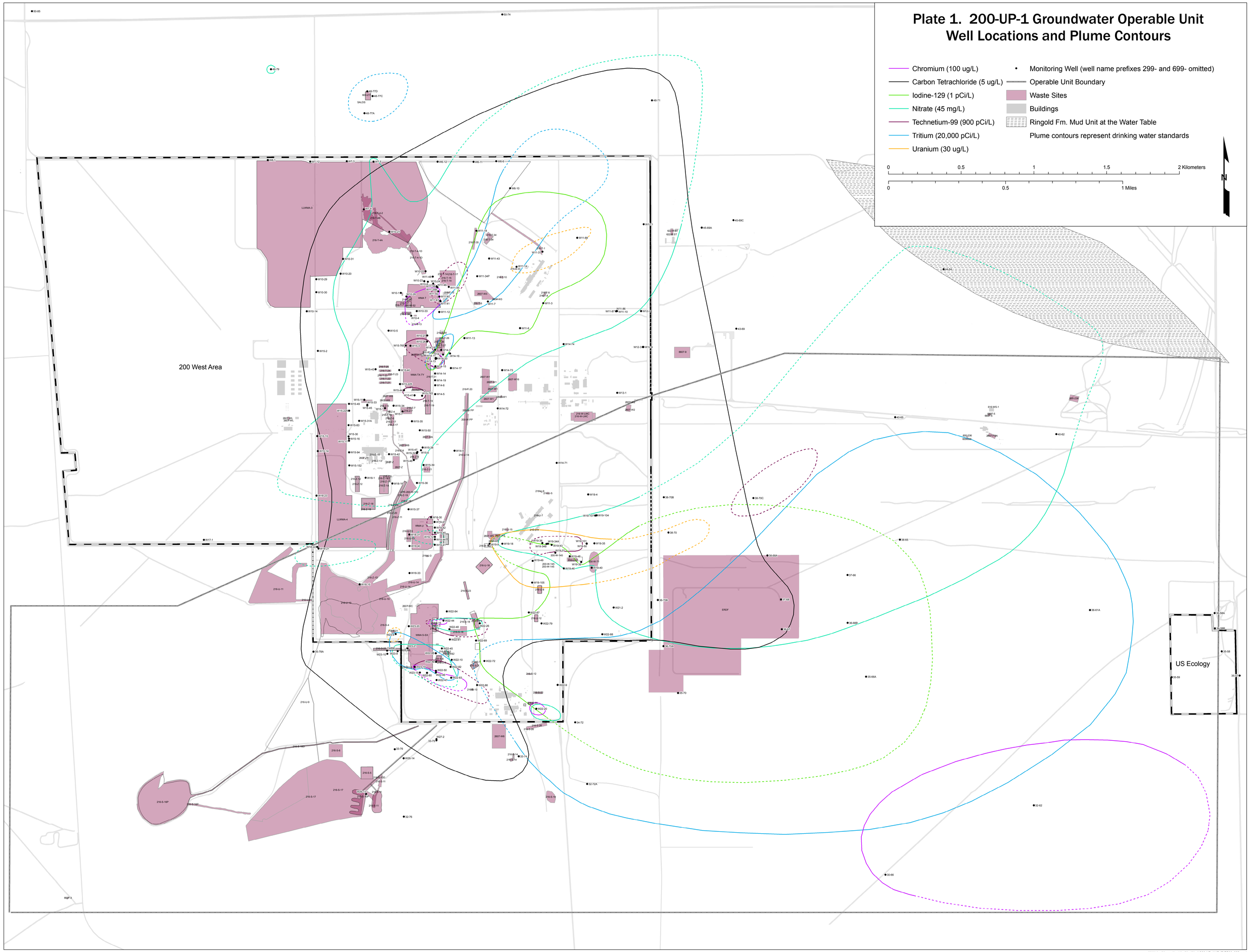
Appendix A

Plate Map

This page intentionally left blank.

Plate 1. 200-UP-1 Groundwater Operable Unit Well Locations and Plume Contours



N:\LinkedHomes\gpm\ArcMapWork\200-UP-1\UP1RIFS09_022.mxd

Appendix B

Annotated Bibliography

This page intentionally left blank.

