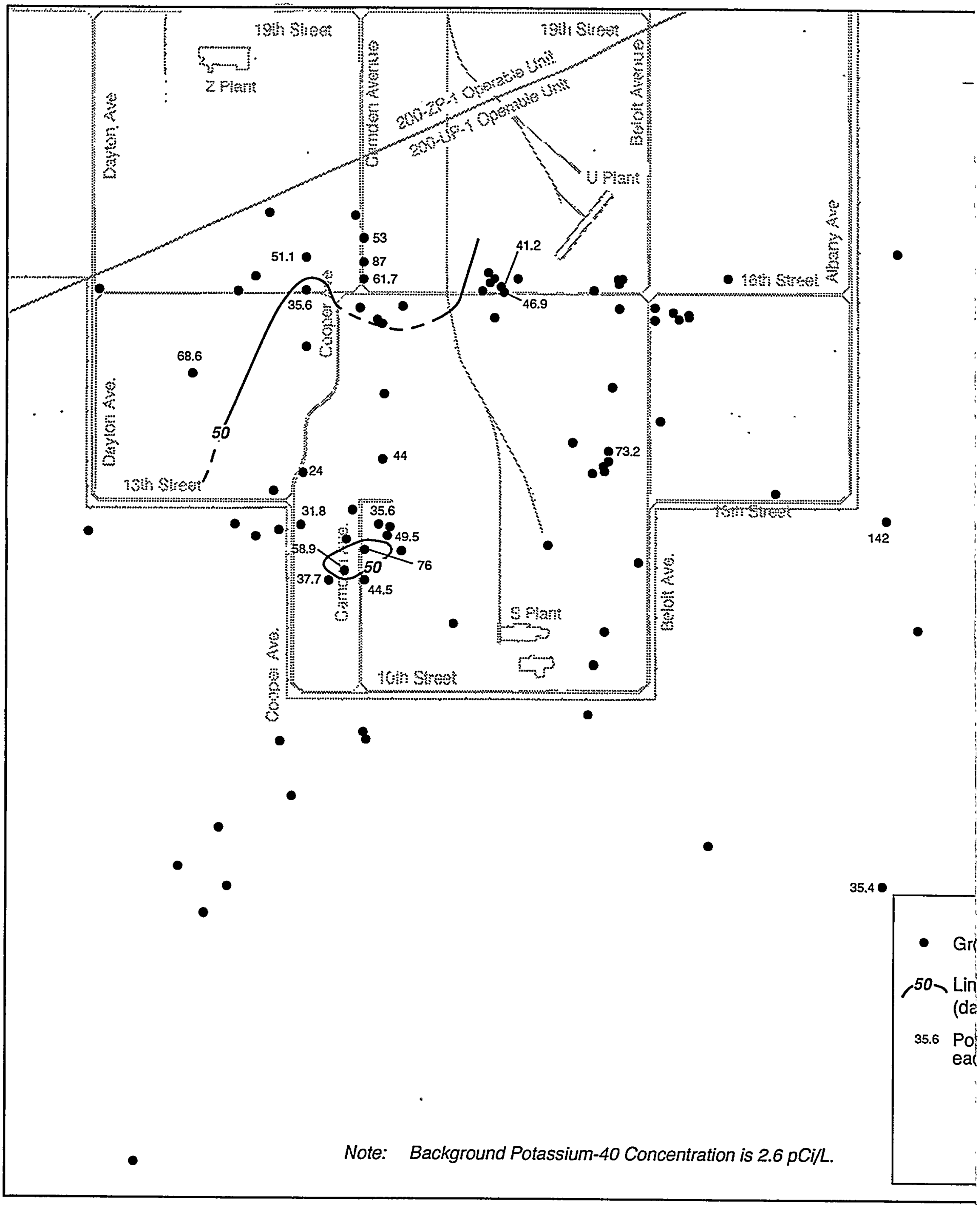


Figure B.1-6. Iodine-129 Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: Background Potassium-40 Concentration is 2.6 pCi/L.

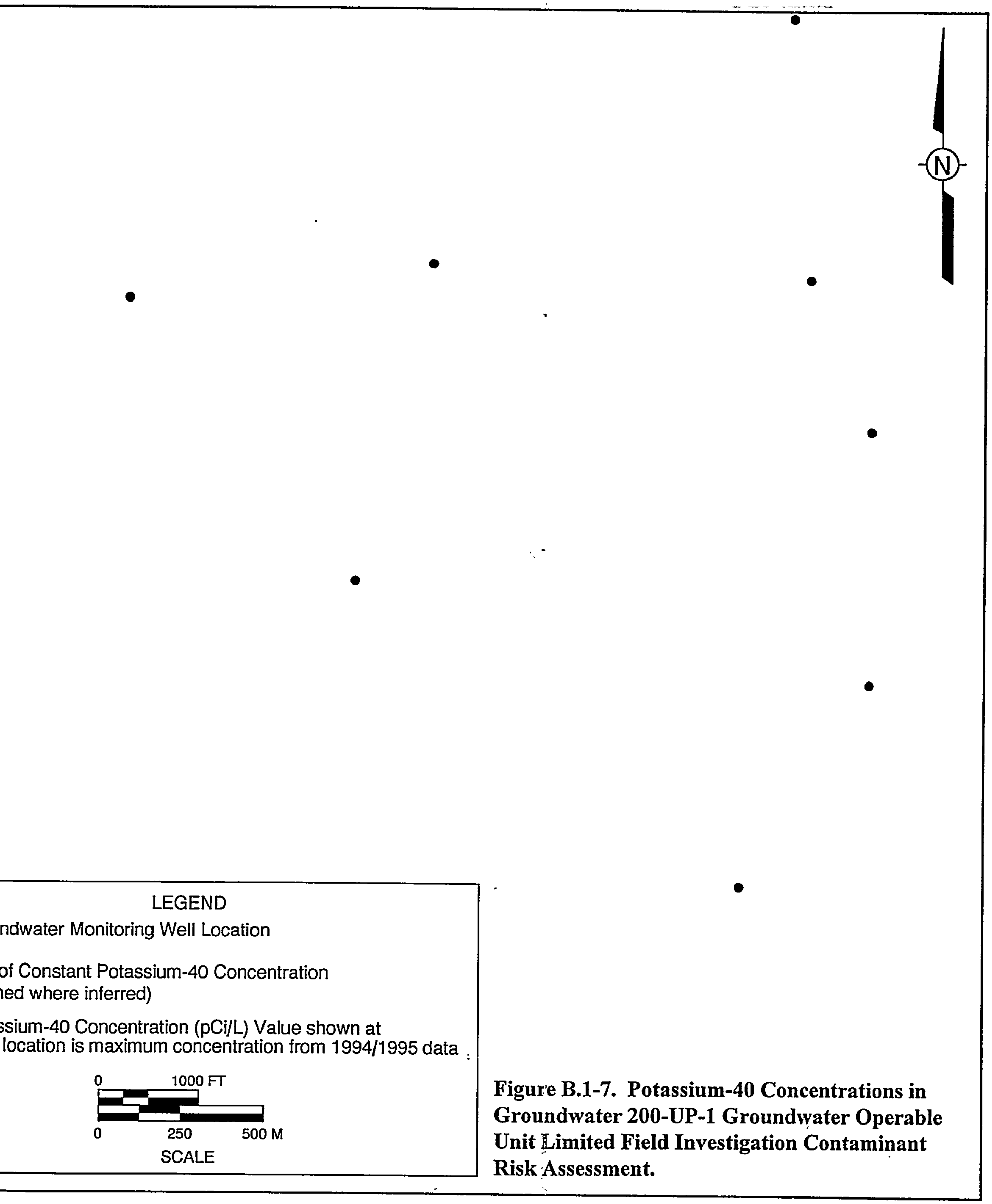
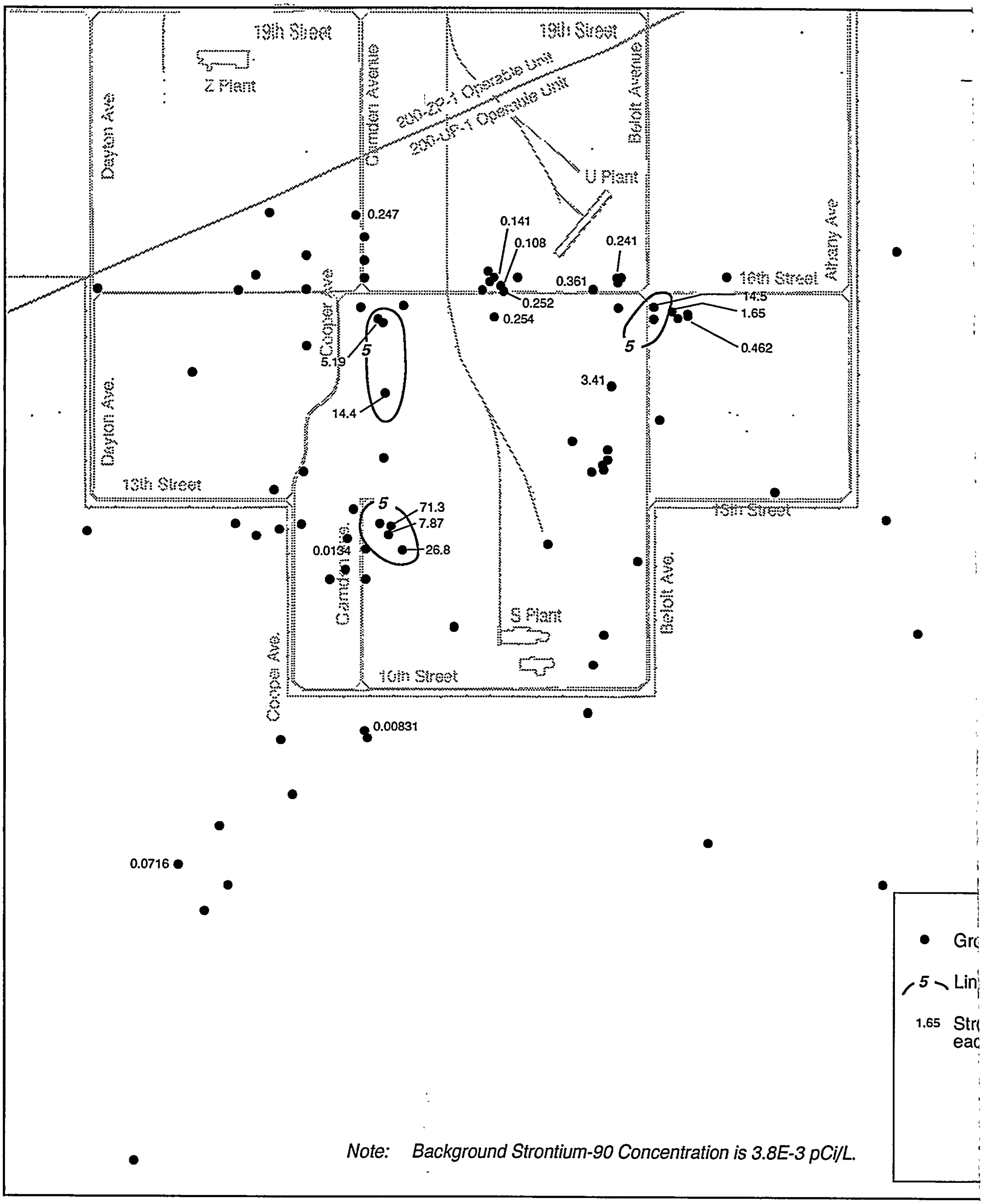


Figure B.1-7. Potassium-40 Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: Background Strontium-90 Concentration is 3.8E-3 pCi/L.

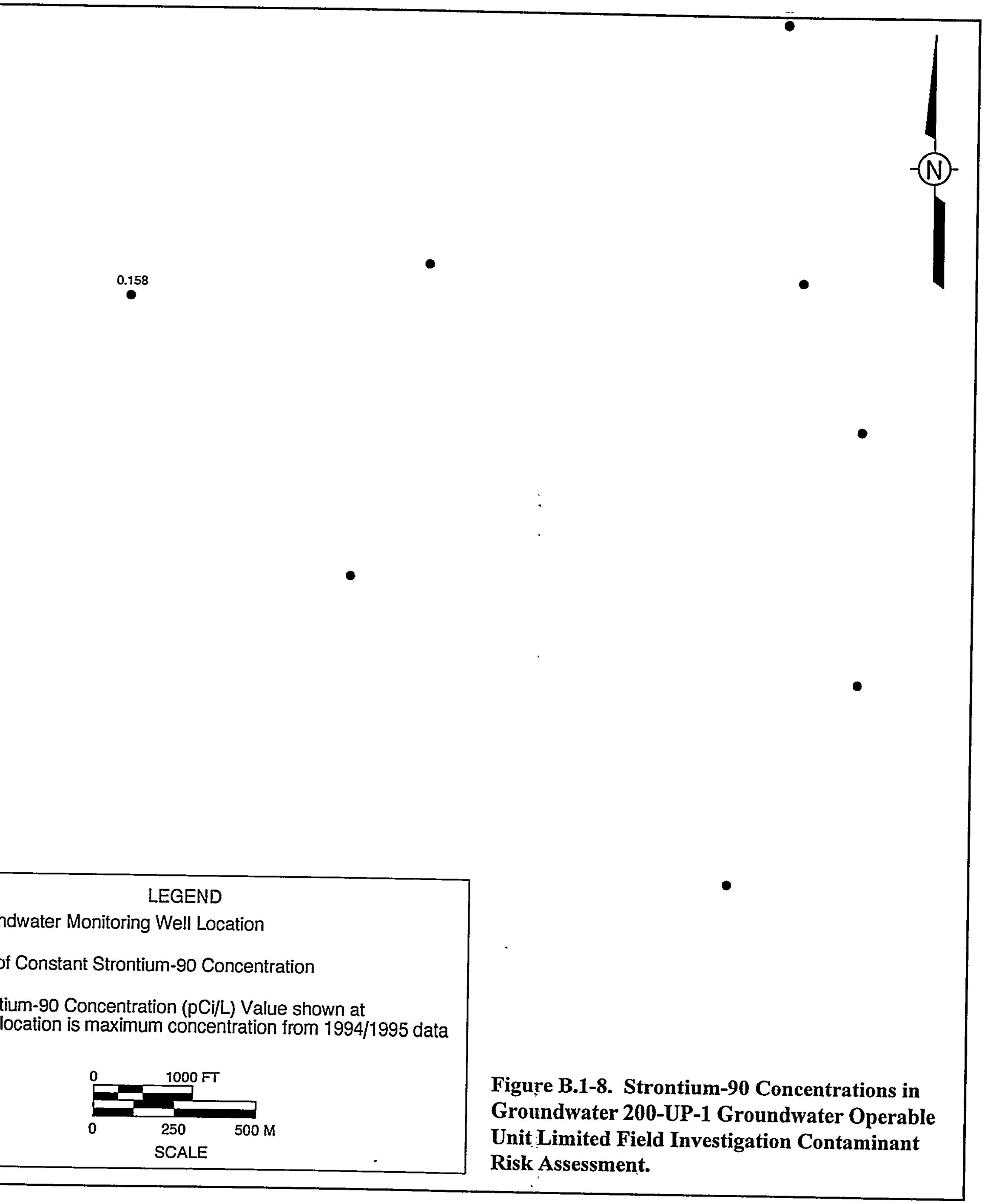
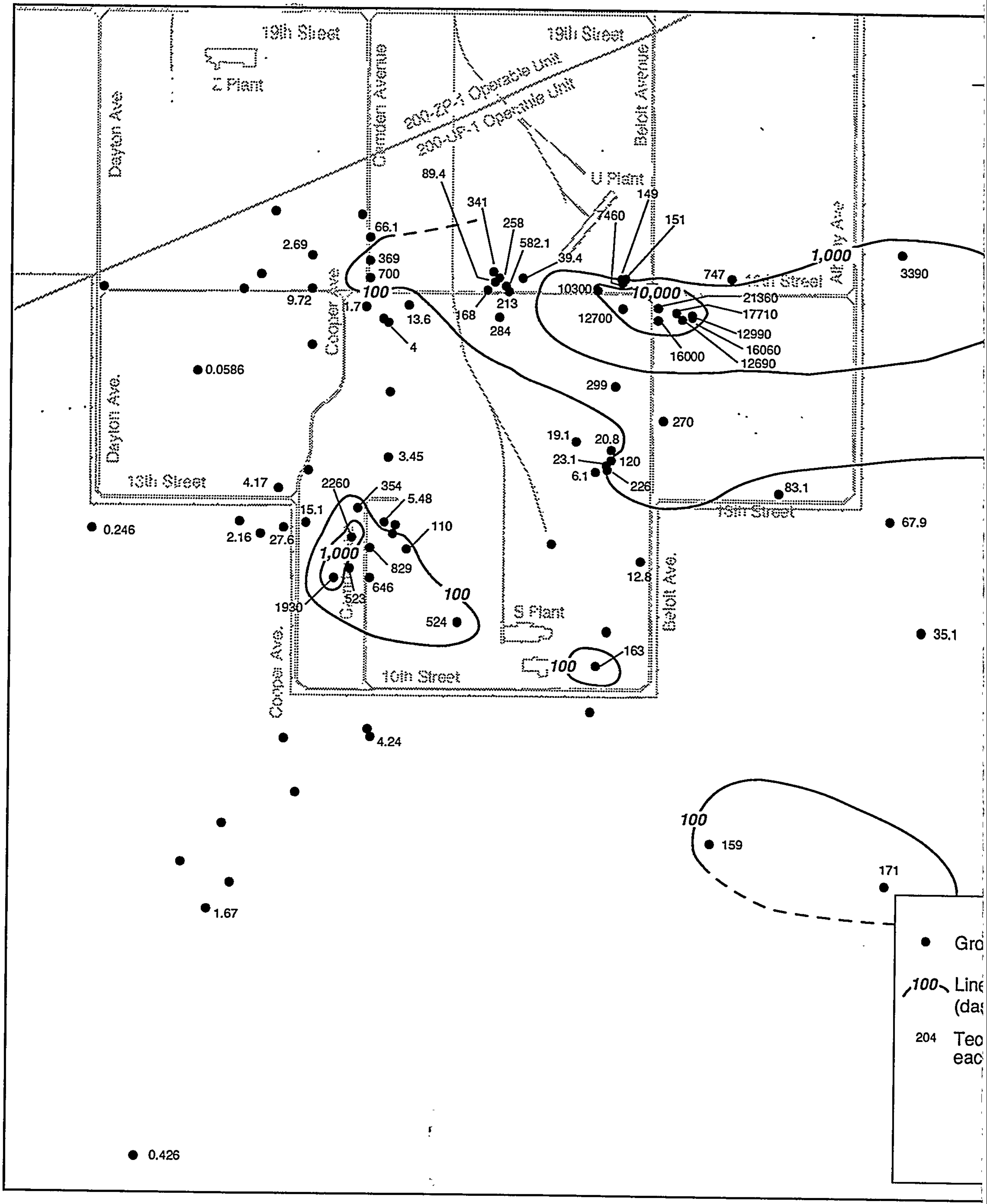


