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Risk-Based Decision Analysis for the 200-ZP-1 Groundwater Operable Unit

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
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Bechtel Hanford, Inc.
Richland, Washington

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Author
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1.0 INTRODUCTION

A risk assessment was conducted for groundwater contaminant plumes within the 200-ZP-1 Operable Unit in the Hanford 200 West Area. The contaminants of potential concern (COPC) that were evaluated in the risk analysis include carbon tetrachloride, chloroform, and trichloroethylene (TCE). The methodology used in the analysis is based on *Risk-Based Decision Analysis for Groundwater Operable Units* (BHI 1995). This methodology consists of three key elements:

- Sample-specific risk characterization which results in visual representations of human health risk associated with groundwater contamination
- Estimation of natural attenuation (dispersion and retardation) as the contamination migrates downgradient from its present location
- Consideration of public health protection at key geographic locations along the natural migration pathway.

Risk assumptions and scenarios were based on *Hanford Site Risk Assessment Methodology* (HSRAM) (DOE-RL 1994). Hypothetical exposure scenarios were assessed based on both current and future plume conditions. For current conditions, a hypothetical industrial groundwater ingestion scenario was evaluated; for future conditions, a residential ingestion scenario was assumed. The industrial ingestion scenario, which is derived from HSRAM, was used in this risk analysis for illustrative purposes only. There is currently no use of the 200 Area groundwater for drinking water, nor is any anticipated for the foreseeable future; therefore, it should not be implied by this risk analysis that the U.S. Department of Energy (DOE) is advocating use of this groundwater for direct human ingestion.

For the limited purposes of this risk assessment, the area where there might be potential exposure to groundwater in the future was assumed to be roughly coincident with the Central Plateau geographic area developed by the Hanford Future Site Uses Working Group. This geographic area encompasses all of the 200 East and West Areas and extends to the north to include the 200 North Area. In the absence of formally identified points of exposure, the Central Plateau geographic area boundary was selected as an appropriate point to use for future exposure scenarios in this risk assessment. It is understood that the hypothetical exposure boundary selected for use in this risk assessment may have little to no relationship to points of exposure or points of compliance that will be identified in the future in accordance with applicable RCRA and CERCLA procedures.

The scope of the risk analysis presented in this report is confined to an evaluation of existing baseline conditions and prediction of plume movement assuming no plume containment or other remediation measures. Plans have been made to conduct an interim remedial measure (IRM) to contain the most concentrated core of the carbon tetrachloride plume to mitigate downgradient migration of the plume. An interim record of decision (IROD) has been signed for implementation of that action. It is expected that this interim action will reduce the further

spread of contamination and thus reduce risks to potential downgradient users of the groundwater. An analysis of risk reduction as a result of the IRM is not within the scope of this assessment but would be subject to future risk analyses when data become available on the performance of the IRM system.

The groundwater contamination is observed in Unit E of the Ringold Formation. The Ringold Formation consists of unconsolidated sediments deposited in alluvial and lacustrine environments. Unit E is the uppermost gravel unit in the Ringold Formation (DOE-RL 1992).

The analytical laboratory data for carbon tetrachloride used in the risk-based decision analysis are from groundwater samples collected from July to September 1994. To augment this data set, carbon tetrachloride results for samples collected in early January 1995 from three additional monitoring wells were included. These wells were 299-W11-3, 299-W11-6, and 299-W11-10.

Because many of the groundwater samples in the July to September 1994 data set were diluted by the laboratory prior to analysis (probably due to high carbon tetrachloride concentrations), the detection limits for chloroform and trichloroethylene in many samples are very high (e.g., 50 or 100 ppb). For this reason, the data sets for chloroform and trichloroethylene were expanded to include groundwater sample results from March 1987 to November 1994.

For current exposure, risk was calculated at each monitoring well using the observed volatile organic concentrations in groundwater from that well. The locations of the groundwater monitoring wells for the 200-ZP-1 Operable Unit are shown in Figure 1. The calculated risk values represent contaminant-specific and total incremental lifetime cancer risks (ILCR), hazard quotients (HQ), and hazard indices (HI). These values were plotted on base maps and risks were contoured.

For future exposure, the transport of the organic constituents was modeled using a two-dimensional analytical flow and transport model called CONMIG (Walton 1989). CONMIG is based on simple and straightforward analytical equations. CONMIG was selected for use because it is capable of simulating an irregularly shaped source as a group of point sources and because it allows consideration of adsorption and decay (both radioactive and degradation). While not formally approved for use by the EPA, EPA is reviewing the modeling calculations performed for the 200-BP-5 Risk-Based Decision Analysis to validate the methodology.

The contaminant transport modeling simulated dispersion and adsorption (retardation) of constituents during migration downgradient from the existing conditions to the hypothetical future-use boundary. The parameters used in the CONMIG simulations are shown in Table 2. In addition, the following hydrogeologic parameters were used in the analytical calculations:

Effective porosity = 0.15
Aquifer thickness = 33 ft
Hydraulic gradient = 0.0023 (average)
Seepage velocity = 0.75 ft/day (average)
Aquifer bulk density = 1.65 gm/cm^3

The calculated risk values represent contaminant-specific and total ILCRs, HQs, and HIs. These values were plotted on linear displacement diagrams and risk was contoured.

Carbon tetrachloride and chloroform have been given an EPA weight-of-evidence classification of B2, probable human carcinogens (IRIS 1995). The carcinogenicity assessment for trichloroethylene is currently in preparation (IRIS 1995). Carbon tetrachloride and chloroform are also considered by the EPA to be toxic due to the noncarcinogenic health effects; however, no noncarcinogenic health effects are currently specified for trichloroethylene (IRIS 1995). The contaminant-specific reference dose for chronic oral exposures (RfD) and oral slope factors (SF) were obtained from the Integrated Risk Information System (IRIS 1995) for each COPC. The SF for trichloroethylene was obtained from a communication with the Superfund Health Risk Technical Support Center (EPA 1995).

2.0 200-ZP-1 EXISTING SITE CONDITIONS

The calculated risk values estimating contaminant-specific and total ILCRs, HQs, and HIs for carbon tetrachloride, chloroform, and trichloroethylene at the 200-ZP-1 Operable Unit are shown in Figures 2 through 8. Carbon tetrachloride is measured in enough monitoring wells to establish a plume. However, chloroform and trichloroethylene must be considered as isolated hot spots. Note that a HQ is not calculated for trichloroethylene because an oral RfD is not available.

Elevated carbon tetrachloride concentrations in groundwater beneath the Z Plant area resulted in ILCRs greater than $5x10^{-4}$ (Figure 2) and HQs in excess of 10 (Figure 3) using the industrial ingestion scenario. ILCRs greater than $1x10^{-5}$ are calculated for a large portion of the 200 West Area (Figure 2). Similarly, HQs greater than 1 are estimated for ingestion of groundwater from a large part of the 200 West Area.