Table B. Bibliography

Reference	Summary
CERCLA Process Activities From Source Identification to Work Plans for the LFI, LFI Results, ROD, and Remedial Design/Remedial Action Work Plan	
DOE/RL-92-16, 1993, *200 West Groundwater Aggregate Area Management Study Report, Rev. 0*	Contains an evaluation of various sources and COCs applicable to the OU. See Section 3-4 for a summary of this document.
DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report, Rev. 0*	This report presents the results of an AAMS for the U Plant aggregate area. This scoping-level study provides the basis for initiating RI/FS activities under CERCLA, as well as RFI/CMS activities under RCRA. The report provides background, environmental setting, and known contamination data. This information provides the basis for development of the preliminary conceptual model and for assessing health and environmental concerns. Preliminary ARARs and preliminary RA technologies are also developed based on the data. Data needs are developed based on data gaps determined during the development of the conceptual model, human health, environmental concerns, ARARs, and RA technologies. The U Plant aggregate area contains a large variety of waste disposal and storage facilities. Based on construction, purpose, or origin, the U Plant aggregate area WMUs fall into one of 10 subgroups. The number of units in each subgroup and the listed subgroups are as follows: • 1 waste management unit (plant, buildings, and storage areas) • 22 tanks and vaults • 12 cribs and drains • 1 reverse well • 10 ponds, ditches, and trenches • 4 septic tanks and associated drain fields • 13 transfer facilities, diversion boxes, and pipelines • 1 basin • 2 burial sites • 34 unplanned releases The final management recommendations include criteria and selection of appropriate Hanford Site past-practice strategy paths (ERA, IRM, and final remedy selection) for individual waste management units and unplanned releases in the U Plant aggregate area.
DOE/RL-91-60, 1992, *S Plant Aggregate Area Management Study Report, Rev. 0*	This report presents the results of an AAMS for the S Plant aggregate area. This scoping-level study provides the basis for initiating RI/FS activities under CERCLA, as well as RCRA RFI/CMS. The report provides background, environmental setting, and known contamination data. This information provides the basis for development of the preliminary conceptual model and for assessing health and environmental concerns. Preliminary ARARs and preliminary RA technologies are also developed based on the data. Data needs are developed based on data gaps determined during the development of the conceptual model, human health, environmental concerns, ARARs, and redial action technologies.

Table B. Bibliography

Reference	Summary
	The S Plant aggregate area contains a variety of waste disposal and storage facilities. Based on construction, purpose, or origin, the S Plant aggregate area waste management units fall into one of 10 subgroups. The number of units in each subgroup and the listed subgroups are as follows: • 4 WMUs (plants, buildings, and storage areas) • 35 tanks and vaults • 13 cribs and drains • 0 reverse well • 13 ponds, ditches, and trenches • 3 septic tanks and associated drain fields • 18 transfer facilities, diversion boxes, and pipelines • 2 basins • 2 burial sites • 45 unplanned releases The final management recommendations include criteria and selection of appropriate Hanford Site past-practice strategy paths (ERA, IRM, and final remedy selection) for individual waste management units and unplanned released in the S Plant aggregate area.
BHI-00150, 1995, *Borehole Summary Report for 200-UP-1 Operable Unit, 200 West Area, Rev. 00*	This report summarized the results of drilling and related characterization activities performed in FY94 for the 200-UP-1 Groundwater OU. The focus of the drilling program was to assess the N&E of the uranium, technetium, and nitrate plumes located beneath U Plant. This multi-contaminant plume was designated as a candidate for an IRM in the 200 West groundwater AAMSR (DOE/RL-92-16). The primary objective of this drilling program was to refine the vertical and horizontal extent of uranium, technetium, and nitrate plumes and the hydrogeology of the saturated zone in the vicinity of the plume. The program consisted of installing four wells screened at various depths, borehole geophysical logging, soil and groundwater sampling, and aquifer testing. The report contains sections describing the various characterization activities and summarizing results: • A stratigraphic interpretation of the 200-UP-1 Groundwater OU in the vicinity of the IRM plume based on existing and new borehole data • Description of the drilling, sampling, aquifer testing, geophysical logging, and construction of four monitoring wells • Drilling investigation and associated soil sampling results (groundwater sampling and results are not discussed in this report) • Radionuclide data obtained from geophysical logs for each of the new wells • Description of analysis results for hydraulic tests conducted to determine the hydraulic properties of the uppermost unconfined aquifer (Ringold unit E) and the confined aquifer (Ringold unit A)
DOE/RL-96-33, 1996, *Limited Field Investigation for the 200-UP-1 Operable Unit, Rev. 0*	Provides data required to refine the site conceptual model and conduct a risk assessment. The following high-priority contaminants were found to exceed MCLs within the 200-UP-1 Groundwater OU: 1,2-dichloroethane, carbon tetrachloride, trichloroethylene, Sr-90, Tc-99, I-129, uranium, cadmium, and chromium. See additional summary in Section 3.5.