Figure B.1-8. Strontium-90 Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.


19th Street
Z Plant
19th Street
Dayton Ave.
Camden Avenue
200-ZP-1 Operable Unit
200-UP-1 Operable Unit
Beloit Avenue
U Plant
Cooper Ave.
Dayton Ave.
13th Street
16th Street
Albany Ave.
15th Street
S Plant
10th Street
Cooper Ave.
Beloit Ave.
100
1,000
10,000
89.4
341
258
582.1
39.4
7460
149
151
66.1
2.69
369
700
9.72
1.7
13.6
4
168
213
284
10300
12700
21360
17710
12990
16060
16000
12690
747
3390
0.0586
299
270
19.1
20.8
23.1
120
6.1
226
83.1
3.45
4.17
2260
354
5.48
15.1
110
0.246
2.16
27.6
829
646
523
1930
524
67.9
12.8
163
35.1
4.24
159
171
1.67
0.426
Gro
Line
(das
204
Tec
eac

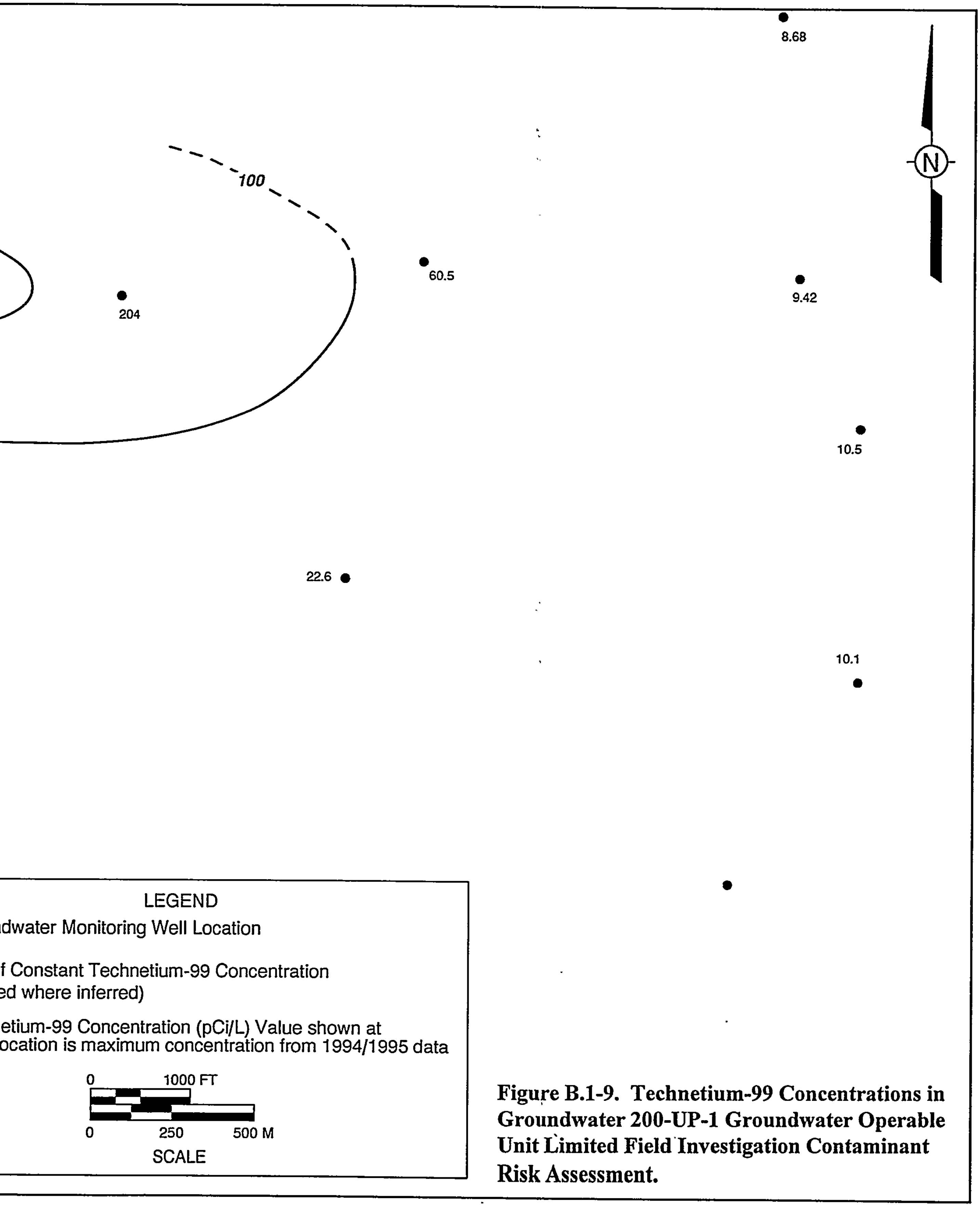
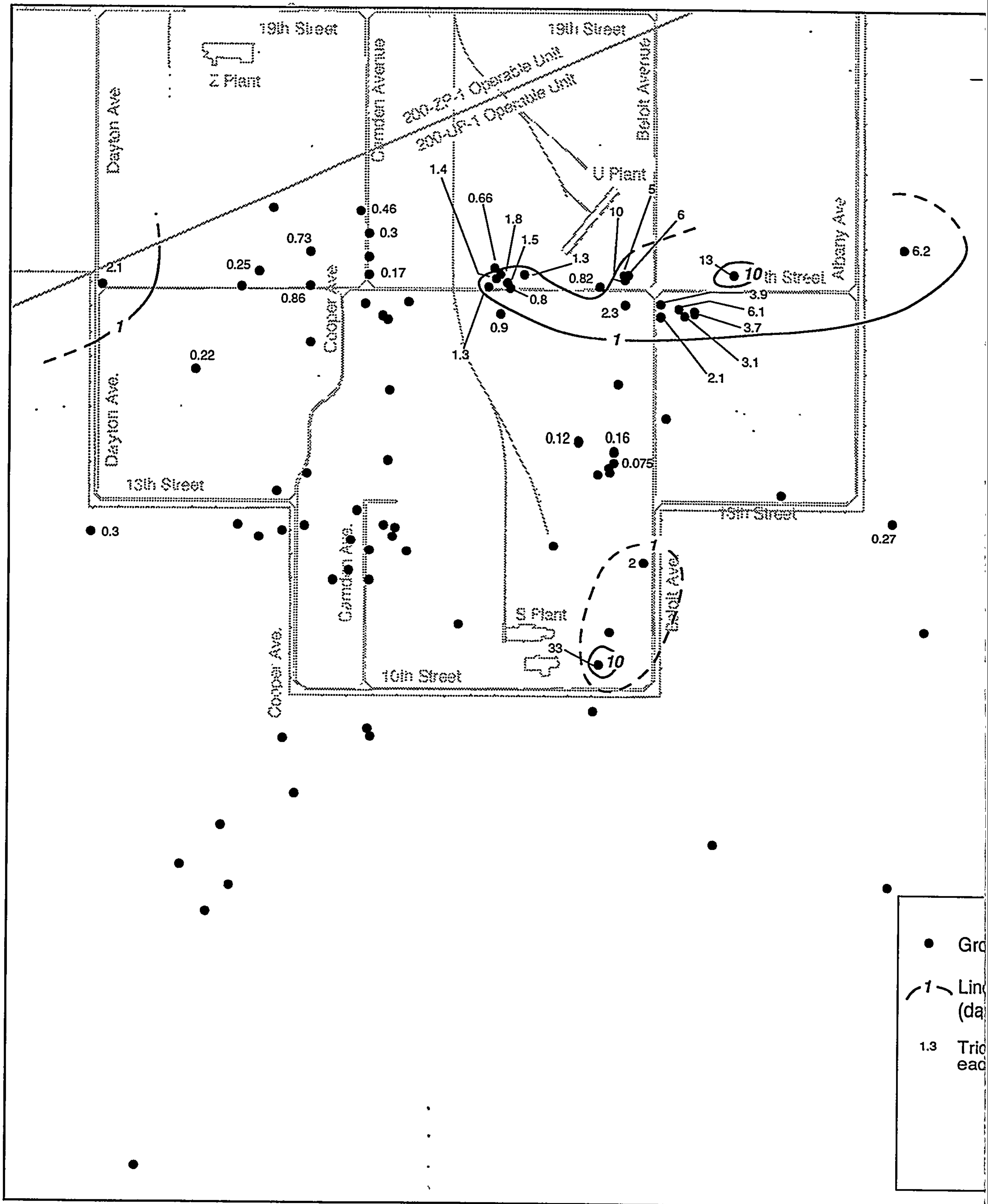


Figure B.1-9. Technetium-99 Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.


19th Street
19th Street
Z Plant
Dayton Ave.
Camden Avenue
200-ZP-1 Operable Unit
200-UP-1 Operable Unit
Beloit Avenue
U Plant
Albany Ave
Cooper Ave
Dayton Ave.
13th Street
15th Street
10th Street
Camden Ave.
Cooper Ave.
S Plant
10th Street
Beloit Ave.
1
10
10
1
1
2.1
0.25
0.73
0.86
0.46
0.3
0.17
0.22
1.4
0.66
1.8
1.5
1.3
0.82
10
5
6
0.8
0.9
1.3
2.3
13
3.9
6.1
3.7
3.1
2.1
6.2
0.12
0.16
0.075
0.3
2
33
0.27
Gro
Lin
(da
1.3
Tric
eac