Relatively small areas with ILCRs greater than $1x10^{-6}$ are observed for exposure to chloroform in groundwater, based on the industrial ingestion scenario (Figure 4). A small area with a chloroform HQ greater than 1 is found to the east of Z Plant (Figure 5). ILCRs for industrial groundwater ingestion of trichloroethylene are all less than $1x10^{-6}$ (Figure 6).

Figure 7 shows the total ILCRs for the industrial ingestion of groundwater containing the volatile organics. Comparison of Figure 7 to Figure 2 indicates that carbon tetrachloride is the predominant contributor to cancer risk at the 200-ZP-1 Groundwater Operable Unit. Likewise, comparison of Figure 8 to Figure 3 indicates that carbon tetrachloride is also the predominant COPC contributing to noncancer risk.

The maximum concentration limit (MCL) for carbon tetrachloride in drinking water is 0.005 mg/L (ppm). The maximum concentration of carbon tetrachloride was 5.2 mg/L in well 299-W15-16 (see Table 3). The maximum concentration of carbon tetrachloride is above the MCL by about a factor of 1,000.

3.0 200-ZP-1 FUTURE CONDITIONS

The calculated risk values estimating contaminant-specific and total ILCRs and HIs for carbon tetrachloride at the hypothetical future-use boundary are shown in Figures 9 and 10. Tables 1 and 2 show the human health default and contaminant transport parameters used to estimate risk at the hypothetical future-use boundary. The size and magnitude of each existing COPC plume or hot spot was approximated as a group of point sources for transport modeling. Contamination is assumed to be historical, so the sources are modeled as slugs rather than continuous sources. As discussed in Section 1.0, a residential groundwater-ingestion scenario was used to estimate future risks to 200-ZP-1 Operable Unit COPCs after migration downgradient to the hypothetical future-use boundary.

The maximum concentration of carbon tetrachloride was migrated 31,250 ft to the hypothetical future-use boundary with an estimated travel time of 183 yrs. The maximum concentration of chloroform was migrated 30,000 ft to the hypothetical future-use boundary with an estimated travel time of 126 yrs. The maximum concentration of trichloroethylene was migrated 25,000 ft to the future-use boundary with an estimated travel time of 119 yrs. Future-use risks are summarized in Section 4.0.

The analytical modeling using CONMIG assumed a historical slug input of groundwater contaminants. It is acknowledged that the presence of dense nonaqueous phase liquids (DNAPL) in the vadose zone, the aquifer, or both may present a continuous source of contaminants moving into the groundwater. The modeling assumes that the source is supplying less contaminants to the groundwater compared to the past, and thus the observed peak groundwater concentrations have already reached a maximum and are now declining with time. The plume data evaluated for the last 5 yrs do not show any discernable change in aquifer concentrations; thus, the assumption that the concentrations have peaked is plausible but yet somewhat uncertain. If the modeling were to assume that the peak concentrations have not yet been realized, then the situation is not readily simulated by modeling because the flux of contamination from the potential DNAPL source(s) is not known. In the extreme, if the flux of contamination moving into the groundwater from a DNAPL source were sufficiently large, the concentrations downgradient would continue to increase such that the concentrations at downgradient points could, for example, reach concentrations similar to that observed near the potential source(s). In this example, if the maximum contaminant concentrations now observed were to reach the hypothetical future use boundary, the associated residential risk would become 9.6×10^{-3}, which is a factor of four higher than the predicted residential risk given the assumptions used in the modeling. Further data on the plume behavior with time are needed to fully resolve this uncertainty in the predictions.

4.0 SUMMARY AND CONCLUSIONS

Carbon tetrachloride is the major human health risk for ingestion of groundwater at the 200-ZP-1 Operable Unit and after migration to the hypothetical future-use boundary. A summary risk table for existing site exposure to carbon tetrachloride, chloroform, and trichloroethylene due to industrial ingestion of groundwater is found in Table 3. The maximum observed plume or hot spot concentration of each COPC is also shown in Table 3 for reference. The corresponding maximum concentration estimated from the analytical modeling is shown in Table 4.

For residential groundwater use at the future-use boundary, chloroform approaches an ILCR threshold of $1x10^{-5}$, and trichloroethylene marginally exceeds an ILCR threshold of $1x10^{-6}$. If estimated human health risks above an ILCR threshold of 1×10^{-4} are the drivers for groundwater remediation, risk assessment results for carbon tetrachloride would suggest groundwater remediation for this volatile organic at the 200-ZP-1 Operable Unit location. Table 5 indicates that at least 98 percent of the human health risk for either industrial or residential ingestion of groundwater can be attributed to carbon tetrachloride.

As described in the risk-based decision analysis methodology document (BHI 1995), the results of this risk analysis could be used as one indicator of a risk-based target remediation area. Determination of a risk-based target remediation area requires analysis of the risk contours at the point of compliance and an assumption of the target risk at that point. Then the required concentrations within the risk-based target remediation area are back-calculated to include the effects of natural attenuation between the two locations. The risk-based target remediation area thus represents that portion of the plume whose concentrations would require reduction in order to meet the target concentrations (target risk) at the point of compliance. This analysis is beyond the scope of this report, and it should be emphasized that there has been no agreement on compliance points or target risks.

5.0 REFERENCES

BHI, 1995, *Risk-Based Decision Analysis for Groundwater Operable Units*, BHI-00161, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1992, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL-92-16, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1994, *Hanford Site Risk Assessment Methodology*, DOE/RL-91-45, Rev. 3 (Draft), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA, 1995, Superfund Health Risk Technical Support Center, 5-3-95, "Carcinogenic Toxicity Information for Trichloroethylene," U.S. Environmental Protection Agency, FAX to Holly O'Grady, IT Corporation, Albuquerque, New Mexico.

Integrated Risk Information System (IRIS), 1995, data file, U.S. Department of Health and Human Services, National Library of Medicine Toxicology Data Network (TOXNET), Bethesda, Maryland.

Montgomery, John H., and Linda M. Welkom, 1990, *Groundwater Chemicals Desk Reference*, Lewis Publishers, Inc., Chelsea, Michigan.