Table B. Bibliography

Reference	Summary
DOE/RL-98-28, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program, Rev. 0*	This document outlines the framework for implementing assessment activities in the 200 Area to ensure consistency in documentation, level of characterization, and decision making. The Implementation Plan also consolidates background information and other typical work plan materials to serve as a single reference source for this type of information. The Implementation Plan does not provide detailed information about the assessment of individual waste sites or groups. Site-specific data needs, DQOs, data collection programs, and associated assessment tasks and schedules will be defined in subsequent group-specific (OU-specific) work plans. A common regulatory framework is established that integrates the RCRA, CERCLA, federal facility regulations, and TPA requirements into one standard approach for 200 Area cleanup activities. The Implementation Plan also streamlines work plans that are required for each waste site group by consolidating background information, providing a single referenceable source of this information. This allows the information in the group-specific work plans to focus on waste group or waste site-specific information. The background information includes an overview of the 200 Area facilities and processes, the operational history, contaminant migration concepts, and a list of COCs. It also documents and evaluates existing information to develop a Site description and conceptual model of expected Site conditions and potential exposure pathways. With this conceptual understanding, preliminary potential ARARs, preliminary RAOs, and RA alternatives are identified. The alternatives are broadly defined but represent potential alternatives that may be implemented at the Site. The identification of potential alternatives helps ensure that the data needed to fully evaluate the alternatives are collected during the RI.
	The specific type and quality of data are to be defined through the site-specific DQOs and form the basis for the data collection programs. The 200 Area strategy recognized the interrelationships between the various activities in the area and the need to integrate with other environmental restoration and Hanford Site projects/programs. The implementation plan describes the approach to interfacing with other programs and agencies, the integrated schedule of activities that addressed both RCRA and CERCLA program requirements, and the public participation process.
DOE/RL-2000-51, 2002, *Interim Action Waste Management Plan for the 200-UP-1 Operable Unit, Rev. 3*	This interim action waste management plan establishes the requirements for management and disposal of waste generated from groundwater wells used to monitor P&T interim action at the 200-UP-1 Groundwater OU. The plan addresses only waste generated from activities related to P&T performance monitoring and 200-UP-1 Groundwater OU groundwater monitoring. The wells addressed by this plan are listed in Appendix A of the document. The activities that will likely generate waste include, but are not limited to, the following: • Groundwater well installation • Groundwater well development, sampling, maintenance, and decommissioning • Maintenance activities associated with the extraction well head and associated valves and piping up to the connection with the pipeline that runs from ERDF to the ETF • Water-level and other in situ groundwater measurements • Screening/analysis of samples • Decontamination of equipment and material • Aquifer testing, geophysical logging, and treatability studies Testing, treatability studies, or other special activities not specifically identified in the applicable work plan (DOE/RL-97-36, Rev. 2, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan*) will be evaluated with the regulatory agencies for coverage under this waste management plan.
RPP-7884, 2002, *Field Investigation Report for Waste Management Area S-SX, Rev. 0*	Provides detailed discussion of COCs and potential migration from the S, SX Tank Farms. See Section 3.4 for a summary of this document.