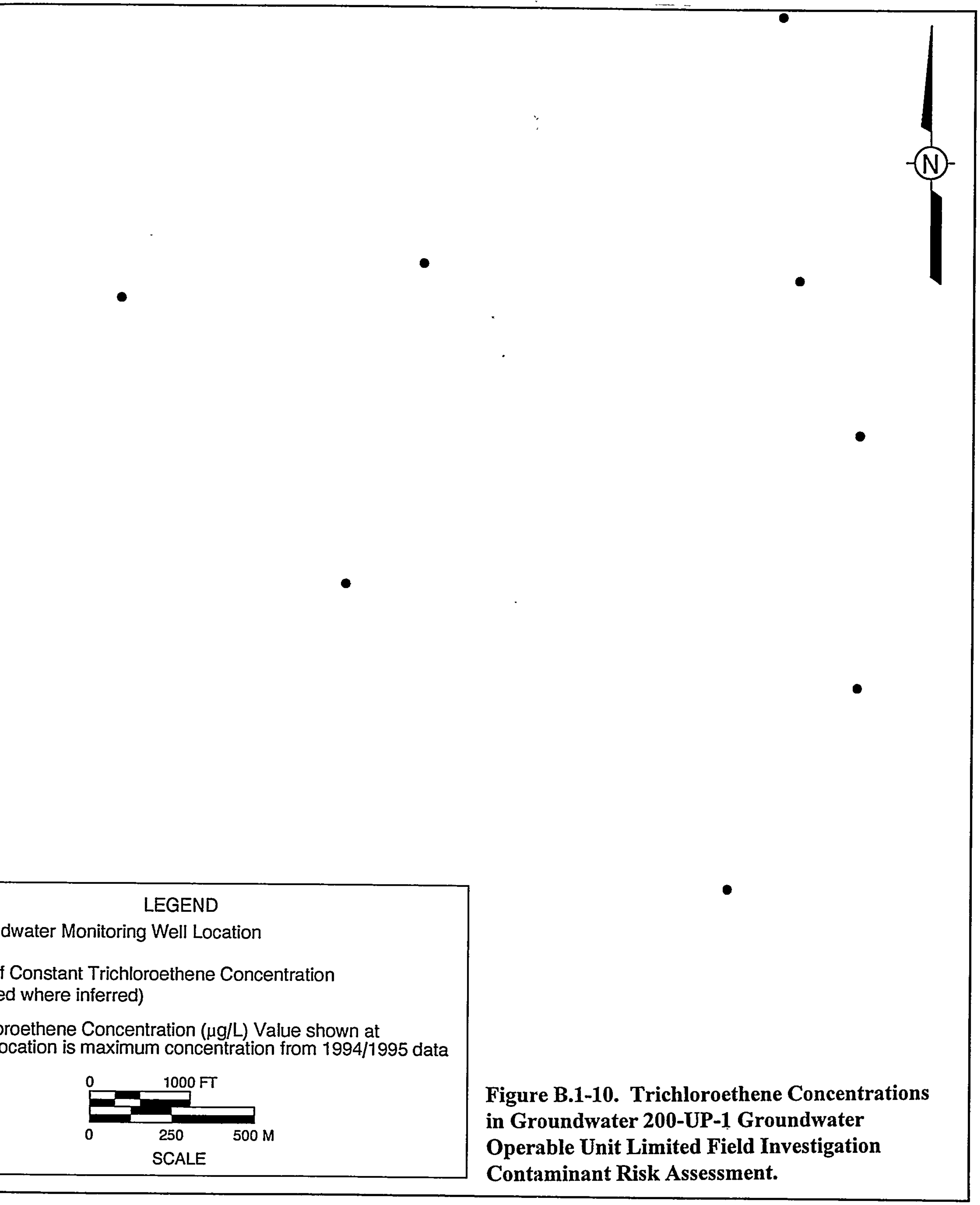
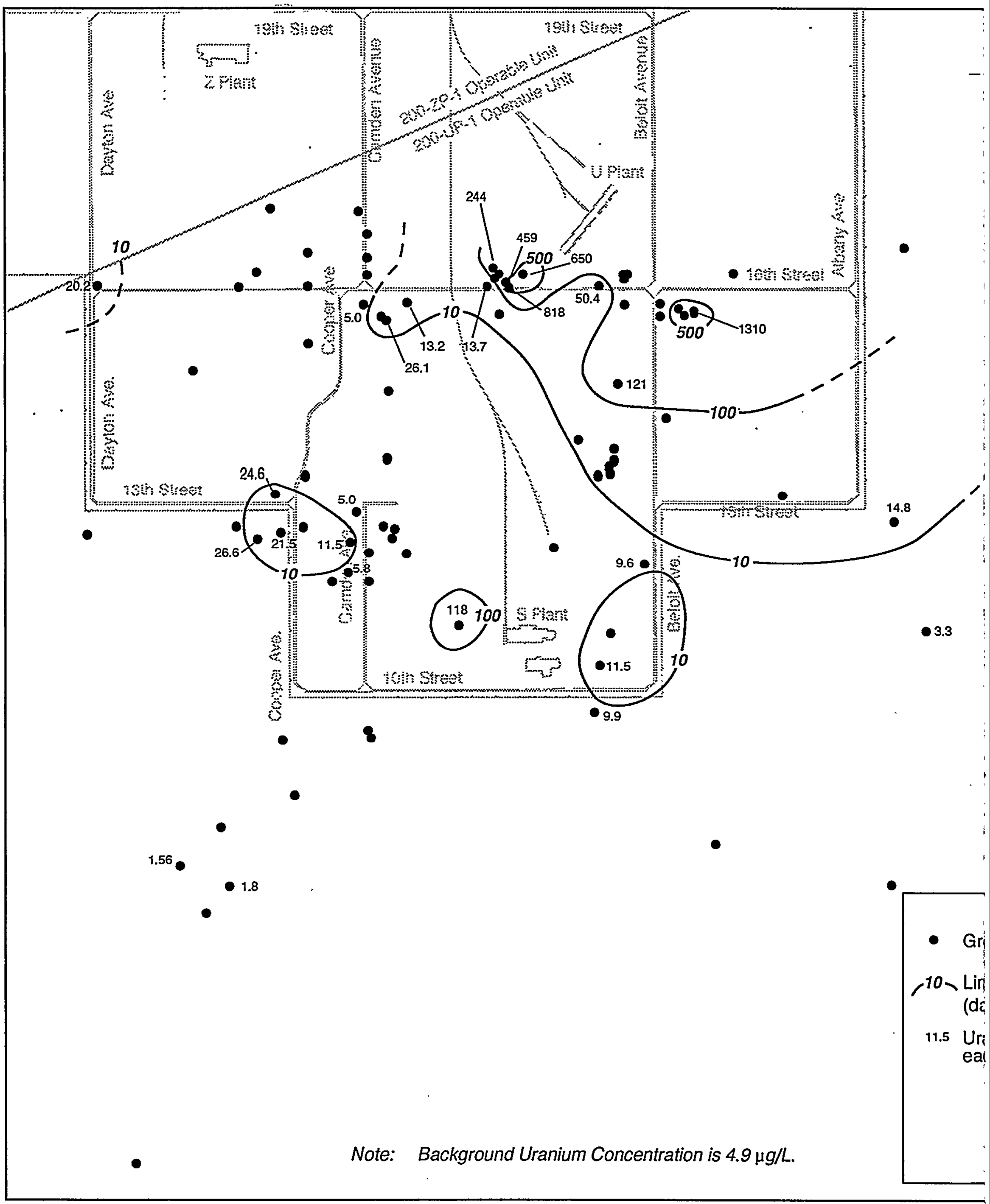


Figure B.1-10. Trichloroethene Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: Background Uranium Concentration is 4.9 µg/L.

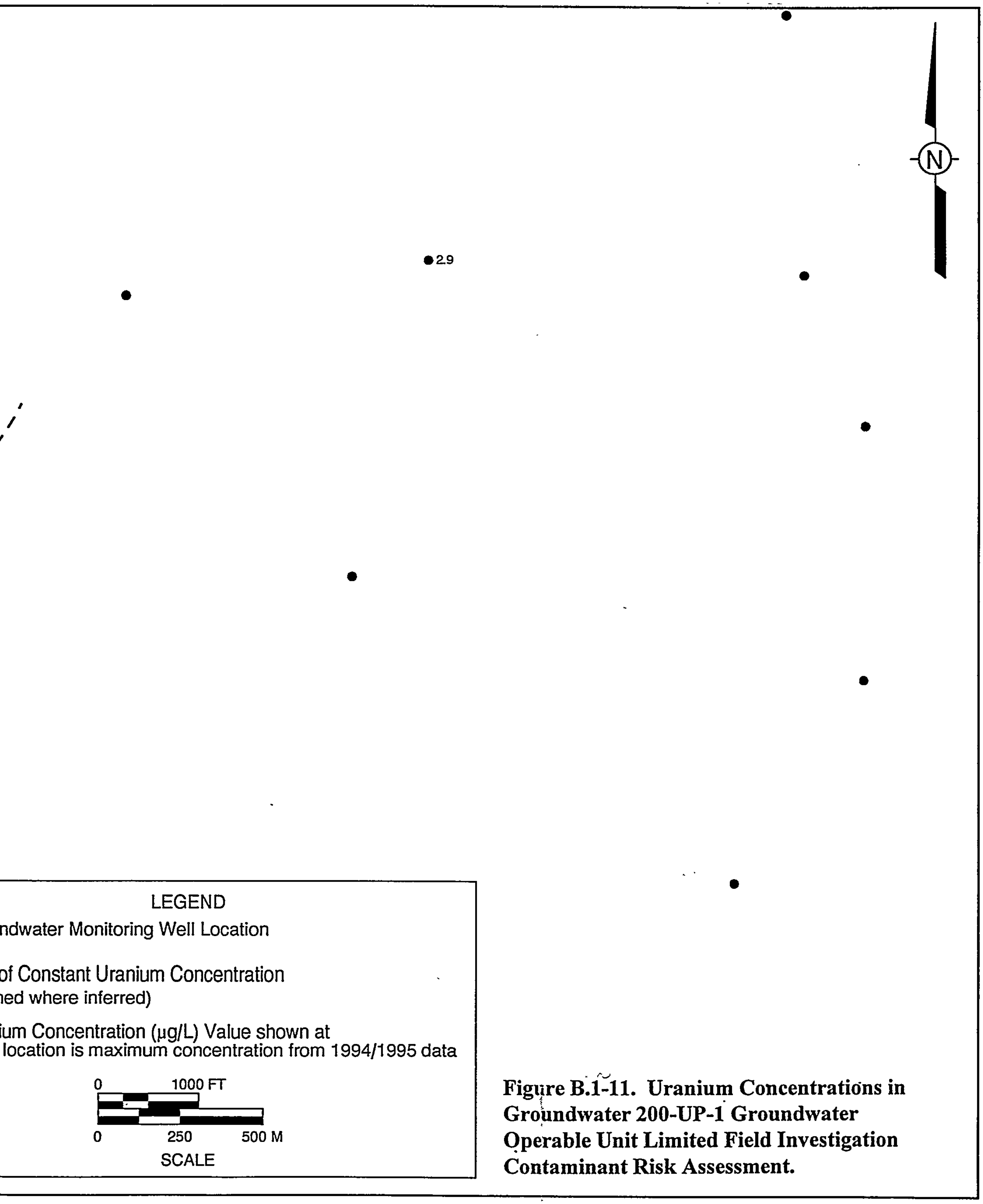
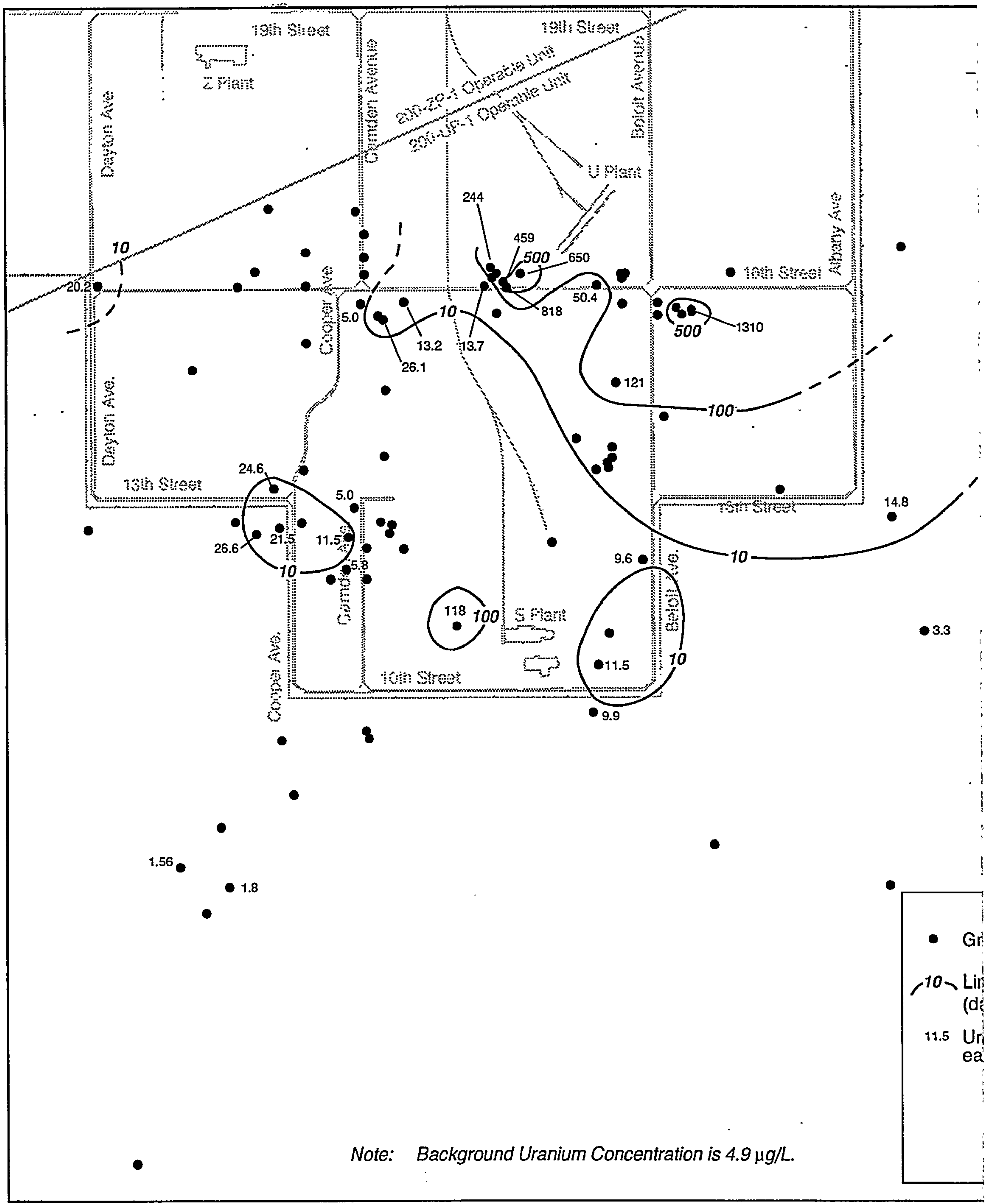


Figure B.1-11. Uranium Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.



Note: Background Uranium Concentration is 4.9 µg/L.

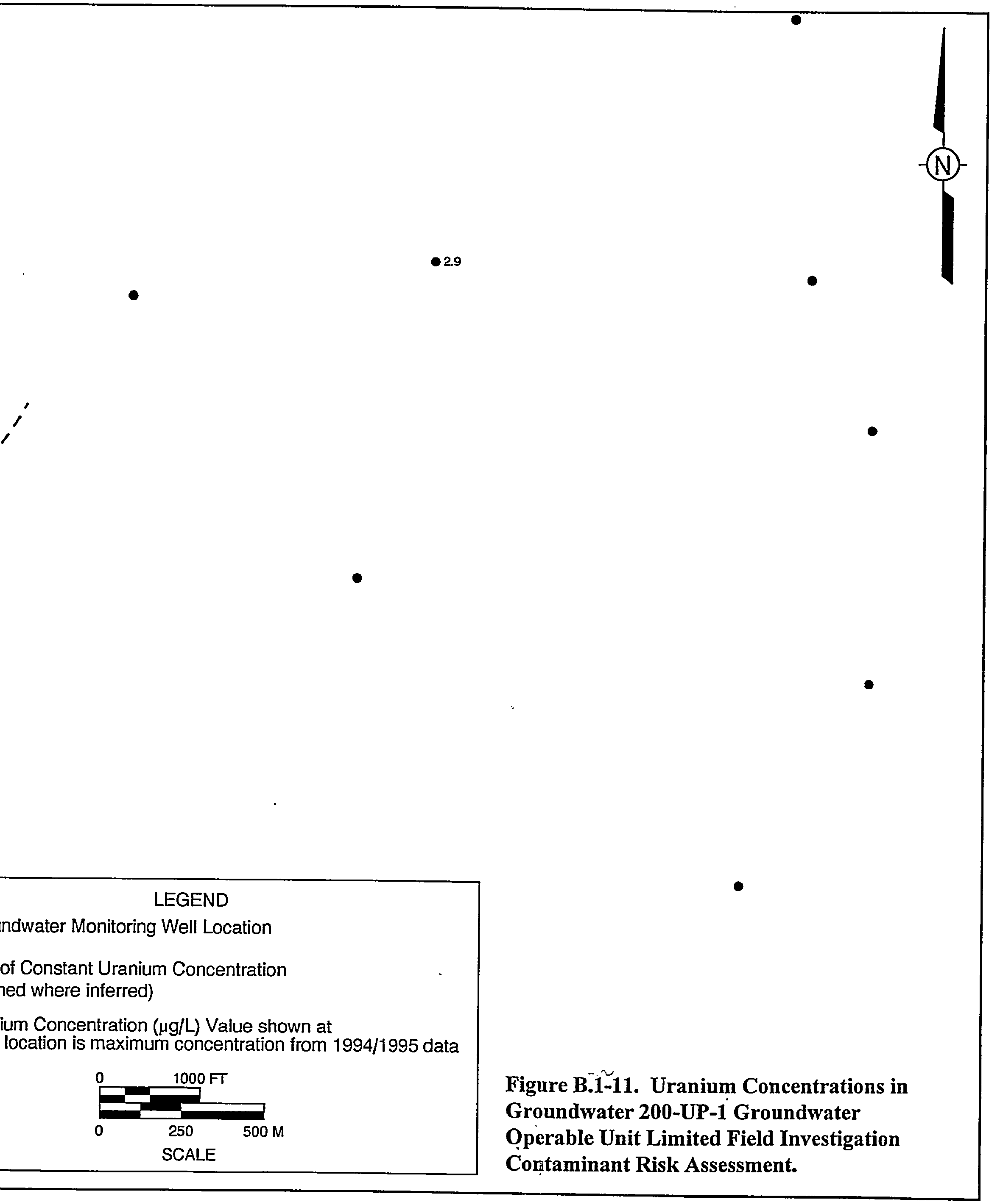


Figure B.1-11. Uranium Concentrations in Groundwater 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