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

Figure 1 200-ZP-1 Groundwater Operable Unit, Groundwater Monitoring Well Locations, 200 West Area

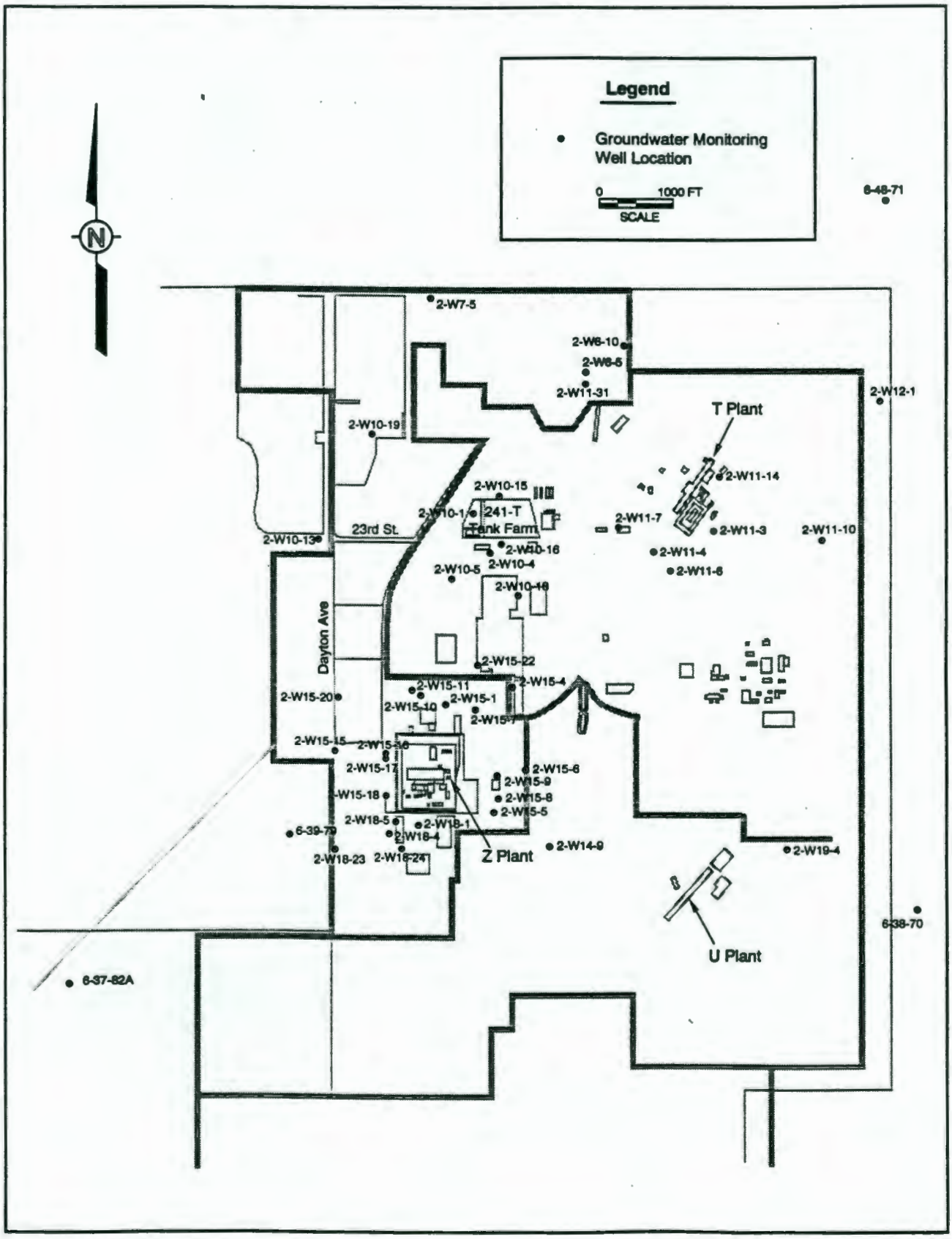


Figure 2 200-ZP-1 Groundwater Operable Unit Incremental Lifetime Cancer Risk for Reasonable Maximum Exposure to Carbon Tetrachloride in Groundwater, Existing Conditions, Industrial Ingestion Scenario

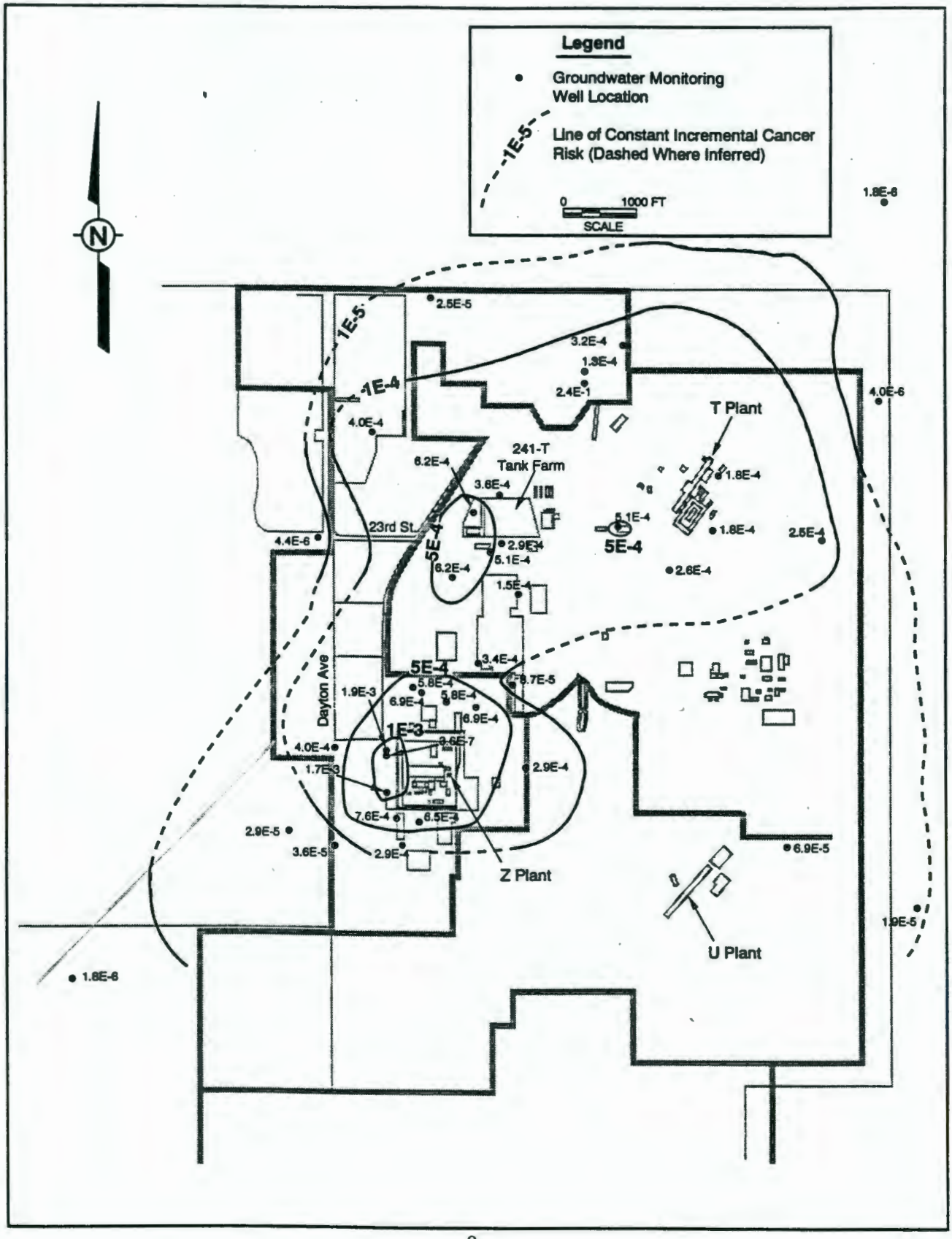


Figure 3 200-ZP-1 Groundwater Operable Unit Hazard Quotient for Reasonable Maximum Exposure to Carbon Tetrachloride in Groundwater, Existing Conditions, Industrial Ingestion Scenario