Table B. Bibliography

Reference	Summary
Interim Remedial Measure	
DOE/RL-95-26, 1995, *Interim Remedial Measure Proposed Plan for the 200-UP-1 Operable Unit, Hanford Washington, Rev. 0*	The IRM proposed plan describes an interim action that was proposed for the 200-UP-1 Groundwater OU. The objectives of the IRM are to contain elevated concentration of uranium and Tc-99 in the 200-UP-1 Groundwater OU and to collect data on aquifer and contaminant response to the selected remediation measure. The proposed plan was developed in accordance with the TPA (Ecology et al., 1989) and summarizes more detailed information available in other documents. The plan discusses the following: • Site background information and studies • A summary of site risks (cancer and non-cancer risk) • Contaminants of potential concern (Tc-99, uranium, and nitrate) • Need for RA • Interim RAOs • Detailed description of alternatives • Comparative analysis of alternatives (using EPA's nine evaluation criteria) • Summary of preferred alternative
	The preferred alternative was P&T. The goals of the RA are to halt the spread of the highly contaminated protection of the contaminant plume, remove contaminant mass, and collect data on aquifer and contaminant response to the remediation measures. The preferred alternative was believed to provide the best balance of trade-offs among the alternatives and will protect human health and the environment.
BHI-00187, 1996, *Engineering Evaluation/Conceptual Plan for the 200-UP-1 Groundwater Operable Unit Interim Remedial Measure, Rev. 2*	This report contains an engineering evaluation and conceptual plan for the IRM to address a uranium and Tc-99 groundwater plume in the 200-UP-1 Groundwater OU. The report provides a historical summary of the type and extent of contamination and information regarding the need for an IRM and its potentially achievable objectives and goals. The report also evaluated alternatives to contain elevated concentrations of uranium and Tc-99 and to obtain information necessary to develop final RAs for the OU. Performance goals for the P&T IRM included the following: • Maintain hydraulic control and contain the high-concentration area of the plume • Prevent uranium and Tc-99 concentrations from increasing downgradient from the containment zone • Reduce uranium, Tc-99, and carbon tetrachloride to the MCLs prior to reinjection or disposal of treated groundwater • Obtain data to support the final remedy • Several specific technical criteria were to be addressed in the evaluation of the IRM following implementation: – Criterion #1 – Is the well field hydraulically containing and/or intercepting the combined uranium and Tc-99 plume? – Criterion #2 – Have contaminant concentrations within or downgradient of the contaminant zone been stabilized or reduced? – Criterion #3 – Is mass removal occurring at a rate that will remove the dissolved contamination in a reasonable period of time and at a reasonable cost? – Criterion #4 – Have data been obtained on aquifer and contaminant response to remediation measures that are sufficient to support a determination of the need for, and feasibility of, final remedial measures for the site? – Criterion #5 – Is the treatment system performance meeting the treatment goals?

Table B. Bibliography

Reference	Summary
EPA/541/R-97/048, 1997, *Record of Decision for the 200-UP-1 Interim Remedial Measure*	The ROD for the 200-UP-1 Groundwater OU presents a description of the selected interim remedy for uranium and Tc-99 groundwater contamination in the vicinity of U Plant. The interim RA was chosen in accordance with CERCLA, SARA, the TPA (Ecology et al., 1989), and, to the extent practicable, the NCP. The State of Washington concurred with the selected remedy. The selected remedy consists of pumping the highest concentration zone of the contaminated plume at 200-UP-1 and treatment using the existing ETF in the 200 East Area. The selected remedy is intended to reduce contaminant mass within the plume and minimize migration of uranium and Tc-99 from the 200 West Area. The high-concentration portion of the plume corresponds to that area having contaminants greater than or equal to levels 10 times greater than the MCL of uranium under WAC 173-340-720(4) ("Model Toxics Control Act--Cleanup," "Ground Water Cleanup Standards"), and 10 times or greater than the MCL for Tc-99. The cleanup level is based solely on an assessment of uranium toxicity and not on cancer risk that it may pose.
	The ETF is a multi-stage facility that can remove and/or destroy a large number of contaminants, including nitrate and carbon tetrachloride, which are present in 200-UP-1 groundwater. The State of Washington has made a "contained-in" determination of carbon tetrachloride for this action to facilitate the treatment of carbon tetrachloride at the ETF. The interim action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed. The groundwater removed will be treated to meet requirements before discharge. This interim action is only part of the total RA for 200-UP-1 and is considered cost effective.
DOE/RL-97-36, 1997, *200-UP-1 Groundwater Remedial Design/Remedial Action Work Plan, Rev. 2*	The 200-UP-1 remedial design report presents the RAOs and rationale for the design and implementation of the selected IRM for the 200-UP-1 Groundwater OU. The RAOs for this IRM are to: (1) hydraulically contain and treat the high-concentration portion of the uranium and Tc-99 groundwater plumes, and (2) provide data to support a final remediation measure. The high-concentration portions of the plume are defined as 480 µg/L for uranium (10 times the WAC 173-340-720[4] cleanup level) and 9,000 pCi/L (10 times the MCL) contour for Tc-99. The groundwater is not classified as a RCRA hazardous waste but will be managed as a RCRA hazardous waste because of the associated "F001" code. The IRM was chosen in accordance with CERCLA, as mandated by SARA, and in accordance with the TPA (Ecology et al., 1989) and the NCP. The preferred alternative (groundwater P&T using the ETF for disposal) was chosen for the following reasons: • Reduction in potential risk to HHE by removing contaminant mass and minimizing migration of the high-concentration portion of the uranium and Tc-99 plumes. • Groundwater would be treated at the state-of-the-art ETF located in the 200 East Area of the Hanford Site. Certain co-contaminants (carbon tetrachloride) will be destroyed, which minimizes waste generation. • The selected remedy would remove the COC and specific co-contaminants of nitrate and carbon tetrachloride that exist within the groundwater.