ATTACHMENT B.2

GROUNDWATER CONTAMINANT FATE AND TRANSPORT MODELING INFORMATION

Table B.2-1. Physical and Hydrogeological Input Data for Contaminant Fate and Transport Modeling[a], 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Parameter	Eastern Groundwater Flow Path		Northern Groundwater Flow Path	
	to the Future-Use Boundary	to the Columbia River	to the Future-Use Boundary	to the Columbia River
Total porosity (%)	0.30	0.30	0.30	0.30
Effective porosity (%)	0.15	0.15	0.15	0.15
Hydraulic conductivity (ft/day)	50	50	50	50
Hydraulic gradient (ft/ft)	1.53E-03	1.15E-03	2.20E-03	1.16E-03
Seepage velocity (ft/day)	0.510	0.383	0.733	0.387
Longitudinal dispersivity (ft)	200	200	200	200
Transverse dispersivity (ft)	20	20	20	20
Aquifer bulk density (g/cm^3)	1.65	1.65	1.65	1.65
Actual flow path length (ft)	38,450	88,060	28,360	60,190
Model grid flow path length[b] (ft)	39,000	88,450	28,500	61,000
Model grid spacing (ft)	1,500	3,050	1,500	3,050

[a] Values are consistent with those used in the 200-UP-1 Groundwater Operable Unit Risk Assessment for the Interim Remedial Measure plumes (BHI 1996).

[b] The model grid flow path length is an even multiple of the model grid spacing. It is the closest distance on the model grid to the actual flow path length.

Table B.2-2. Distribution Coefficients and Half-Lives for Contaminants of Potential Concern[a], 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminants Risk Assessment.

Contaminant of Potential Concern	Distribution Coefficient (mL/g)[b]	Half-Life (years)
1,2-Dichloroethane	0.014	NA[c]
1,1-Dichloroethylene	0.065	NA
Arsenic	0	NA
Cadmium	15	NA
Carbon tetrachloride	0.110	NA
Chloroform	0.031	NA
Chromium	0	NA
Fluoride	0	NA
Iodine-129	0	1.6E+07
Potassium-40	0	1.3E+09
Selenium	0	NA
Strontium-90	20	28.5
Technetium-99	0	213,000
Trichloroethylene	0.130	NA
Uranium	1	4.5E+09[d]

[a] Values from the *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1992b). The distribution coefficients for organic contaminants of potential concern were calculated from the soil/organic matter partition coefficient assuming that the organic carbon content of aquifer solids is 0.1 weight percent (DOE-RL 1992b).

[b] Units are milliliters per gram.

[c] Not applicable, the contaminant of potential concern is not radioactive.

[d] Assuming that the uranium is uranium-238.

Table B.2-3. Summary of Fate and Transport Modeling 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Current Maximum Concentration[a] (µg/L, unless noted)[b]	Eastern Groundwater Flow Path						Northern Groundwater Flow Path					
		To the Future-Use Boundary			To the Columbia River			To the Future-Use Boundary			To the Columbia River		
		Predicted Maximum Concentration (µg/L, unless noted)	AF[c]	Travel Time[d] (Years)	Predicted Maximum Concentration (µg/L, unless noted)	AF	Travel Time[d] (Years)	Predicted Maximum Concentration (µg/L, unless noted)	AF	Travel Time[d] (Years)	Predicted Maximum Concentration (µg/L, unless noted)	AF	Travel Time (Years)
1,2-Dichloroethane	5.5	0.037	149	225	0.016	344	680	0.051	108	115	0.024	229	465
1,1-Dichloroethylene	3.2	0.034	94	285	0.015	213	855	0.046	70	145	0.022	145	585
Arsenic	18	2.7	6.7	205	1.2	15	620	3.3	5.5	105	1.6	11	425
Cadmium	22	0.091	242	17,400	0.040	550	52,600	0.12	183	8,830	0.058	379	35,900
Carbon tetrachloride	1,800	550	3.3	315	280	6.4	980	670	2.7	160	370	4.9	680
Chloroform	29	15	1.9	220	7.7	3.8	700	18	1.6	105	11	2.6	465
Chromium VI	250	19	13	190	10	25	610	25	10	95	13	19	410
Fluoride	2,400	220	11	200	100	24	620	290	8.3	100	140	17	420
Iodine-129	86.1[e]	19[e]	4.5	195	8.4[e]	10	615	24[e]	3.6	100	12[e]	7.2	420
Potassium-40	142[e]	30[e]	4.7	200	15[e]	9.5	620	39[e]	3.6	100	20[e]	7.1	420
Selenium	12.8	0.077	166	210	0.034	376	630	0.11	116	105	0.049	261	430
Strontium-90	71.3[e]	0[e]	NA[f]	23,000	0[e]	NA	69,900	0[e]	NA	11,700	0[e]	NA	47,600
Technetium-99	2,260[e]	73[e]	31	205	33[e]	68	625	100[e]	23	105	46[e]	49	430
Trichloroethylene	33	1.6	21	350	0.75	44	1,060	2.2	15	175	1.1	30	705
Uranium	118	3.8	31	1,280	1.8	66	4,010	5.1	23	635	2.5	47	2,700

[a] Using 1994 and 1995 data. The technetium-99 and uranium maximum concentrations do not include data from the plumes subject to the Interim Remedial Measure.
[b] Units are micrograms per liter, unless noted.
[c] AF = attenuation factor. The attenuation factor is defined as the current maximum concentration divided by the predicted maximum concentration. For nonradioactive contaminants, attenuation is due to dispersion; and for radioactive contaminants, attenuation is due to dispersion and radioactive decay.
[d] Travel calculation and assumptions are given in Walton (1989).
[e] Concentration units are picocuries per liter.
[f] The attenuation factor is not calculated because the concentration is zero.

ATTACHMENT B.3

PREDICTED CONCENTRATIONS OF 200-UP-1 GROUNDWATER OPERABLE UNIT RISK ASSESSMENT CONTAMINANTS OF POTENTIAL CONCERN AT THE COLUMBIA RIVER

Table B.3-1. Predicted Maximum Concentrations at the Columbia River Using the Eastern Flow Path 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)[a]	Maximum Contaminant Level[b] (µg/L, unless noted)	Travel Time (years)
1,2-Dichloroethane	0.016	5	680
1,1-Dichloroethylene	0.015	7	855
Arsenic	1.2	50	620
Cadmium	0.040	5	52,600
Carbon tetrachloride	280	5	980
Chloroform	7.7	7.17 or 71.7[c]	700
Chromium VI	10	100	610
Fluoride	100	4,000	620
Iodine-129	8.4[d]	21[d]	615
Potassium-40	15[d]	295	620
Selenium	0.034	50	630
Strontium-90	0[d]	8[d]	69,900
Technetium-99	33[d]	900[d]	625
Trichloroethylene	0.75	5	1,060
Uranium	1.8	20	4,010

[a] Units are micrograms per liter, unless noted.

[b] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from *Title 40, Code of Federal Regulations, Part 141, Subparts B and G* (U.S. Environmental Protection Agency, 1995b). The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127 (U.S. Environmental Protection Agency, 1991).

[c] The MCL for chloroform is a risk-based standard derived from the *Washington Administrative Code (WAC), Title 173, Chapter 173-340, Model Toxics Control Act–Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards* (WSDE, 1991). The first value given is for residential exposure and the second is for nonresidential exposure.

[d] Concentration units are picocuries per liter.

Table B.3-2. Predicted Maximum Concentrations at the Columbia River Using the Northern Flow Path 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment.

Contaminant of Potential Concern	Concentration (µg/L, unless noted)[a]	Maximum Contaminant Level[b] (µg/L, unless noted)	Travel Time (years)
1,2-Dichloroethane	0.024	5	465
1,1-Dichloroethylene	0.022	7	585
Arsenic	1.6	50	425
Cadmium	0.058	5	35,900
Carbon tetrachloride	370	5	680
Chloroform	11	7.17 or 71.7[c]	465
Chromium VI	13	100	410
Fluoride	140	4,000	420
Iodine-129	12[d]	21[d]	420
Potassium-40	20[d]	295	420
Selenium	0.049	50	430
Strontium-90	0[d]	8[d]	47,600
Technetium-99	46[d]	900[d]	430
Trichloroethylene	1.1	5	705
Uranium	2.5	20	2,700

[a] Units are micrograms per liter, unless noted.

[b] Maximum contaminant levels (MCL) for strontium-90 and nonradioactive contaminants of potential concern (COPC) are from *Title 40, Code of Federal Regulations, Part 141, Subparts B and G* (U.S. Environmental Protection Agency, 1995b). The MCLs for other radioactive COPCs are from the *Federal Register*, Vol. 56, No. 138, 33050–33127 (U.S. Environmental Protection Agency, 1991).

[c] The MCL for chloroform is a risk-based standard derived from the *Washington Administrative Code (WAC), Title 173, Chapter 173-340, Model Toxics Control Act—Cleanup, Part VII—Cleanup Standards, WAC 173-340-720 Groundwater Cleanup Standards* (WSDE, 1991). The first value given is for residential exposure and the second is for nonresidential exposure.

[d] Concentration units are picocuries per liter.