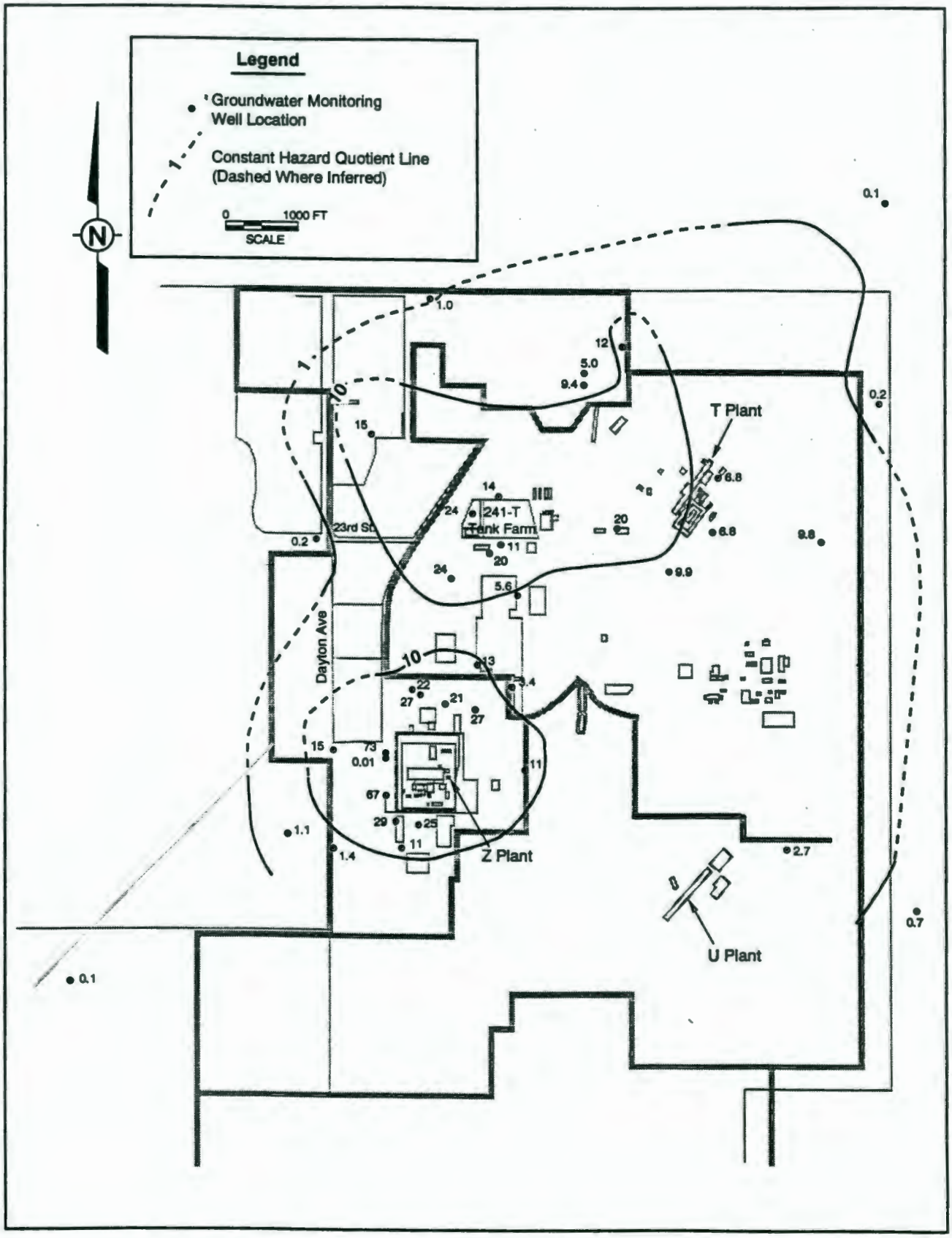


Figure 4 200-ZP-1 Groundwater Operable Unit Incremental Lifetime Cancer Risk for Reasonable Maximum Exposure to Chloroform in Groundwater, Existing Conditions, Industrial Ingestion Scenario