Table B. Bibliography

Reference	Summary
DOE/RL-96-81, 1997, *Waste Site Grouping for 200 Areas Soil Investigations, Rev. 0*	The analogous site approach concept was a key element in the development of the *200 Areas Soil Remediation Strategy – Environmental Restoration Program* (DOE/RL-96-67) because many of the 200 Area waste sites share similarities in geological conditions, functions, and types of waste received. As a result, the need to establish waste site groups for 200 Area waste sites was identified as an initial step in the implementation of DOE/RL-96-67. The purpose of this document was to identify logical waste site groups for characterization based on criteria established in DOE/RL-96-67. Specific objectives of the document included the following: • Finalize waste site groups based on the approach and preliminary groupings identified in the DOE/RL-96-67. • Prioritize the waste site groups based on criteria developed in DOE/RL-96-67. • Select representative sites that best represent typical and worst-case condition for each waste group. • Develop conceptual models for each waste group.
	Waste site group prioritization and representative site selection will support a more efficient and cost-effective approach to characterizing the 200 Area waste sites. Characterization efforts will be limited to representative sites, the data from which will be used for RA decisions for all waste sites within a group (consistent with the analogous site approach). Waste site group properties will be used to establish a sequence in which the representative sites are expected to be addressed. The conceptual models developed in this document provide an initial prediction of the N&E of primary COC and support the selection of representative sites and prioritization of groups.

Table B. Bibliography

Reference	Summary
Groundwater Management and Current Sampling	
DOE/RL-2002-68, 2003, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection, Rev. 0*	This document lays out a plan developed by DOE, in conjunction with EPA and Ecology, to accelerate Hanford Site cleanup. The goal is to return groundwater to its highest beneficial use where practicable, which will at least prevent further degradation. The previous baseline shows remediation beginning in 2008 and extending to 2024. The new accelerated schedules illustrated in this document show that the baseline will begin in 2004 and will be completed by 2012. The document contains discussion of specific results that can be expected using the accelerated plan for cleanup. These results and expected dates of completion include the following: • Remediate high-risk wastes: 2011 • Shrink the contaminated areas: 2112 • Reduce recharge: 2012 • Remediate groundwater: 2012 • Evaluate groundwater monitoring needs: ongoing Plans to deal with waste sites in immediate proximity to the tank farms require additional work and will depend greatly on the strategy employed to close the tanks. The regions selected for completion by 2012 avoid those areas immediately adjacent to tank farms until an integrated approach to waste site remediation and tank closure can be developed. In addition to accelerated schedules for cleanup and groundwater protection, the document contains definitions and discussion of various proposed groundwater protection boundaries (core zone and outside the core zone). As part of the integrated accelerated plan, an area closure strategy is discussed. Three major areas in the 200-UP-1 Groundwater OU are identified, which include the following: • U Plant area closure • S Tank Farm area closure • REDOX area closure When cleanup is implemented on an area-by-area basis, these coordinated efforts to control sources, implement RA, and assess and monitor impact are expected to place major portions of the 200 Area plateau into a condition of long-term stewardship monitoring starting in 2006.
CP-15329, 2003, *Data Quality Objectives Summary Report for Establishing a RCRA/ CERCLA/AEA Integrated 200 West and 200 East Area Groundwater Monitoring Network, Rev. 0*	The purpose of this DQO process was to assess the current groundwater monitoring well networks for the 200 West and 200 East Areas. This assessment was needed to address changing contaminant plume conditions (plume migration) and to ensure that monitoring activities meet the requirements for remediation performance monitoring (CERCLA monitoring), Sitewide surveillance monitoring to meet the requirements of DOE orders, and detection/assessment monitoring to meet the requirements of RCRA. This DQO summary report was prepared in support of DOE's Cleanup, Constraints, Challenges Team (C3T) process.