ATTACHMENT B.4

CURRENT-CONDITION COMMERCIAL/INDUSTRIAL EXPOSURE SCENARIO INTAKE AND RISK TABLE

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 1 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W18-15	Carbon tetrachloride	8/3/95 11:20	100	ug/L	2.8E-04	9.8E-04	3.6E-05	1.4E+00	90.0	99.0
299-W18-15	Chloroform	8/3/95 11:20	14	ug/L	3.9E-05	1.4E-04	2.4E-07	1.4E-02	0.6	1.0
299-W18-15	Potassium-40	8/3/95 11:20	68.6	pCi/L	3.4E+05	NA	3.8E-06	NA	9.3	0.0
299-W18-15	Technetium-99	10/5/94 12:50	0.0586	pCi/L	2.9E+02	NA	3.8E-10	NA	0.0	0.0
299-W18-15	Trichloroethene	8/3/95 11:20	0.22	ug/L	6.2E-07	2.2E-06	6.8E-09	3.6E-04	0.0	0.0
						Total:	4.0E-05	1.4E+00	100.0	100.0
299-W18-21	Carbon tetrachloride	5/9/95 11:20	1800	ug/L	5.0E-03	1.8E-02	6.5E-04	2.5E+01	99.9	99.9
299-W18-21	Chloroform	5/9/95 11:20	13	ug/L	3.6E-05	1.3E-04	2.2E-07	1.3E-02	0.0	0.1
299-W18-21	Trichloroethene	5/9/95 11:20	2.1	ug/L	5.9E-06	2.1E-05	6.5E-08	3.4E-03	0.0	0.0
299-W18-21	Uranium	11/28/94 10:45	20.2	ug/L	3.4E+04	NA	6.7E-07	NA	0.1	0.0
						Total:	6.6E-04	2.5E+01	100.0	100.0
299-W18-25	Carbon tetrachloride	2/13/95 10:25	100	ug/L	2.8E-04	9.8E-04	3.6E-05	1.4E+00	93.0	99.5
299-W18-25	Chloroform	2/13/95 10:25	6.3	ug/L	1.8E-05	6.2E-05	1.1E-07	6.2E-03	0.3	0.4
299-W18-25	Iodine-129	9/22/94 11:30	0.598	pCi/L	3.0E+03	NA	5.7E-07	NA	1.4	0.0
299-W18-25	Potassium-40	9/22/94 11:30	35.6	pCi/L	1.8E+05	NA	2.0E-06	NA	5.0	0.0
299-W18-25	Technetium-99	3/28/94 8:30	9.72	pCi/L	4.9E+04	NA	6.3E-08	NA	0.2	0.0
299-W18-25	Trichloroethene	2/13/95 10:25	0.86	ug/L	2.4E-06	8.4E-06	2.6E-08	1.4E-03	0.1	0.1
						Total:	3.9E-05	1.4E+00	100.0	100.0
299-W18-29	Arsenic	3/11/94 8:00	18	ug/L	5.0E-05	1.8E-04	7.5E-05	5.9E-01	91.2	67.3
299-W18-29	Carbon tetrachloride	3/11/94 8:00	19	ug/L	5.3E-05	1.9E-04	6.9E-06	2.7E-01	8.3	30.4
299-W18-29	Chloroform	3/11/94 8:00	20	ug/L	5.6E-05	2.0E-04	3.4E-07	2.0E-02	0.4	2.2
299-W18-29	Trichloroethene	3/11/94 8:00	0.25	ug/L	7.0E-07	2.4E-06	7.7E-09	4.1E-04	0.0	0.0
						Total:	8.3E-05	8.7E-01	100.0	100.0
299-W18-30	Carbon tetrachloride	6/28/94 9:50	180	ug/L	5.0E-04	1.8E-03	6.5E-05	2.5E+00	99.8	99.8
299-W18-30	Chloroform	6/28/94 9:50	5.1	ug/L	1.4E-05	5.0E-05	8.7E-08	5.0E-03	0.1	0.2
299-W18-30	Trichloroethene	6/28/94 9:50	0.46	ug/L	1.3E-06	4.5E-06	1.4E-08	7.5E-04	0.0	0.0
						Total:	6.6E-05	2.5E+00	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 2 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W18-31	Carbon tetrachloride	6/28/94 9:25	120	ug/L	3.4E-04	1.2E-03	4.4E-05	1.7E+00	93.2	91.8
299-W18-31	Chloroform	6/28/94 9:25	18	ug/L	5.0E-05	1.8E-04	3.1E-07	1.8E-02	0.7	1.0
299-W18-31	Fluoride	3/22/94 10:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	7.1
299-W18-31	Potassium-40	3/22/94 10:00	51.1	pCi/L	2.6E+05	NA	2.8E-06	NA	6.0	0.0
299-W18-31	Technetium-99	3/22/94 10:00	2.69	pCi/L	1.3E+04	NA	1.7E-08	NA	0.0	0.0
299-W18-31	Trichloroethene	6/28/94 9:25	0.73	ug/L	2.0E-06	7.1E-06	2.2E-08	1.2E-03	0.0	0.1
						Total:	4.7E-05	1.8E+00	100.0	100.0
299-W18-32	Carbon tetrachloride	5/9/95 12:10	7.3	ug/L	2.0E-05	7.1E-05	2.7E-06	1.0E-01	99.1	98.7
299-W18-32	Chloroform	5/9/95 12:10	1.4	ug/L	3.9E-06	1.4E-05	2.4E-08	1.4E-03	0.9	1.3
						Total:	2.7E-06	1.0E-01	100.0	100.0
299-W18-33	Carbon tetrachloride	2/15/95 12:50	23	ug/L	6.4E-05	2.3E-04	8.4E-06	3.2E-01	99.8	70.9
299-W18-33	Chloroform	2/15/95 12:50	1.2	ug/L	3.4E-06	1.2E-05	2.0E-08	1.2E-03	0.2	0.3
299-W18-33	Fluoride	6/7/94 8:31	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	28.8
						Total:	8.4E-06	4.5E-01	100.0	100.0
299-W19-1	Carbon tetrachloride	6/3/94 10:00	1.1	ug/L	3.1E-06	1.1E-05	4.0E-07	1.5E-02	68.4	10.5
299-W19-1	Chloroform	6/3/94 10:00	0.32	ug/L	8.9E-07	3.1E-06	5.5E-09	3.1E-04	0.9	0.2
299-W19-1	Fluoride	6/3/94 10:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	89.3
299-W19-1	Technetium-99	12/19/94 10:30	1.7	pCi/L	8.5E+03	NA	1.1E-08	NA	1.9	0.0
299-W19-1	Uranium	6/3/94 10:00	5.04	ug/L	8.4E+03	NA	1.7E-07	NA	28.8	0 0
						Total:	5.8E-07	1.5E-01	100.0	100.0
299-W19-11	Carbon tetrachloride	4/6/95 11:45	319	ug/L	8.9E-04	3.1E-03	1.2E-04	4.5E+00	93.0	96.3
299-W19-11	Chloroform	4/6/95 11:45	5.7	ug/L	1.6E-05	5.6E-05	9.7E-08	5.6E-03	0.1	0.1
299-W19-11	Fluoride	10/19/94 10:25	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	3.5
299-W19-11	Iodine-129	10/19/94 10:25	2.64	pCi/L	1.3E+04	NA	2.5E-06	NA	2.0	0.0
299-W19-11	Potassium-40	4/6/95 11:45	41.2	pCi/L	2.1E+05	NA	2.3E-06	NA	1.8	0.0
299-W19-11	Strontium-90	9/23/94 0:00	0.108	pCi/L	5.4E+02	NA	1.9E-08	NA	0.0	0.0
299-W19-11	Technetium-99	3/28/94 14:44	582.1	pCi/L	2.9E+06	NA	3.8E-06	NA	3.0	0.0
299-W19-11	Trichloroethene	4/6/95 11:45	1.5	ug/L	4.2E-06	1.5E-05	4.6E-08	2.4E-03	0.0	0.1
						Total:	1.2E-04	4.6E+00	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 3 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-12	Carbon tetrachloride	9/26/94 0:00	45	ug/L	1.3E-04	4.4E-04	1.6E-05	6.3E-01	68.5	82.6
299-W19-12	Chloroform	9/26/94 0:00	2	ug/L	5.6E-06	2.0E-05	3.4E-08	2.0E-03	0.1	0.3
299-W19-12	Fluoride	9/18/95 11:21	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	17.1
299-W19-12	Iodine-129	10/13/94 9:47	0.305	pCi/L	1.5E+03	NA	2.9E-07	NA	1.2	0.0
299-W19-12	Potassium-40	3/29/94 13:13	87	pCi/L	4.4E+05	NA	4.8E-06	NA	20.1	0.0
299-W19-12	Technetium-99	8/3/95 13:00	369	pCi/L	1.8E+06	NA	2.4E-06	NA	10.1	0.0
						Total:	2.4E-05	7.6E-01	100.0	100.0
299-W19-13	Carbon tetrachloride	9/19/94 0:00	150	ug/L	4.2E-04	1.5E-03	5.5E-05	2.1E+00	94.7	93.9
299-W19-13	Chloroform	10/13/94 10:30	3.2	ug/L	8.9E-06	3.1E-05	5.5E-08	3.1E-03	0.1	0.1
299-W19-13	Fluoride	10/13/94 10:30	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	5.8
299-W19-13	Iodine-129	10/13/94 10:30	1.12	pCi/L	5.6E+03	NA	1.1E-06	NA	1.8	0.0
299-W19-13	Strontium-90	9/19/94 0:00	0.254	pCi/L	1.3E+03	NA	4.6E-08	NA	0.1	0.0
299-W19-13	Technetium-99	10/13/94 10:30	284	pCi/L	1.4E+06	NA	1.8E-06	NA	3.2	0.0
299-W19-13	Trichloroethene	10/13/94 10:30	0.9	ug/L	2.5E-06	8.8E-06	2.8E-08	1.5E-03	0.0	0.1
						Total:	5.8E-05	2.2E+00	100.0	100.0
299-W19-15	Carbon tetrachloride	4/13/95 9:00	284	ug/L	7.9E-04	2.8E-03	1.0E-04	4.0E+00	98.1	95.9
299-W19-15	Chloroform	4/13/95 9:00	5.2	ug/L	1.5E-05	5.1E-05	8.9E-08	5.1E-03	0.1	0.1
299-W19-15	Fluoride	10/13/94 10:30	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	3.9
299-W19-15	Iodine-129	10/13/94 10:30	0.301	pCi/L	1.5E+03	NA	2.9E-07	NA	0.3	0.0
299-W19-15	Technetium-99	10/13/94 10:30	168	pCi/L	8.4E+05	NA	1.1E-06	NA	1.0	0.0
299-W19-15	Trichloroethene	4/13/95 9:00	1.3	ug/L	3.6E-06	1.3E-05	4.0E-08	2.1E-03	0.0	0.1
299-W19-15	Uranium	10/13/94 10:30	13.7	ug/L	2.3E+04	NA	4.6E-07	NA	0.4	0.0
						Total:	1.1E-04	4.1E+00	100.0	100.0
299-W19-16	Carbon tetrachloride	11/17/94 9:10	440	ug/L	1.2E-03	4.3E-03	1.6E-04	6.2E+00	98.1	99.9
299-W19-16	Chloroform	11/17/94 9:10	3.8	ug/L	1.1E-05	3.7E-05	6.5E-08	3.7E-03	0.0	0.1
299-W19-16	Iodine-129	12/13/94 10:30	0.756	pCi/L	3.8E+03	NA	7.2E-07	NA	0.4	0.0
299-W19-16	Technetium-99	6/21/94 8:55	341	pCi/L	1.7E+06	NA	2.2E-06	NA	1.4	0.0
299-W19-16	Trichloroethene	11/17/94 9:10	0.66	ug/L	1.8E-06	6.5E-06	2.0E-08	1.1E-03	0.0	0.0
						Total:	1.6E-04	6.2E+00	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 4 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-17	Carbon tetrachloride	10/25/94 11:37	300	ug/L	8.4E-04	2.9E-03	1.1E-04	4.2E+00	99.4	96.5
299-W19-17	Chloroform	10/25/94 11:37	3.7	ug/L	1.0E-05	3.6E-05	6.3E-08	3.6E-03	0.1	0.1
299-W19-17	Fluoride	10/25/94 11:37	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	3.4
299-W19-17	Technetium-99	10/25/94 11:37	89.4	pCi/L	4.5E+05	NA	5.8E-07	NA	0.5	0.0
299-W19-17	Trichloroethene	10/25/94 11.37	1.4	ug/L	3.9E-06	1.4E-05	4.3E-08	2.3E-03	0.0	0.1
						Total:	1.1E-04	4.3E+00	100.0	100.0
299-W19-18	Carbon tetrachloride	4/6/95 10 00	282	ug/L	7.9E-04	2.8E-03	1.0E-04	3.9E+00	97.6	95.7
299-W19-18	Chloroform	6/23/94 11:45	29	ug/L	8.1E-05	2.8E-04	4.9E-07	2.8E-02	0.5	0.7
299-W19-18	Fluoride	4/6/95 10 00	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	3.6
299-W19-18	Iodine-129	4/6/95 10 00	1.84	pCi/L	9.2E+03	NA	1.7E-06	NA	1.7	0.0
299-W19-18	Technetium-99	6/23/94 11:45	39.4	pCi/L	2.0E+05	NA	2.6E-07	NA	0.2	0.0
299-W19-18	Trichloroethene	4/6/95 10:00	1.3	ug/L	3.6E-06	1.3E-05	4.0E-08	2.1E-03	0.0	0.1
						Total:	1.1E-04	4.1E+00	100.0	100.0
299-W19-19	Carbon tetrachloride	8/16/95 8:40	84	ug/L	2.3E-04	8.2E-04	3.1E-05	1.2E+00	92.8	76.2
299-W19-19	Chloroform	2/9/94 8:15	5.3	ug/L	1.5E-05	5.2E-05	9.0E-08	5.2E-03	0.3	0.3
299-W19-19	Fluoride	2/9/94 8:15	2000	ug/L	5.6E-03	2.0E-02	NC	3.3E-01	0.0	21.2
299-W19-19	Iodine-129	9/15/94 0:00	1.89	pCi/L	9.5E+03	NA	1.8E-06	NA	5.5	0.0
299-W19-19	Selenium	9/15/94 0:00	12.8	ug/L	3.6E-05	1.3E-04	NA	2.5E-02	0.0	1.6
299-W19-19	Strontium-90	9/15/94 0:00	1.65	pCi/L	8.3E+03	NA	3.0E-07	NA	0.9	0.0
299-W19-19	Trichloroethene	8/16/95 8:40	6.1	ug/L	1.7E-05	6.0E-05	1.9E-07	9.9E-03	0.6	0.6
						Total:	3.3E-05	1.5E+00	100.0	100.0
299-W19-2	Carbon tetrachloride	6/30/94 0:00	11	ug/L	3.1E-05	1.1E-04	4.0E-06	1.5E-01	26.7	98.7
299-W19-2	Chloroform	6/30/94 0:00	2	ug/L	5.6E-06	2.0E-05	3.4E-08	2.0E-03	0.2	1.3
299-W19-2	Iodine-129	9/22/94 0:00	8.83	pCi/L	4.4E+04	NA	8.4E-06	NA	56.0	0.0
299-W19-2	Strontium-90	6/30/94 0:00	3.41	pCi/L	1.7E+04	NA	6.1E-07	NA	4.1	0.0
299-W19-2	Technetium-99	6/30/94 0:00	299	pCi/L	1.5E+06	NA	1.9E-06	NA	13.0	0.0
						Total:	1.5E-05	1.6E-01	100.0	100.0
299-W19-20	Carbon tetrachloride	2/21/95 10:40	19	ug/L	5.3E-05	1.9E-04	6.9E-06	2.7E-01	96.1	51.9
299-W19-20	Chloroform	2/21/95 10:40	1.8	ug/L	5.0E-06	1.8E-05	3.1E-08	1.8E-03	0.4	0.3
299-W19-20	Fluoride	2/21/95 10:40	1500	ug/L	4.2E-03	1.5E-02	NC	2.4E-01	0.0	47.8
299-W19-20	Iodine-129	9/29/94 0:00	0.175	pCi/L	8.8E+02	NA	1.7E-07	NA	2.3	0.0
299-W19-20	Strontium-90	9/29/94 0:00	0.462	pCi/L	2.3E+03	NA	8.3E-08	NA	1.2	0.0
						Total:	7.2E-06	5.1E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 5 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-21	Arsenic	9/20/94 0:00	17.1	ug/L	4.8E-05	1.7E-04	7.2E-05	5.6E-01	94.5	81.6
299-W19-21	Carbon tetrachloride	9/20/94 0:00	9	ug/L	2.5E-05	8.8E-05	3.3E-06	1.3E-01	4.3	18.4
299-W19-21	Chloroform	4/3/95 11:30	0.15	ug/L	4.2E-07	1.5E-08	2.6E-09	1.5E-04	0.0	0.0
299-W19-21	Technetium-99	7/8/94 0:00	4	pCi/L	2.0E+04	NA	2.6E-08	NA	0.0	0.0
299-W19-21	Uranium	6/7/94 9:30	26.1	ug/L	4.4E+04	NA	8.7E-07	NA	1.1	0.0
						Total:	7.6E-05	6.8E-01	100.0	100.0
299-W19-23	Carbon tetrachloride	2/21/95 12:27	63	ug/L	1.8E-04	6.2E-04	2.3E-05	8.8E-01	97.3	70.6
299-W19-23	Chloroform	2/9/94 9:00	4.8	ug/L	1.3E-05	4.7E-05	8.2E-08	4.7E-03	0.3	0.4
299-W19-23	Fluoride	5/23/94 10:30	2200	ug/L	6.2E-03	2.2E-02	NC	3.6E-01	0.0	28.8
299-W19-23	Iodine-129	2/9/94 9:00	0.524	pCi/L	2.6E+03	NA	5.0E-07	NA	2.1	0.0
299-W19-23	Trichloroethene	2/21/95 12:27	2.1	ug/L	5.9E-06	2.1E-05	6.5E-08	3.4E-03	0.3	0.3
						Total:	2.4E-05	1.2E+00	100.0	100.0
299-W19-24	Carbon tetrachloride	2/21/95 11:40	100	ug/L	2.8E-04	9.8E-04	3.6E-05	1.4E+00	91.6	82.1
299-W19-24	Chloroform	2/22/94 9:00	4.6	ug/L	1.3E-05	4.5E-05	7.8E-08	4.5E-03	0.2	0.3
299-W19-24	Fluoride	2/22/94 9:00	1800	ug/L	5.0E-03	1.8E-02	NC	2.9E-01	0.0	17.2
299-W19-24	Iodine-129	2/22/94 9:00	0.549	pCi/L	2.7E+03	NA	5.2E-07	NA	1.3	0.0
299-W19-24	Strontium-90	3/23/94 13:14	14.5	pCi/L	7.3E+04	NA	2.6E-06	NA	6.6	0.0
299-W19-24	Trichloroethene	2/21/95 11:40	3.9	ug/L	1.1E-05	3.8E-05	1.2E-07	6.4E-03	0.3	0.4
						Total:	4.0E-05	1.7E+00	100.0	100.0
299-W19-25	Carbon tetrachloride	2/14/94 10:00	47	ug/L	1.3E-04	4.6E-04	1.7E-05	6.6E-01	93.4	73.3
299-W19-25	Chloroform	2/14/94 10:00	4.5	ug/L	1.3E-05	4.4E-05	7.7E-08	4.4E-03	0.4	0.5
299-W19-25	Fluoride	2/14/94 10:00	1400	ug/L	3.9E-03	1.4E-02	NC	2.3E-01	0.0	25.5
299-W19-25	Iodine-129	2/14/94 10:00	1.07	pCi/L	5.4E+03	NA	1.0E-06	NA	5.6	0.0
299-W19-25	Trichloroethene	2/14/94 10:00	3.7	ug/L	1.0E-05	3.6E-05	1.1E-07	6.0E-03	0.6	0.7
						Total:	1.8E-05	9.0E-01	100.0	100.0
299-W19-26	Carbon tetrachloride	2/21/95 13:08	48	ug/L	1.3E-04	4.7E-04	1.7E-05	6.7E-01	99.1	71.4
299-W19-26	Chloroform	2/9/94 8:30	3.4	ug/L	9.5E-06	3.3E-05	5.8E-08	3.3E-03	0.3	0.4
299-W19-26	Fluoride	2/9/94 8:30	1600	ug/L	4.5E-03	1.6E-02	NC	2.6E-01	0.0	27.8
299-W19-26	Trichloroethene	2/21/95 13:08	3.1	ug/L	8.7E-06	3.0E-05	9.5E-08	5.1E-03	0.5	0.5
						Total:	1.8E-05	9.4E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 6 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-27	Arsenic	8/15/95 9:00	13	ug/L	3.6E-05	1.3E-04	5.5E-05	4.2E-01	92.8	59.7
299-W19-27	Carbon tetrachloride	2/9/94 9:40	10	ug/L	2.8E-05	9.8E-05	3.6E-06	1.4E-01	6.2	19.7
299-W19-27	Fluoride	2/15/95 12:10	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	20.7
299-W19-27	Iodine-129	2/9/94 9:40	0.0983	pCi/L	4.9E+02	NA	9.3E-08	NA	0.2	0.0
299-W19-27	Technetium-99	2/9/94 9:40	13.6	pCi/L	6.8E+04	NA	8.8E-08	NA	0.2	0.0