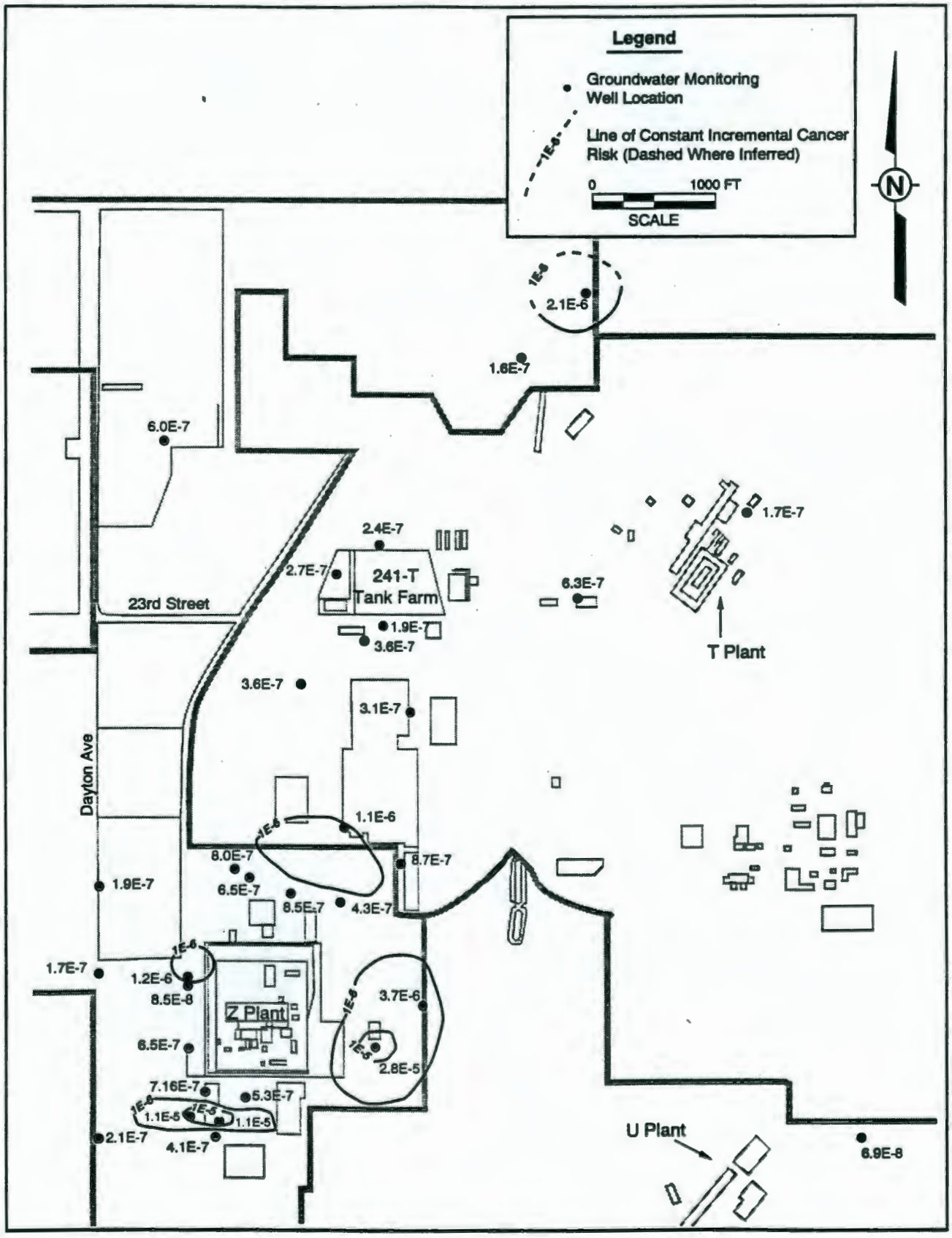


Figure 5 200-ZP-1 Groundwater Operable Unit Hazard Quotient for Reasonable Maximum Exposure to Chloroform in Groundwater, Existing Conditions, Industrial Ingestion Scenario

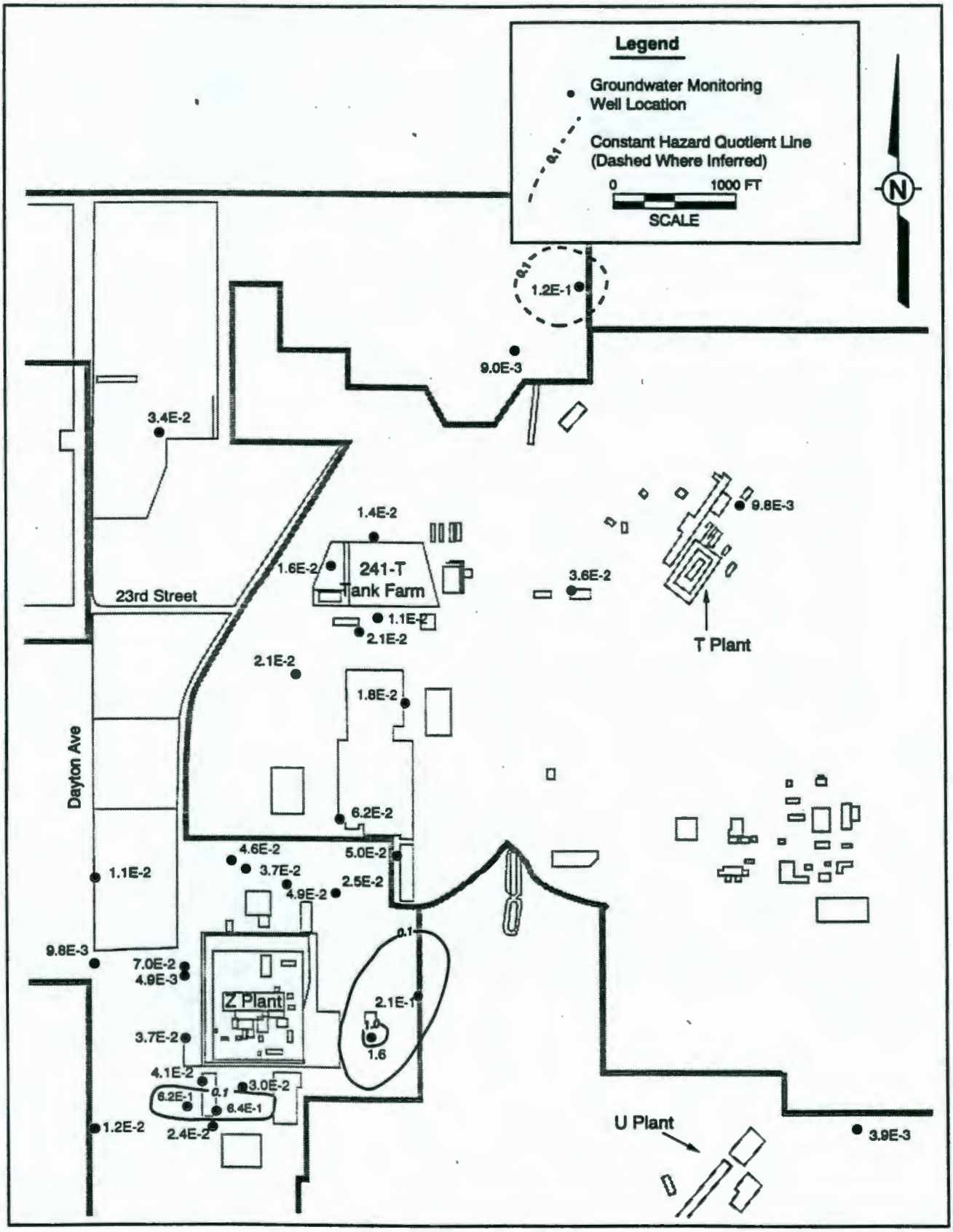


Figure 6 200-ZP-1 Groundwater Operable Unit Incremental Lifetime Cancer Risk for Reasonable Maximum Exposure to Trichloroethylene in Groundwater, Existing Conditions, Industrial Ingestion Scenario

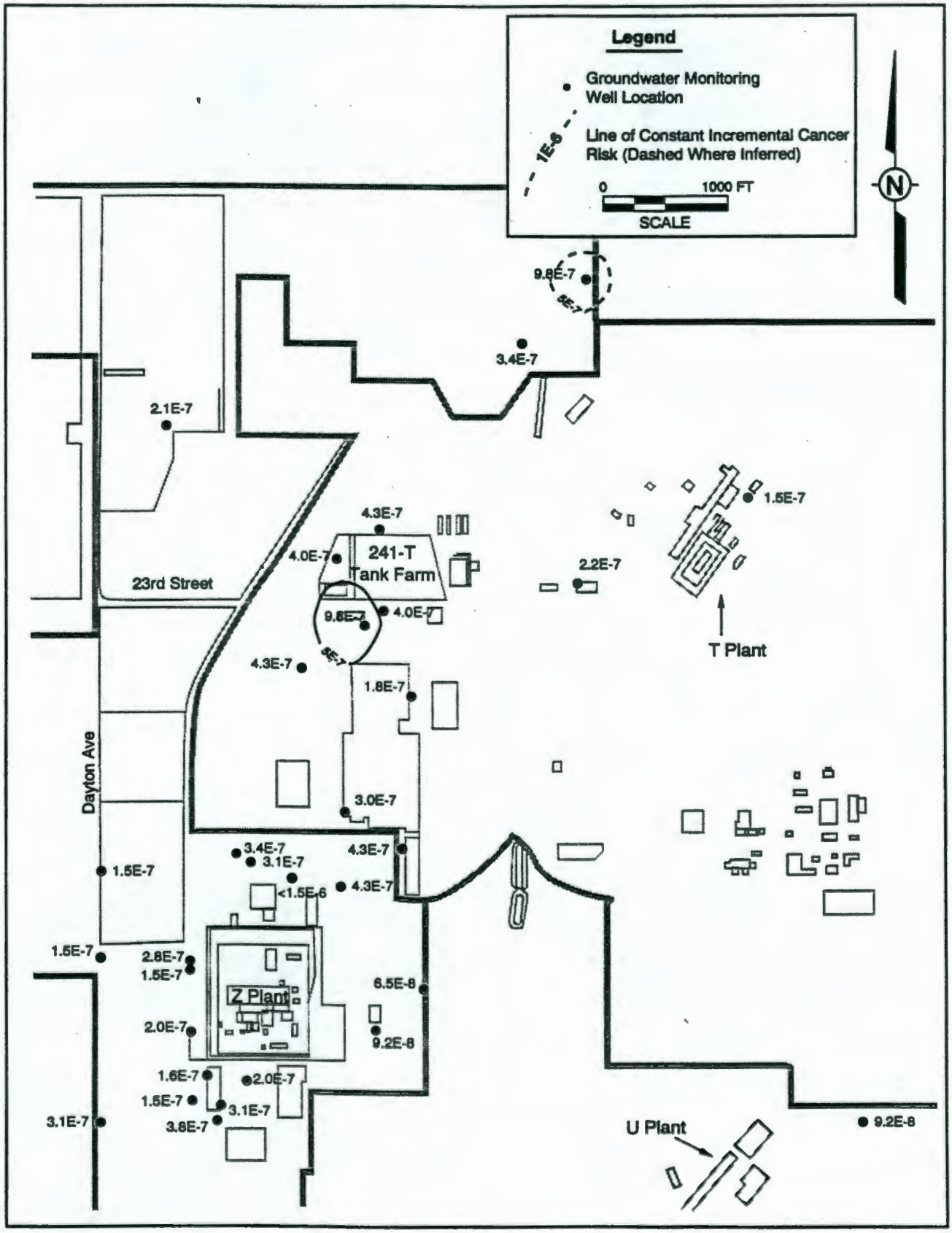


Figure 7 200-ZP-1 Groundwater Operable Unit Incremental Lifetime Cancer Risk for Reasonable Maximum Exposure to Carbon Tetrachloride, Chloroform, and Trichloroethylene in Groundwater, Existing Conditions, Industrial Ingestion Scenario

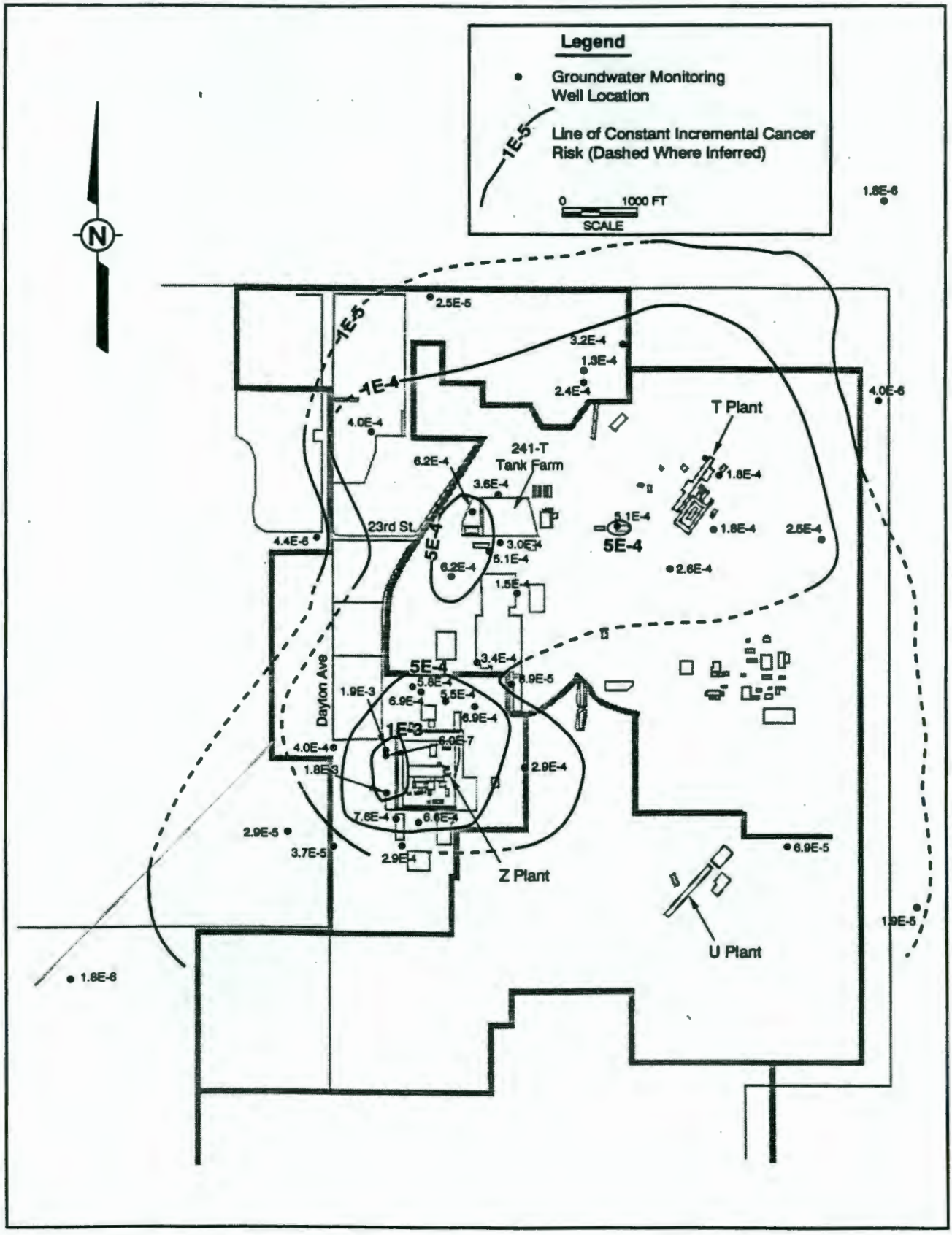
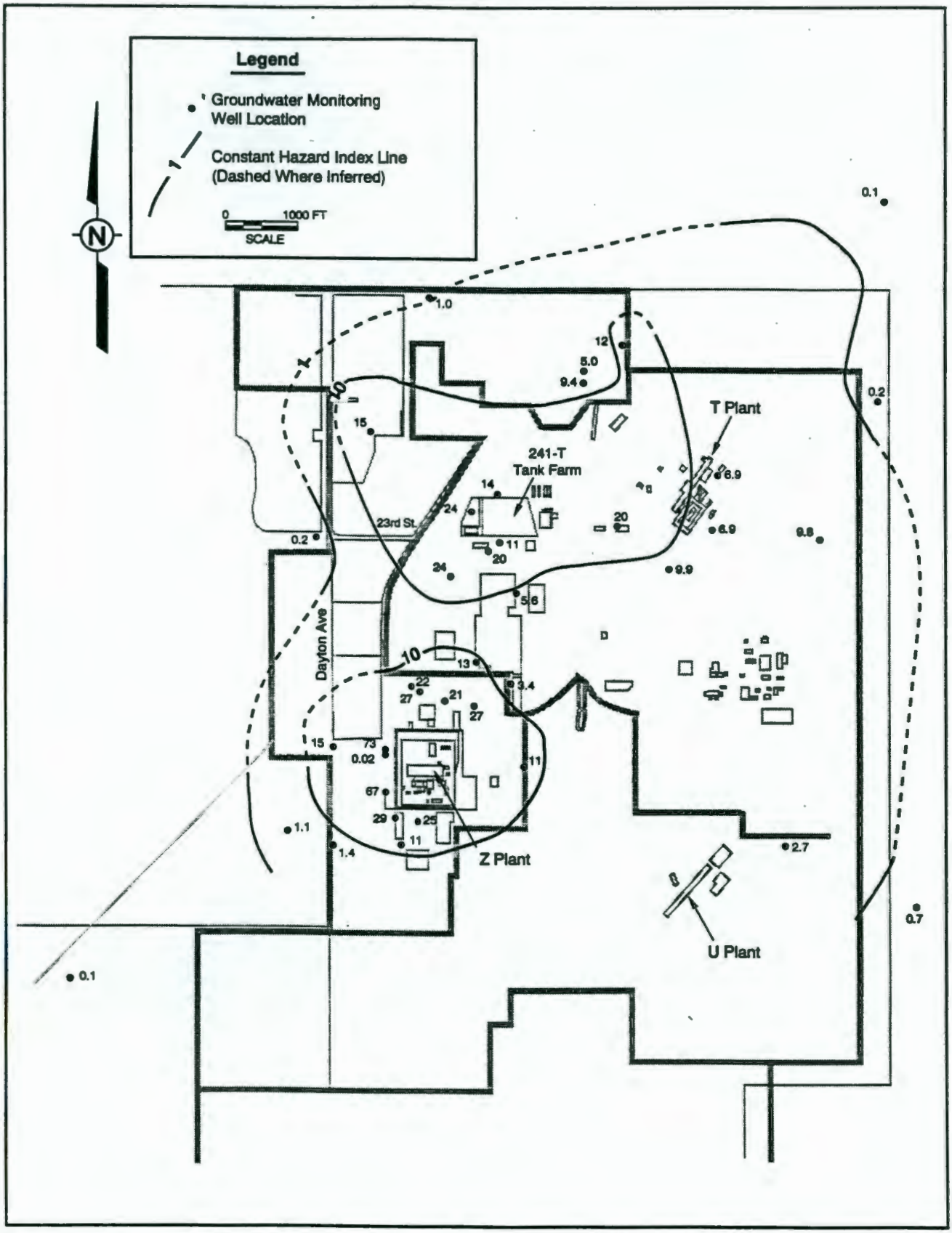