299-W19-27	Uranium	2/9/94 9:40	13.2	ug/L	2.2E+04	NA	4.4E-07	NA	0.8	0.0
						Total:	5.9E-05	7.1E-01	100.0	100.0
299-W19-28	Carbon tetrachloride	2/9/94 10:00	23	ug/L	6.4E-05	2.3E-04	8.4E-06	3.2E-01	92.9	40.1
299-W19-28	Chloroform	2/9/94 10:00	1.8	ug/L	5.0E-06	1.8E-05	3.1E-08	1.8E-03	0.3	0.2
299-W19-28	Chromium	2/9/94 10:00	160	ug/L	4.5E-04	1.6E-03	NC	3.1E-01	0.0	39.1
299-W19-28	Fluoride	2/9/94 10:00	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	20.4
299-W19-28	Iodine-129	2/9/94 10:00	0.549	pCi/L	2.7E+03	NA	5.2E-07	NA	5.8	0.0
299-W19-28	Strontium-90	2/9/94 10:00	0.361	pCi/L	1.8E+03	NA	6.5E-08	NA	0.7	0.0
299-W19-28	Trichloroethene	2/9/94 10:00	0.82	ug/L	2.3E-06	8.0E-06	2.5E-08	1.3E-03	0.3	0.2
						Total:	9.0E-06	8.0E-01	100.0	100.0
299-W19-29	Carbon tetrachloride	8/17/95 12:23	470	ug/L	1.3E-03	4.6E-03	1.7E-04	6.6E+00	99.4	99.6
299-W19-29	Chloroform	8/17/95 12:23	7	ug/L	2.0E-05	6.8E-05	1.2E-07	6.8E-03	0.1	0.1
299-W19-29	Iodine-129	2/17/94 9:00	0.676	pCi/L	3.4E+03	NA	6.4E-07	NA	0.4	0.0
299-W19-29	Trichloroethene	1/30/95 11:50	10	ug/L	2.8E-05	9.8E-05	3.1E-07	1.6E-02	0.2	0.2
						Total:	1.7E-04	6.6E+00	100.0	100.0
299-W19-3	Carbon tetrachloride	10/20/94 11:15	130	ug/L	3.6E-04	1.3E-03	4.7E-05	1.8E+00	83.3	91.6
299-W19-3	Chloroform	10/20/94 11:15	2.2	ug/L	6.2E-06	2.2E-05	3.8E-08	2.2E-03	0.1	0.1
299-W19-3	Fluoride	4/6/95 11:15	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	8.2
299-W19-3	Iodine-129	4/6/95 11:15	5.67	pCi/L	2.8E+04	NA	5.4E-06	NA	9.5	0.0
299-W19-3	Potassium-40	4/6/95 11:15	46.9	pCi/L	2.3E+05	NA	2.6E-06	NA	4.5	0.0
299-W19-3	Strontium-90	10/20/94 11:15	0.252	pCi/L	1.3E+03	NA	4.5E-08	NA	0.1	0.0
299-W19-3	Technetium-99	10/20/94 11:15	213	pCi/L	1.1E+06	NA	1.4E-06	NA	2.4	0.0
299-W19-3	Trichloroethene	10/20/94 11:15	0.8	ug/L	2.2E-06	7.8E-06	2.5E-08	1.3E-03	0.0	0.1
						Total:	5.7E-05	2.0E+00	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 7 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-30	Carbon tetrachloride	1/27/94 9:30	93	ug/L	2.6E-04	9.1E-04	3.4E-05	1.3E+00	97.0	76.5
299-W19-30	Chloroform	1/27/94 9:30	5.2	ug/L	1.5E-05	5.1E-05	8.9E-08	5.1E-03	0.3	0.3
299-W19-30	Fluoride	5/17/95 11:27	2400	ug/L	6.7E-03	2.3E-02	NC	3.9E-01	0.0	23.0
299-W19-30	Iodine-129	4/13/95 11:11	0.946	pCi/L	4.7E+03	NA	9.0E-07	NA	2.6	0.0
299-W19-30	Trichloroethene	1/27/94 9:30	2.3	ug/L	6.4E-06	2.3E-05	7.1E-08	3.8E-03	0.2	0.2
						Total:	3.5E-05	1.7E+00	100.0	100.0
299-W19-31	Carbon tetrachloride	3/28/94 10:00	80	ug/L	2.2E-04	7.8E-04	2.9E-05	1.1E+00	86.2	88.2
299-W19-31	Chloroform	2/11/95 9:42	2.9	ug/L	8.1E-06	2.8E-05	4.9E-08	2.8E-03	0.1	0.2
299-W19-31	Fluoride	6/28/94 10:20	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	11.6
299-W19-31	Iodine-129	9/29/94 0:00	1.29	pCi/L	6.5E+03	NA	1.2E-06	NA	3.6	0.0
299-W19-31	Potassium-40	9/22/94 9:00	53	pCi/L	2.7E+05	NA	2.9E-06	NA	8.6	0.0
299-W19-31	Strontium-90	9/29/94 0:00	0.247	pCi/L	1.2E+03	NA	4.4E-08	NA	0.1	0.0
299-W19-31	Technetium-99	9/29/94 0:00	66.1	pCi/L	3.3E+05	NA	4.3E-07	NA	1.3	0.0
299-W19-31	Trichloroethene	2/11/95 9:42	0.3	ug/L	8.4E-07	2.9E-06	9.2E-09	4.9E-04	0.0	0.0
						Total:	3.4E-05	1.3E+00	100.0	100.0
299-W19-32	Carbon tetrachloride	2/11/95 11:20	31	ug/L	8.7E-05	3.0E-04	1.1E-05	4.3E-01	58.6	55.7
299-W19-32	Chloroform	9/22/94 9:45	1.1	ug/L	3.1E-06	1.1E-05	1.9E-08	1.1E-03	0.1	0.1
299-W19-32	Chromium	7/25/94 8:15	92	ug/L	2.6E-04	9.0E-04	NC	1.8E-01	0.0	23.1
299-W19-32	Fluoride	9/22/94 9:45	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	21.0
299-W19-32	Potassium-40	9/22/94 9:45	61.7	pCi/L	3.1E+05	NA	3.4E-06	NA	17.6	0.0
299-W19-32	Technetium-99	3/28/94 9:15	700	pCi/L	3.5E+06	NA	4.6E-06	NA	23.7	0.0
299-W19-32	Trichloroethene	2/11/95 11:20	0.17	ug/L	4.8E-07	1.7E-06	5.2E-09	2.8E-04	0.0	0.0
						Total:	1.9E-05	7.8E-01	100.0	100.0
299-W19-34A	Carbon tetrachloride	10/3/94 0:00	93	ug/L	2.6E-04	9.1E-04	3.4E-05	1.3E+00	96.0	98.2
299-W19-34A	Chloroform	10/3/94 0:00	14	ug/L	3.9E-05	1.4E-04	2.4E-07	1.4E-02	0.7	1.0
299-W19-34A	Technetium-99	1/30/95 11:07	151	pCi/L	7.6E+05	NA	9.8E-07	NA	2.8	0.0
299-W19-34A	Trichloroethene	5/11/95 11:00	6	ug/L	1.7E-05	5.9E-05	1.8E-07	9.8E-03	0.5	0.7
						Total:	3.5E-05	1.3E+00	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 8 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-34B	Carbon tetrachloride	8/17/95 12:36	77	ug/L	2.2E-04	7.5E-04	2.8E-05	1.1E+00	89.6	96.9
299-W19-34B	Chloroform	5/17/95 10:25	10	ug/L	2.8E-05	9.8E-05	1.7E-07	9.8E-03	0.5	0.9
299-W19-34B	Iodine-129	8/5/94 11:30	2.03	pCi/L	1.0E+04	NA	1.9E-06	NA	6.2	0.0
299-W19-34B	Selenium	8/5/94 11:30	8.6	ug/L	2.4E-05	8.4E-05	NA	1.7E-02	0.0	1.5
299-W19-34B	Strontium-90	8/5/94 11:30	0.241	pCi/L	1.2E+03	NA	4.3E-08	NA	0.1	0.0
299-W19-34B	Technetium-99	8/5/94 11:30	149	pCi/L	7.5E+05	NA	9.7E-07	NA	3.1	0.0
299-W19-34B	Trichloroethene	8/17/95 12:36	5	ug/L	1.4E-05	4.9E-05	1.5E-07	8.2E-03	0.5	0.7
						Total:	3.1E-05	1.1E+00	100.0	100.0
299-W19-35	Carbon tetrachloride	9/30/94 0:00	120	ug/L	3.4E-04	1.2E-03	4.4E-05	1.7E+00	89.1	98.5
299-W19-35	Chloroform	9/30/94 0:00	4	ug/L	1.1E-05	3.9E-05	6.8E-08	3.9E-03	0.1	0.2
299-W19-35	Technetium-99	5/17/95 9:59	747	pCi/L	3.7E+06	NA	4.9E-06	NA	9.9	0.0
299-W19-35	Trichloroethene	9/30/94 0:00	13	ug/L	3.6E-05	1.3E-04	4.0E-07	2.1E-02	0.8	1.2
						Total:	4.9E-05	1.7E+00	100.0	100.0
299-W19-38	Carbon tetrachloride	8/23/95 16:00	40	ug/L	1.1E-04	3.9E-04	1.5E-05	5.6E-01	88.6	98.8
299-W19-38	Chloroform	8/23/95 16:00	7	ug/L	2.0E-05	6.8E-05	1.2E-07	6.8E-03	0.7	1.2
299-W19-38	Technetium-99	8/23/95 16:00	270	pCi/L	1.4E+06	NA	1.8E-06	NA	10.7	0.0
						Total:	1.6E-05	5.7E-01	100.0	100.0
299-W19-9	Carbon tetrachloride	10/20/94 9:30	260	ug/L	7.3E-04	2.5E-03	9.4E-05	3.6E+00	96.0	95.5
299-W19-9	Chloroform	10/20/94 9:30	4.2	ug/L	1.2E-05	4.1E-05	7.2E-08	4.1E-03	0.1	0.1
299-W19-9	Fluoride	10/20/94 9:30	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	4.3
299-W19-9	Iodine-129	9/23/94 0:00	2.22	pCi/L	1.1E+04	NA	2.1E-06	NA	2.1	0.0
299-W19-9	Strontium-90	9/23/94 0:00	0.141	pCi/L	7.1E+02	NA	2.5E-08	NA	0.0	0.0
299-W19-9	Technetium-99	6/21/94 10:24	258	pCi/L	1.3E+06	NA	1.7E-06	NA	1.7	0.0
299-W19-9	Trichloroethene	10/20/94 9:30	1.8	ug/L	5.0E-06	1.8E-05	5.5E-08	2.9E-03	0.1	0.1
						Total:	9.8E-05	3.8E+00	100.0	100.0
299-W19-91	Cadmium	6/7/94 10:45	22	ug/L	6.2E-05	2.2E-04	NC	4.3E-01	0.0	100.0
299-W19-91	Strontium-90	2/17/94 9:30	14.4	pCi/L	7.2E+04	NA	2.6E-06	NA	100.0	0.0
						Total:	2.6E-06	4.3E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 9 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W19-92	Chloroform	2/17/94 8:45	0.11	ug/L	3.1E-07	1.1E-06	1.9E-09	1.1E-04	0.2	100.0
299-W19-92	Iodine-129	2/17/94 8:45	0.1	pCi/L	5.0E+02	NA	9.5E-08	NA	9.2	0.0
299-W19-92	Strontium-90	2/17/94 8:45	5.19	pCi/L	2.6E+04	NA	9.3E-07	NA	90.6	0.0
						Total:	1.0E-06	1.1E-04	100.0	100.0
299-W21-1	Carbon tetrachloride	9/19/94 0:00	8	ug/L	2.2E-05	7.8E-05	2.9E-06	1.1E-01	25.2	41.3
299-W21-1	Chloroform	9/19/94 0:00	2	ug/L	5.6E-06	2.0E-05	3.4E-08	2.0E-03	0.3	0.7
299-W21-1	Fluoride	6/21/94 12:00	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	54.2
299-W21-1	Iodine-129	9/19/94 0:00	8.5	pCi/L	4.3E+04	NA	8.1E-06	NA	69.9	0.0
299-W21-1	Selenium	9/19/94 0:00	5.3	ug/L	1.5E-05	5.2E-05	NA	1.0E-02	0.0	3.8
299-W21-1	Technetium-99	6/30/94 0:00	83.1	pCi/L	4.2E+05	NA	5.4E-07	NA	4.7	0.0
						Total:	1.2E-05	2.7E-01	100.0	100.0
299-W22-1	Strontium-90	6/30/95 12:06	71.3	pCi/L	3.6E+05	NA	1.3E-05	NA	100.0	0.0
						Total:	1.3E-05	0.0E+00	100.0	0.0
299-W22-10	Potassium-40	3/6/95 11:15	49.5	pCi/L	2.5E+05	NA	2.7E-06	NA	33.0	0.0
299-W22-10	Strontium-90	6/21/95 14:00	26.8	pCi/L	1.3E+05	NA	4.8E-06	NA	58.4	0.0
299-W22-10	Technetium-99	7/11/94 10:10	110	pCi/L	5.5E+05	NA	7.2E-07	NA	8.7	0.0
						Total:	8.3E-06	0.0E+00	100.0	0.0
299-W22-2	Carbon tetrachloride	3/6/95 10:00	0.9	ug/L	2.5E-06	8.8E-06	3.3E-07	1.3E-02	16.2	8.8
299-W22-2	Fluoride	3/6/95 10:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	91.2
299-W22-2	Iodine-129	3/6/95 10:00	0.285	pCi/L	1.4E+03	NA	2.7E-07	NA	13.4	0.0
299-W22-2	Strontium-90	7/11/94 9:45	7.87	pCi/L	3.9E+04	NA	1.4E-06	NA	70.3	0.0
						Total:	2.0E-06	1.4E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 10 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W22-20	1,1-Dichloroethene	2/17/95 10:30	3.2	ug/L	8.9E-06	3.1E-05	5.4E-06	3.5E-03	37.2	0.4
299-W22-20	1,2-Dichloroethane	2/17/95 10:30	5.5	ug/L	1.5E-05	5.4E-05	1.4E-06	NC	9.7	0.0
299-W22-20	Carbon tetrachloride	2/16/94 10:30	6.4	ug/L	1.8E-05	6.3E-05	2.3E-06	8.9E-02	16.1	11.1
299-W22-20	Chloroform	2/16/94 10:30	9	ug/L	2.5E-05	8.8E-05	1.5E-07	8.8E-03	1.1	1.1
299-W22-20	Chromium	2/16/94 10:30	250	ug/L	7.0E-04	2.4E-03	NC	4.9E-01	0.0	60.6
299-W22-20	Fluoride	8/30/94 12 15	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	20.2
299-W22-20	Iodine-129	2/17/95 10 30	2.85	pCi/L	1.4E+04	NA	2.7E-06	NA	18.8	0.0
299-W22-20	Technetium-99	2/16/94 10:30	163	pCi/L	8.2E+05	NA	1.1E-06	NA	7.4	0.0
299-W22-20	Trichloroethene	2/16/94 10:30	33	ug/L	9.2E-05	3.2E-04	1.0E-06	5.4E-02	7.0	6.7
299-W22-20	Uranium	11/17/94 10.13	11.5	ug/L	1.9E+04	NA	3.8E-07	NA	2.7	0.0
						Total:	1.4E-05	8.1E-01	100.0	100.0
299-W22-21	Carbon tetrachloride	6/5/95 12:41	0.053	ug/L	1.5E-07	5.2E-07	1.9E-08	7.4E-04	0.2	0.6
299-W22-21	Fluoride	6/5/95 12:41	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	99.4
299-W22-21	Iodine-129	6/5/95 12:41	3.81	pCi/L	1.9E+04	NA	3.6E-06	NA	32.9	0.0
299-W22-21	Technetium-99	7/19/95 10:00	524	pCi/L	2.6E+06	NA	3.4E-06	NA	31.0	0.0
299-W22-21	Uranium	12/19/94 8:30	118	ug/L	2.0E+05	NA	3.9E-06	NA	35.9	0.0
						Total:	1.1E-05	1.3E-01	100.0	100.0
299-W22-22	Carbon tetrachloride	9/26/94 10:31	4.2	ug/L	1.2E-05	4.1E-05	1.5E-06	5.9E-02	43.4	31.0
299-W22-22	Chloroform	9/26/94 10:31	0.36	ug/L	1.0E-06	3.5E-06	6.1E-09	3.5E-04	0.2	0.2
299-W22-22	Fluoride	9/26/94 10:31	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	68.8
299-W22-22	Iodine-129	9/26/94 10:31	1.93	pCi/L	9.7E+03	NA	1.8E-06	NA	52.1	0.0
299-W22-22	Technetium-99	4/18/95 10:17	23.1	pCi/L	1.2E+05	NA	1.5E-07	NA	4.3	0.0
						Total:	3.5E-06	1.9E-01	100.0	100.0
299-W22-23	Carbon tetrachloride	3/2/94 9:15	0.65	ug/L	1.8E-06	6.4E-06	2.4E-07	9.1E-03	1.1	5.3
299-W22-23	Chloroform	3/2/94 9:15	0.24	ug/L	6.7E-07	2.3E-06	4.1E-09	2.3E-04	0.0	0.1
299-W22-23	Fluoride	9/22/94 18:20	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	94.6
299-W22-23	Iodine-129	3/2/94 9:15	22.2	pCi/L	1.1E+05	NA	2.1E-05	NA	98.7	0.0
299-W22-23	Technetium-99	9/22/94 18:20	6.1	pCi/L	3.1E+04	NA	4.0E-08	NA	0.2	0.0
						Total:	2.1E-05	1.7E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 11 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W22-39	Carbon tetrachloride	2/14/95 13:10	0.32	ug/L	8.9E-07	3.1E-06	1.2E-07	4.5E-03	1.2	3.3
299-W22-39	Chloroform	2/14/95 13:10	0.2	ug/L	5.6E-07	2.0E-06	3.4E-09	2.0E-04	0.0	0.1
299-W22-39	Fluoride	2/14/95 13:10	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	96.5
299-W22-39	Potassium-40	3/18/94 10:00	76	pCi/L	3.8E+05	NA	4.2E-06	NA	43.1	0.0
299-W22-39	Technetium-99	2/14/95 13:10	829	pCi/L	4.1E+06	NA	5.4E-06	NA	55.6	0.0
						Total:	9.7E-06	1.4E-01	100.0	100.0
299-W22-40	Carbon tetrachloride	12/15/94 9:40	10	ug/L	2.8E-05	9.8E-05	3.6E-06	1.4E-01	46.5	48.6
299-W22-40	Chloroform	12/15/94 9:40	0.81	ug/L	2.3E-06	7.9E-06	1.4E-08	7.9E-04	0.2	0.3
299-W22-40	Fluoride	6/14/95 12:10	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	51.0
299-W22-40	Potassium-40	8/16/95 10:00	73.2	pCi/L	3.7E+05	NA	4.0E-06	NA	51.5	0.0
299-W22-40	Technetium-99	6/14/95 12:10	20.8	pCi/L	1.0E+05	NA	1.4E-07	NA	1.7	0.0
299-W22-40	Trichloroethene	12/15/94 9:40	0.16	ug/L	4.5E-07	1.6E-06	4.9E-09	2.6E-04	0.1	0.1
						Total:	7.8E-06	2.9E-01	100.0	100.0
299-W22-41	Carbon tetrachloride	6/27/94 10:40	6.2	ug/L	1.7E-05	6.1E-05	2.3E-06	8.7E-02	65.9	32.5
299-W22-41	Chloroform	3/4/94 9:45	0.47	ug/L	1.3E-06	4.6E-06	8.0E-09	4.6E-04	0.2	0.2
299-W22-41	Fluoride	6/15/95 8:58	1100	ug/L	3.1E-03	1.1E-02	NC	1.8E-01	0.0	67.3
299-W22-41	Iodine-129	9/23/94 9:30	0.393	pCi/L	2.0E+03	NA	3.7E-07	NA	10.9	0.0
299-W22-41	Technetium-99	3/4/94 9:45	120	pCi/L	6.0E+05	NA	7.8E-07	NA	22.8	0.0
299-W22-41	Trichloroethene	6/27/94 10:40	0.075	ug/L	2.1E-07	7.3E-07	2.3E-09	1.2E-04	0.1	0.0
						Total:	3.4E-06	2.7E-01	100.0	100.0
299-W22-42	Carbon tetrachloride	12/15/94 10:30	5.4	ug/L	1.5E-05	5.3E-05	2.0E-06	7.5E-02	13.0	22.7
299-W22-42	Chloroform	12/15/94 10:30	0.7	ug/L	2.0E-06	6.8E-06	1.2E-08	6.8E-04	0.1	0.2
299-W22-42	Chromium	9/23/94 10:15	31	ug/L	8.7E-05	3.0E-04	NC	6.1E-02	0.0	18.2
299-W22-42	Fluoride	6/14/95 11:20	1200	ug/L	3.4E-03	1.2E-02	NC	2.0E-01	0.0	58.9
299-W22-42	Iodine-129	6/14/95 11:20	12.3	pCi/L	6.2E+04	NA	1.2E-05	NA	77.2	0.0
299-W22-42	Technetium-99	6/14/95 11:20	226	pCi/L	1.1E+06	NA	1.5E-06	NA	9.7	0.0
						Total:	1.5E-05	3.3E-01	100.0	100.0