Figure 8 200-ZP-1 Groundwater Operable Unit Hazard Index for Reasonable Maximum Exposure to Carbon Tetrachloride and Chloroform in Groundwater, Existing Conditions, Industrial Ingestion Scenario



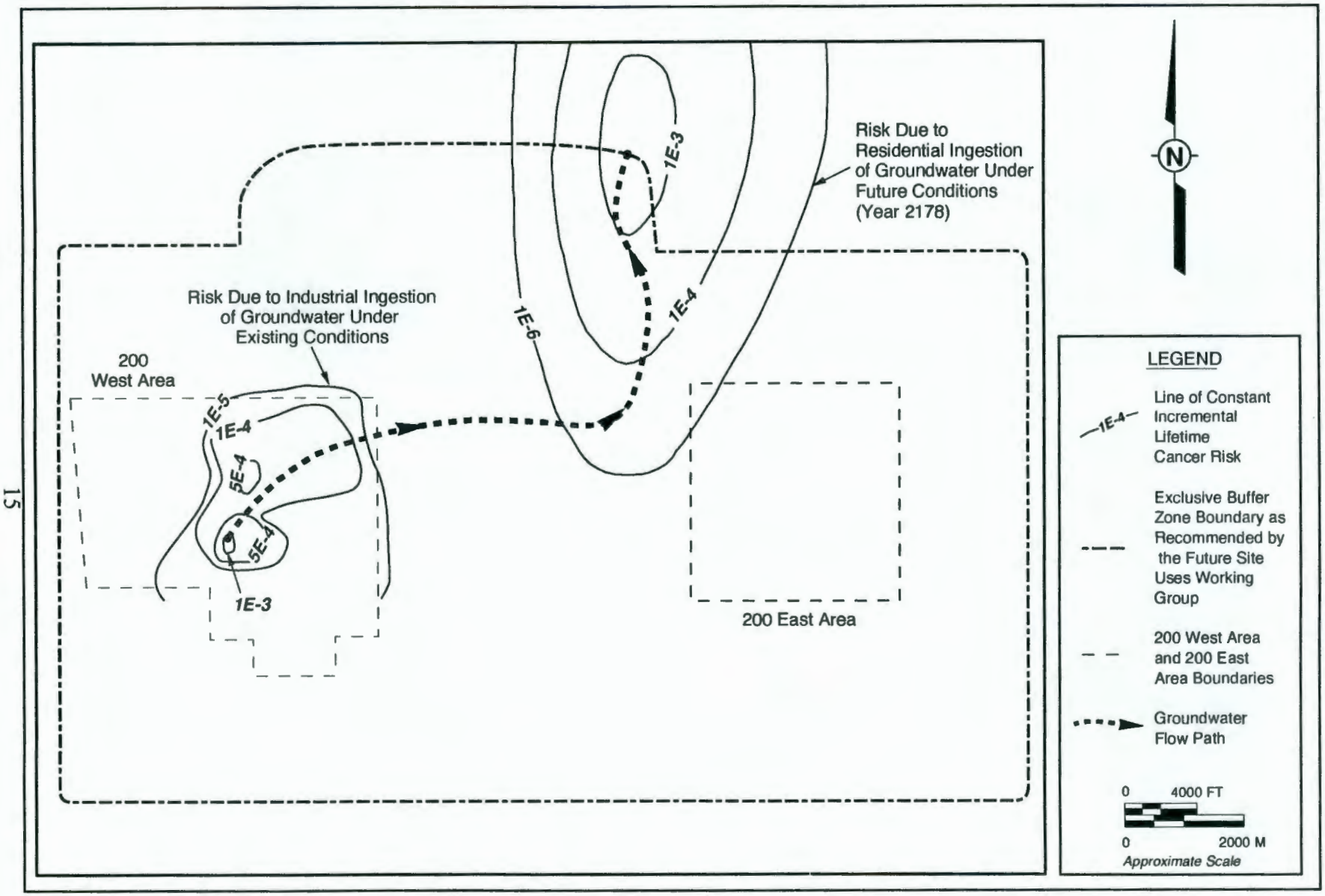


Figure 9 Incremental Lifetime Cancer Risk for Reasonable Maximum Exposure to Carbon Tetrachloride in Groundwater, Existing and Future Conditions

Figure 10 Hazard Quotient for Reasonable Maximum Exposure to Carbon Tetrachloride in Groundwater, Existing and Future Conditions

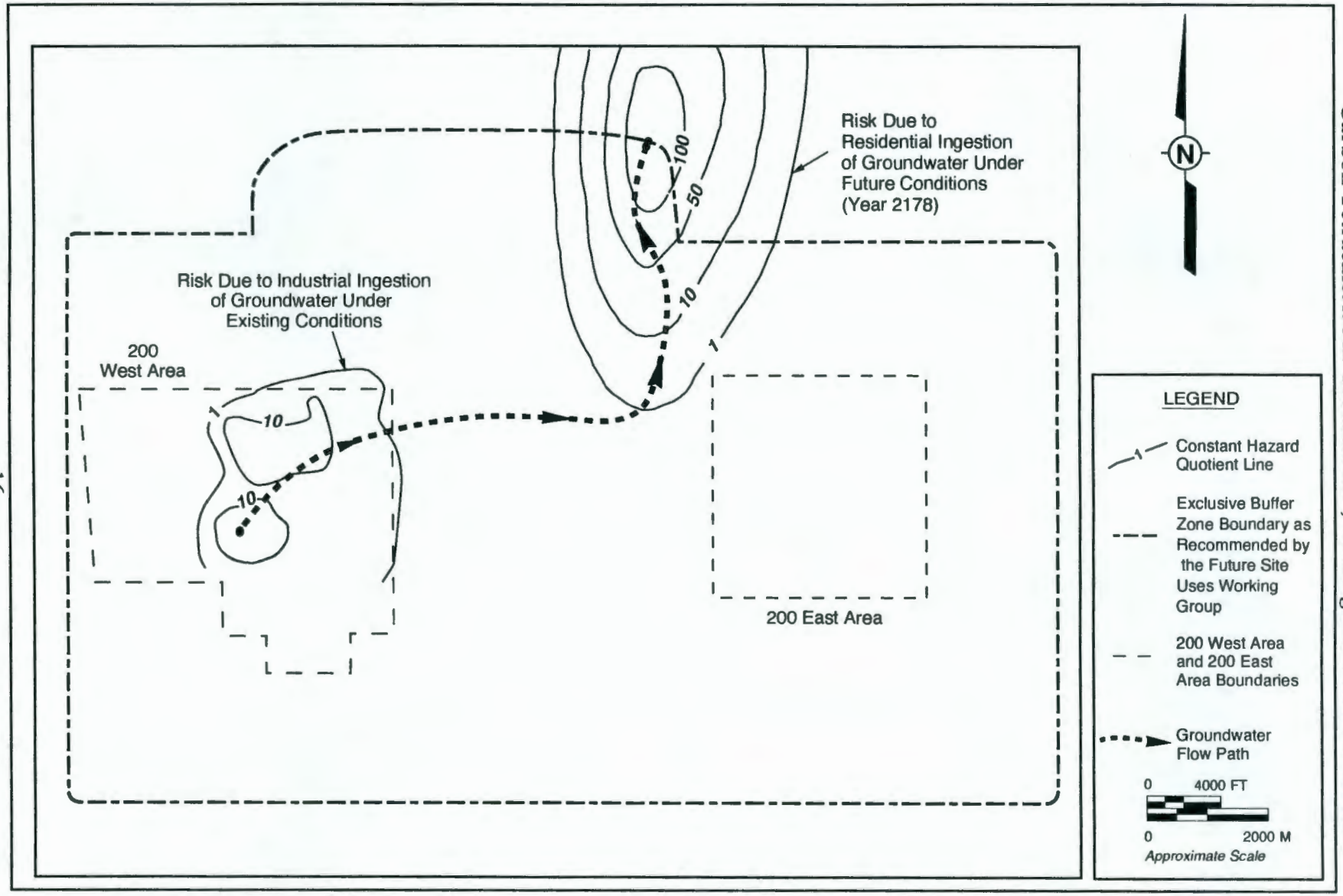


Table 1 HSRAM Human Health Risk Default Parameters

Exposure Parameters	Industrial Non-Carcinogenic	Industrial Carcinogenic	Residential Non-Carcinogenic	Residential Carcinogenic
Intake Rate (L/day)	1	1	1	2
Summary Intake Factor (L/Kg-day)	9.8E-3	2.8E-3	6.3E-2	1.2E-2
Exposure Frequency (day/yr)	250	250	365	365
Exposure Duration (yr)	20	20	6	30
Body Weight (Kg)	70	70	16	70
Averaging Time (days)	20 X 365	70 X 365	6 X 365	70 X 365

Table 2 Contaminant Transport Model CONMIG Parameters

Contaminant	Hydraulic Conductivity (ft/d)	Hydraulic Gradient	Dispersivity (ft)	Kd (ml/g)
Carbon Tetrachloride	50	2.06E-3	200 Long., 20 Trans.	1.1E-1
Chloroform	50	2.15E-3	200 Long., 20 Trans.	3.1E-2
TCE	50	2.55E-3	200 Long., 20 Trans.	1.3E-1

Table 3 Summary Risk Table for Existing Site Exposure

Chemical	Maximum Observed Plume Concentration (ppb)	Maximum ILCR, Industrial Ingestion of Groundwater	Maximum HQ, Industrial Ingestion of Groundwater
Carbon Tetrachloride	5200 (299-W15-16)[a]	1.9E-3	73
Chloroform	1650 (299-W15-08)[a]	2.8E-5	1.6
Trichloroethylene	32 (299-W10-04)[a] (299-W06-10)[a]	9.8E-7	NA
Totals	NA	1.9E-3	75 (HI)

Notes: [a] Monitoring well location where maximum measured concentration occurs
NA = Not Applicable

Table 4 Summary Risk Table for Future-Use Boundary

Chemical	Estimated Maximum Concentration at Future-Use Boundary (ppb)	Estimated Maximum Risk for Residential Ingestion of Groundwater	
		ILCR	HQ
Carbon Tetrachloride	1516	2.4E-3	140
Chloroform	128	9.6E-6	0.8
Trichloroethylene	17	2.3E-6	NA
Totals	NA	2.4E-3	141 (HI)

Notes: NA = Not Applicable

Table 5 Percent Contaminant Contribution to Total Risk

Chemical	Existing Site		Future-Use Boundary	
	Industrial Ingestion of Groundwater (%)		Residential Ingestion of Groundwater (%)	
	ILCR	HQ	ILCR	HQ
Carbon Tetrachloride	97.93	97.83	99.50	99.40
Chloroform	1.55	2.17	0.41	0.60
Trichloroethylene	0.52	NA	0.09	0.00
Totals	100.00	100.00	100.00	100.00

Notes: NA = Not Applicable

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