299-W22-43	Carbon tetrachloride	9/22/94 17:15	8	ug/L	2.2E-05	7.8E-05	2.9E-06	1.1E-01	95.5	40.6
299-W22-43	Chloroform	3/2/94 10:45	0.63	ug/L	1.8E-06	6.2E-06	1.1E-08	6.2E-04	0.4	0.2
299-W22-43	Fluoride	9/22/94 17:15	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	59.1
299-W22-43	Technetium-99	12/15/94 10:40	19.1	pCi/L	9.6E+04	NA	1.2E-07	NA	4.1	0.0
299-W22-43	Trichloroethene	3/2/94 10:45	0.12	ug/L	3.4E-07	1.2E-06	3.7E-09	2.0E-04	0.1	0.1
						Total:	3.0E-06	2.8E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 12 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W22-44	Carbon tetrachloride	3/18/94 9:30	1.4	ug/L	3.9E-06	1.4E-05	5.1E-07	2.0E-02	17.2	100.0
299-W22-44	Potassium-40	10/4/94 10:30	44	pCi/L	2.2E+05	NA	2.4E-06	NA	82.0	0.0
299-W22-44	Technetium-99	3/18/94 9:30	3.45	pCi/L	1.7E+04	NA	2.2E-08	NA	0.8	0.0
						Total:	3.0E-06	2.0E-02	100.0	100.0
299-W22-45	Chloroform	3/22/94 9:00	0.2	ug/L	5.6E-07	2.0E-06	3.4E-09	2.0E-04	0.2	0.1
299-W22-45	Fluoride	3/22/94 9:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	99.9
299-W22-45	Potassium-40	3/22/94 9:00	35.6	pCi/L	1.8E+05	NA	2.0E-06	NA	98.0	0.0
299-W22-45	Technetium-99	2/15/95 10:05	5.48	pCi/L	2.7E+04	NA	3.6E-08	NA	1.8	0.0
						Total:	2.0E-06	1.3E-01	100.0	100.0
299-W22-46	Carbon tetrachloride	4/18/95 11:00	0.9	ug/L	2.5E-06	8.8E-06	3.3E-07	1.3E-02	4.7	8.8
299-W22-46	Fluoride	2/14/95 11:58	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	91.2
299-W22-46	Iodine-129	4/18/95 11:00	0.0604	pCi/L	3.0E+02	NA	5.7E-08	NA	0.8	0.0
299-W22-46	Potassium-40	9/20/94 11:30	44.5	pCi/L	2.2E+05	NA	2.4E-06	NA	34.8	0.0
299-W22-46	Technetium-99	3/22/94 10:00	646	pCi/L	3.2E+06	NA	4.2E-06	NA	59.7	0.0
						Total:	7.0E-06	1.4E-01	100.0	100.0
299-W22-7	Carbon tetrachloride	8/21/95 11:00	2	ug/L	5.6E-06	2.0E-05	7.3E-07	2.8E-02	100.0	100.0
						Total:	7.3E-07	2.8E-02	100.0	100.0
299-W22-9	Carbon tetrachloride	7/5/95 13:45	46	ug/L	1.3E-04	4.5E-04	1.7E-05	6.4E-01	16.9	99.5
299-W22-9	Iodine-129	9/20/94 10:45	86.1	pCi/L	4.3E+05	NA	8.2E-05	NA	82.6	0.0
299-W22-9	Technetium-99	9/20/94 10:45	12.8	pCi/L	6.4E+04	NA	8.3E-08	NA	0.1	0.0
299-W22-9	Trichloroethene	7/5/95 13:45	2	ug/L	5.6E-06	2.0E-05	6.2E-08	3.3E-03	0.1	0.5
299-W22-9	Uranium	9/20/94 10:45	9.59	ug/L	1.6E+04	NA	3.2E-07	NA	0.3	0.0
						Total:	9.9E-05	6.5E-01	100.0	100.0
299-W23-10	Carbon tetrachloride	3/20/95 9:00	11	ug/L	3.1E-05	1.1E-04	4.0E-06	1.5E-01	81.4	99.6
299-W23-10	Chloroform	3/20/95 9:00	0.6	ug/L	1.7E-06	5.9E-06	1.0E-08	5.9E-04	0.2	0.4
299-W23-10	Technetium-99	10/13/94 11:30	2.16	pCi/L	1.1E+04	NA	1.4E-08	NA	0.3	0.0
299-W23-10	Uranium	3/20/95 9:00	26.6	ug/L	4.4E+04	NA	8.9E-07	NA	18.1	0.0
						Total:	4.9E-06	1.5E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 13 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W23-11	Arsenic	8/29/95 10:00	10.9	ug/L	3.0E-05	1.1E-04	4.6E-05	3.6E-01	100.0	100.0
						Total:	4.6E-05	3.6E-01	100.0	100.0
299-W23-13	Carbon tetrachloride	2/8/95 9:30	3	ug/L	8.4E-06	2.9E-05	1.1E-06	4.2E-02	38.2	99.1
299-W23-13	Chloroform	3/18/94 8:30	0.4	ug/L	1.1E-06	3.9E-06	6.8E-09	3.9E-04	0.2	0.9
299-W23-13	Iodine-129	3/18/94 8:30	0.459	pCi/L	2.3E+03	NA	4.4E-07	NA	15.3	0.0
299-W23-13	Potassium-40	3/18/94 8:30	24	pCi/L	1.2E+05	NA	1.3E-06	NA	46.3	0.0
						Total:	2.9E-06	4.2E-02	100.0	100.0
299-W23-14	Carbon tetrachloride	2/14/95 10:00	27	ug/L	7.5E-05	2.6E-04	9.8E-06	3.8E-01	82.6	99.8
299-W23-14	Chloroform	2/14/95 10:00	0.7	ug/L	2.0E-06	6.8E-06	1.2E-08	6.8E-04	0.1	0.2
299-W23-14	Iodine-129	3/18/94 8:15	0.223	pCi/L	1.1E+03	NA	2.1E-07	NA	1.8	0.0
299-W23-14	Potassium-40	3/18/94 8:15	31.8	pCi/L	1.6E+05	NA	1.7E-06	NA	14.7	0.0
299-W23-14	Technetium-99	9/20/94 10:00	15.1	pCi/L	7.6E+04	NA	9.8E-08	NA	0.8	0.0
						Total:	1.2E-05	3.8E-01	100.0	100.0
299-W23-15	Carbon tetrachloride	2/8/95 8:50	4.4	ug/L	1.2E-05	4.3E-05	1.6E-06	6.2E-02	9.7	32.0
299-W23-15	Fluoride	2/14/95 9:25	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	68.0
299-W23-15	Iodine-129	3/18/94 9:30	0.344	pCi/L	1.7E+03	NA	3.3E-07	NA	2.0	0.0
299-W23-15	Potassium-40	9/20/94 10:30	37.7	pCi/L	1.9E+05	NA	2.1E-06	NA	12.5	0.0
299-W23-15	Technetium-99	3/18/94 9:30	1930	pCi/L	9.7E+06	NA	1.3E-05	NA	75.8	0.0
						Total:	1.7E-05	1.9E-01	100.0	100.0
299-W23-2	Carbon tetrachloride	7/31/95 10:30	1.14	ug/L	3.2E-06	1.1E-05	4.1E-07	1.6E-02	2.7	10.9
299-W23-2	Fluoride	9/27/94 9:30	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	89.1
299-W23-2	Technetium-99	9/27/94 9:30	2260	pCi/L	1.1E+07	NA	1.5E-05	NA	94.8	0.0
299-W23-2	Uranium	9/27/94 9:30	11.5	ug/L	1.9E+04	NA	3.8E-07	NA	2.5	0.0
						Total:	1.5E-05	1.5E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 14 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W23-3	Carbon tetrachloride	7/26/95 11:15	0.2	ug/L	5.6E-07	2.0E-06	7.3E-08	2.8E-03	1.1	2.1
299-W23-3	Chloroform	7/26/95 11:15	0.068	ug/L	1.9E-07	6.7E-07	1.2E-09	6.7E-05	0.0	0.0
299-W23-3	Fluoride	9/27/94 10:30	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	97.9
299-W23-3	Potassium-40	7/26/95 11:15	58.9	pCi/L	2.9E+05	NA	3.2E-06	NA	46.9	0.0
299-W23-3	Strontium-90	9/27/94 10:30	0.0134	pCi/L	6.7E+01	NA	2.4E-09	NA	0.0	0.0
299-W23-3	Technetium-99	9/27/94 10:30	523	pCi/L	2.6E+06	NA	3.4E-06	NA	49.2	0.0
299-W23-3	Uranium	7/26/95 11:15	5.78	ug/L	9.7E+03	NA	1.9E-07	NA	2.8	0.0
						Total:	6.9E-06	1.3E-01	100.0	100.0
299-W23-4	Carbon tetrachloride	9/1/95 13:00	5	ug/L	1.4E-05	4.9E-05	1.8E-06	7.0E-02	68.2	100.0
299-W23-4	Technetium-99	7/25/94 8:45	4.17	pCi/L	2.1E+04	NA	2.7E-08	NA	1.0	0.0
299-W23-4	Uranium	6/21/95 14:40	24.6	ug/L	4.1E+04	NA	8.2E-07	NA	30.8	0.0
						Total:	2.7E-06	7.0E-02	100.0	100.0
299-W23-7	Fluoride	9/27/94 11:30	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
299-W23-7	Technetium-99	9/27/94 11:30	354	pCi/L	1.8E+06	NA	2.3E-06	NA	93.3	0.0
299-W23-7	Uranium	9/27/94 11:30	4.95	ug/L	8.3E+03	NA	1.7E-07	NA	6.7	0.0
						Total:	2.5E-06	1.3E-01	100.0	100.0
299-W23-9	Carbon tetrachloride	4/18/95 13:00	1.5	ug/L	4.2E-06	1.5E-05	5.5E-07	2.1E-02	37.8	100.0
299-W23-9	Technetium-99	10/14/94 9:30	27.6	pCi/L	1.4E+05	NA	1.8E-07	NA	12.4	0.0
299-W23-9	Uranium	10/14/94 9:30	21.5	ug/L	3.6E+04	NA	7.2E-07	NA	49.8	0.0
						Total:	1.4E-06	2.1E-02	100.0	100.0
299-W26-10	Carbon tetrachloride	7/17/95 10:30	1.3	ug/L	3.6E-06	1.3E-05	4.7E-07	1.8E-02	58.6	100.0
299-W26-10	Iodine-129	6/21/94 8:30	0.352	pCi/L	1.8E+03	NA	3.3E-07	NA	41.4	0.0
						Total:	8.1E-07	1.8E-02	100.0	100.0
299-W26-12	Chloroform	12/7/94 12:00	0.28	ug/L	7.8E-07	2.7E-06	4.8E-09	2.7E-04	2.3	100.0
299-W26-12	Iodine-129	6/21/94 9:30	0.212	pCi/L	1.1E+03	NA	2.0E-07	NA	97.0	0.0
299-W26-12	Strontium-90	6/21/94 9:30	0.00831	pCi/L	4.2E+01	NA	1.5E-09	NA	0.7	0.0
						Total:	2.1E-07	2.7E-04	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 15 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
299-W26-7	Chromium	12/7/94 11:30	170	ug/L	4.8E-04	1.7E-03	NC	3.3E-01	0.0	100.0
299-W26-7	Strontium-90	6/16/94 8:30	0.0716	pCi/L	3.6E+02	NA	1.3E-08	NA	100.0	0.0
						Total:	1.3E-08	3.3E-01	100.0	100.0
299-W26-8	Carbon tetrachloride	7/17/95 9:45	3.9	ug/L	1.1E-05	3.8E-05	1.4E-06	5.5E-02	100.0	100.0
						Total:	1.4E-06	5.5E-02	100.0	100.0
299-W27-1	Carbon tetrachloride	1/25/95 10:04	0.66	ug/L	1.8E-06	6.5E-06	2.4E-07	9.2E-03	5.0	27.2
299-W27-1	Chloroform	1/19/94 11:26	10	ug/L	2.8E-05	9.8E-05	1.7E-07	9.8E-03	3.6	28.9
299-W27-1	Iodine-129	1/25/95 10:04	4.23	pCi/L	2.1E+04	NA	4.0E-06	NA	84.5	0.0
299-W27-1	Selenium	1/25/95 10:04	7.6	ug/L	2.1E-05	7.4E-05	NA	1.5E-02	0.0	43.9
299-W27-1	Uranium	1/19/94 11:26	9.86	ug/L	1.6E+04	NA	3.3E-07	NA	6.9	0.0
						Total:	4.8E-06	3.4E-02	100.0	100.0
299-W27-2	Carbon tetrachloride	1/20/95 9:25	5.3	ug/L	1.5E-05	5.2E-05	1.9E-06	7.4E-02	98.3	99.5
299-W27-2	Chloroform	1/20/95 9:25	0.35	ug/L	9.8E-07	3.4E-06	6.0E-09	3.4E-04	0.3	0.5
299-W27-2	Technetium-99	1/20/95 9:25	4.24	pCi/L	2.1E+04	NA	2.8E-08	NA	1.4	0.0
						Total:	2.0E-06	7.4E-02	100.0	100.0
699-29-78	Fluoride	3/24/95 13:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
699-29-78	Iodine-129	1/13/94 9:00	0.039	pCi/L	2.0E+02	NA	3.7E-08	NA	93.0	0.0
699-29-78	Technetium-99	1/13/94 9:00	0.426	pCi/L	2.1E+03	NA	2.8E-09	NA	7.0	0.0
						Total:	4.0E-08	1.3E-01	100.0	100.0
699-32-62	Chromium	9/22/95 10:00	220	ug/L	6.2E-04	2.2E-03	NC	4.3E-01	0.0	76.7
699-32-62	Fluoride	9/22/95 10:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	23.3
						Total:	0.0E+00	5.6E-01	0.0	100.0
699-32-70B	Iodine-129	3/3/94 10:00	2.82	pCi/L	1.4E+04	NA	2.7E-06	NA	46.7	0.0
699-32-70B	Potassium-40	5/2/95 13:14	35.4	pCi/L	1.8E+05	NA	1.9E-06	NA	33.9	0.0
699-32-70B	Technetium-99	3/3/94 10:00	171	pCi/L	8.6E+05	NA	1.1E-06	NA	19.4	0.0
						Total:	5.7E-06	0.0E+00	100.0	0.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 16 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
699-32-72A	Technetium-99	6/21/94 10:00	17.4	pCi/L	8.7E+04	NA	1.1E-07	NA	100.0	0.0
						Total:	1.1E-07	0.0E+00	100.0	0.0
699-32-72B	Carbon tetrachloride	10/25/94 9 01	0.14	ug/L	3.9E-07	1.4E-06	5.1E-08	2.0E-03	2.8	1.4
699-32-72B	Chloroform	8/3/94 10 40	3.7	ug/L	1.0E-05	3.6E-05	6.3E-08	3.6E-03	3.4	2.7
699-32-72B	Fluoride	10/25/94 9 01	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	95.9
699-32-72B	Iodine-129	10/25/94 9.01	0.723	pCi/L	3.6E+03	NA	6.9E-07	NA	37.4	0.0
699-32-72B	Technetium-99	8/3/94 10:40	159	pCi/L	8.0E+05	NA	1.0E-06	NA	56.3	0.0
						Total:	1.8E-06	1.4E-01	100.0	100.0
699-32-77	Chloroform	2/22/95 10:00	0.6	ug/L	1.7E-06	5.9E-06	1.0E-08	5.9E-04	48.5	0.4
699-32-77	Fluoride	2/22/95 10:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	99.6
699-32-77	Technetium-99	2/17/94 8:30	1.67	pCi/L	8.4E+03	NA	1.1E-08	NA	51.5	0.0
						Total:	2.1E-08	1.3E-01	100.0	100.0
699-34-61	Carbon tetrachloride	1/10/95 9:30	0.69	ug/L	1.9E-06	6.8E-06	2.5E-07	9.6E-03	76.6	3.1
699-34-61	Chloroform	5/6/94 8:40	0.64	ug/L	1.8E-06	6.3E-06	1.1E-08	6.3E-04	3.3	0.2
699-34-61	Chromium	1/27/94 10:05	80	ug/L	2.2E-04	7.8E-04	NC	1.6E-01	0.0	49.9
699-34-61	Fluoride	10/25/94 11:00	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	46.8
699-34-61	Technetium-99	1/10/95 9:30	10.1	pCi/L	5.1E+04	NA	6.6E-08	NA	20.1	0.0
						Total:	3.3E-07	3.1E-01	100.0	100.0
699-35-66A	Fluoride	12/16/94 10:30	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
699-35-66A	Iodine-129	3/9/95 10:50	10	pCi/L	5.0E+04	NA	9.5E-06	NA	98.5	0.0
699-35-66A	Technetium-99	12/16/94 10:30	22.6	pCi/L	1.1E+05	NA	1.5E-07	NA	1.5	0.0
						Total:	9.6E-06	1.3E-01	100.0	100.0
699-35-70	Fluoride	8/31/94 9:10	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
699-35-70	Iodine-129	2/17/95 9:00	37.8	pCi/L	1.9E+05	NA	3.6E-05	NA	99.4	0.0
699-35-70	Technetium-99	2/22/94 10:00	35.1	pCi/L	1.8E+05	NA	2.3E-07	NA	0.6	0.0
						Total:	3.6E-05	1.3E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 17 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
699-35-78A	Carbon tetrachloride	1/27/94 11:00	96	ug/L	2.7E-04	9.4E-04	3.5E-05	1.3E+00	99.8	90.9
699-35-78A	Chloroform	1/27/94 11:00	3.2	ug/L	8.9E-06	3.1E-05	5.5E-08	3.1E-03	0.2	0.2
699-35-78A	Fluoride	1/27/94 11:00	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	8.8
699-35-78A	Technetium-99	1/27/94 11:00	0.246	pCi/L	1.2E+03	NA	1.6E-09	NA	0.0	0.0
699-35-78A	Trichloroethene	1/27/94 11:00	0.3	ug/L	8.4E-07	2.9E-06	9.2E-09	4.9E-04	0.0	0.0
						Total:	3.5E-05	1.5E+00	100.0	100.0
699-36-61A	Technetium-99	1/27/94 12:15	10.5	pCi/L	5.3E+04	NA	6.8E-08	NA	100.0	0.0
						Total:	6.8E-08	0.0E+00	100.0	0.0
699-36-70A	Carbon tetrachloride	10/21/94 14:30	8.9	ug/L	2.5E-05	8.7E-05	3.2E-06	1.2E-01	6.6	41.3
699-36-70A	Chloroform	10/21/94 14:30	1.3	ug/L	3.6E-06	1.3E-05	2.2E-08	1.3E-03	0.0	0.4
699-36-70A	Fluoride	6/15/95 12:34	1000	ug/L	2.8E-03	9.8E-03	NC	1.6E-01	0.0	54.2
699-36-70A	Iodine-129	2/10/95 13:23	38.8	pCi/L	1.9E+05	NA	3.7E-05	NA	75.4	0.0
699-36-70A	Potassium-40	10/11/94 18:50	142	pCi/L	7.1E+05	NA	7.8E-06	NA	16.0	0.0
699-36-70A	Selenium	1/3/95 11:00	6.1	ug/L	1.7E-05	6.0E-05	NA	1.2E-02	0.0	4.0
699-36-70A	Technetium-99	6/15/95 12:34	67.9	pCi/L	3.4E+05	NA	4.4E-07	NA	0.9	0.0
699-36-70A	Trichloroethene	10/21/94 14:30	0.27	ug/L	7.5E-07	2.6E-06	8.3E-09	4.4E-04	0.0	0.1
699-36-70A	Uranium	11/2/94 18:30	14.8	ug/L	2.5E+04	NA	4.9E-07	NA	1.0	0.0
						Total:	4.9E-05	3.0E-01	100.0	100.0
699-38-61	Fluoride	10/25/94 9:31	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
699-38-61	Iodine-129	8/3/94 8:45	1.1	pCi/L	5.5E+03	NA	1.0E-06	NA	94.5	0.0
699-38-61	Technetium-99	1/27/94 11:30	9.42	pCi/L	4.7E+04	NA	6.1E-08	NA	5.5	0.0
						Total:	1.1E-06	1.3E-01	100.0	100.0
699-38-65	Fluoride	9/1/94 12:42	800	ug/L	2.2E-03	7.8E-03	NC	1.3E-01	0.0	100.0
699-38-65	Iodine-129	2/16/94 1:00	5.55	pCi/L	2.8E+04	NA	5.3E-06	NA	93.1	0.0
699-38-65	Technetium-99	2/16/94 1:00	60.5	pCi/L	3.0E+05	NA	3.9E-07	NA	6.9	0.0
						Total:	5.7E-06	1.3E-01	100.0	100.0

Table B.4-1. Current-Condition Commercial/Industrial Intake and Risk 200-UP-1 Groundwater Operable Unit Limited Field Investigation Contaminant Risk Assessment. (sheet 18 of 18)

Monitoring Well	Contaminant of Potential Concern	Sample Collection Date and Time	Concentration	Units	Commercial/ Industrial Carcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Noncarcinogenic Ingestion Intake (mg/kg-day)	Commercial/ Industrial Carcinogenic Ingestion Risk	Commercial/ Industrial Noncarcinogenic Ingestion Risk	Percent of Total Carcinogenic Ingestion Risk (percent)	Percent of Total Noncarcinogenic Ingestion Risk (percent)
699-38-68A	Carbon tetrachloride	9/27/94 0:00	5	ug/L	1.4E-05	4.9E-05	1.8E-06	7.0E-02	39.1	98.6
699-38-68A	Chloroform	9/27/94 0:00	1	ug/L	2.8E-06	9.8E-06	1.7E-08	9.8E-04	0.4	1.4
699-38-68A	Iodine-129	9/27/94 0:00	1.54	pCi/L	7.7E+03	NA	1.5E-06	NA	31.5	0.0
699-38-68A	Strontium-90	9/27/94 0:00	0.158	pCi/L	7.9E+02	NA	2.8E-08	NA	0.6	0.0
699-38-68A	Technetium-99	5/17/95 12:28	204	pCi/L	1.0E+06	NA	1.3E-06	NA	28.5	0.0
						Total:	4.7E-06	7.1E-02	100.0	100.0
699-38-70	Carbon tetrachloride	5/22/95 9:30	54	ug/L	1.5E-04	5.3E-04	2.0E-05	7.5E-01	90.1	82.3
699-38-70	Chloroform	9/30/94 9:30	6	ug/L	1.7E-05	5.9E-05	1.0E-07	5.9E-03	0.5	0.6
699-38-70	Fluoride	5/22/95 9:30	900	ug/L	2.5E-03	8.8E-03	NC	1.5E-01	0.0	16.0
699-38-70	Iodine-129	1/21/94 9:29	1.97	pCi/L	9.9E+03	NA	1.9E-06	NA	8.6	0.0
699-38-70	Trichloroethene	1/21/94 9:29	6.2	ug/L	1.7E-05	6.1E-05	1.9E-07	1.0E-02	0.9	1.1
						Total:	2.2E-05	9.2E-01	100.0	100.0
699-40-62	Iodine-129	1/24/94 10:00	0.36	pCi/L	1.8E+03	NA	3.4E-07	NA	85.8	0.0
699-40-62	Technetium-99	1/24/94 10:00	8.68	pCi/L	4.3E+04	NA	5.6E-08	NA	14.2	0.0
						Total:	4.0E-07	0.0E+00	100.0	0.0

Notes:
mg/kg-d = Milligrams per kilogram-day.
ug/L = Micrograms per liter.
pCi/L = Picocuries per liter.
NC = Risk is not calculated because a toxicity value is not available.
NA = Risk or intake is not applicable because chemical or radionuclide is not a contaminant of concern.

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