Table B. Bibliography

Reference	Summary
	Because of the changing shape of the groundwater contaminant plume contours over time and changing programmatic needs, the 200 West and 200 East groundwater monitoring network is required to be periodically re-evaluated. The objective of the groundwater CERCLA remediation performance monitoring program is to provide a routine assessment of the effectiveness of groundwater remediation activities within the 200-ZP-1 and 200-UP-1 Groundwater OUs. The objectives of the Sitewide surveillance monitoring program are as follows: • Determine baseline conditions of groundwater quality and quantity • Characterize and define hydrogeologic, physical, and chemical trends in the groundwater system • Identify existing and potential groundwater contamination sources • Assess existing and emerging groundwater quality problems • Evaluate existing and potential offsite impacts of groundwater contamination • Provide data on which decisions can be made concerning land disposal practices and the management and protection of groundwater resources Finally, the objective of the RCRA detection program is to identify if TSD units are impacting groundwater quality. If impacts to groundwater are detected, the objective of the RCRA assessment program is to define the rate and extent of contaminant migration. This DQO process identified the optimum number of groundwater wells to be monitored to meet these objectives and determined that a number of new groundwater wells needed to be installed. The identity of wells in the monitoring network, sampling frequency, analyses to be performed, detection limit requirements, and other analytical performance requirements (precision and accuracy) were defined in this document. The resultant groundwater monitoring network fulfilled the needs of the three major Hanford Site regulatory monitoring activities (CERCLA, RCRA, and AEA).
CP-15315, 2003, *Data Quality Objectives Summary Report Supporting the 200-UP-1 Operable Unit Remedial Investigation/Feasibility Study Process, Rev. 0*	The purpose of this DQO process was to identify and evaluate the data needs required to support the RI/FS process for the 200-UP-1 Groundwater OU. The report defines and evaluates the data needs to support defining the N&E of contamination, risk assessment, evaluation of RA alternatives, and long-term monitoring of completed RAs. The RI/FS process for the 200-UP-1 Groundwater OU was scoped in accordance with the scoping requirements contained in 40 CFR 300.430(b), "National Oil and Hazardous Substances Pollution Contingency Plan," "Remedial Investigation/Feasibility Study and Selection of Remedy." To fulfill the requirements to "identify likely response scenarios," the FS will identify a range of alternatives that include the following: • Restoration of groundwater to its highest beneficial use everywhere within the plume boundary, within a reasonable restoration timeframe, by implementing one or more potentially applicable technologies (including MNA for individual contaminants). • If it is determined that it is not technically practicable to restore the groundwater to its highest beneficial use, then alternate action levels will be established within the plume boundary, followed by implementing one or more potentially applicable technologies. • If it is determined that it is not technically practicable to achieve alternate action levels everywhere within the plume boundary, then one or more conditional points of compliance will be established, beginning at the boundary of individual waste area groups (groupings of proximate waste sites) and going next to the plume boundary. The plume boundary for many contaminants in the 200 Areas is roughly coincident with the "core zone" of 200 Area waste sites.

Table B. Bibliography

Reference	Summary
	RA alternatives have not been fully evaluated at this time, and some refinement may be needed as alternative actions are selected. However, it is anticipated that the following remediation options will be considered in the 200-UP-1 FS: • No action • Institutional controls • Monitored natural attenuation • Groundwater P&T (using onsite treatment system that may include injection of treated water) The DQO process was applied to determine whether additional data were needed to support implementation of the RI/FS process for the 200-UP-1 Groundwater OU. It was determined through the DQO process that additional data would be necessary. This document identifies the sampling requirements, analyses to be performed, detection limit requirements, and other analytical performance requirements (precision and accuracy) for the data to be collected.
PNNL-14187, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*	This report presents the results of groundwater and vadose zone monitoring and remediation for FY02 on the Site. Water-level monitoring was performed to evaluate groundwater flow directions, to track changes in water levels, and to relate such changes to evolving disposal practices. Water levels over most of the Site continued to decline between March 2001 and March 2002. The most extensive plumes are tritium, I-129, and nitrate, which all had multiple sources and are mobile in groundwater. The largest portions of these plumes are migrating from the central Site to the southeast, toward the Columbia River. Concentrations of tritium, nitrate, and some other contaminants continued to exceed DWSs in groundwater discharging to the river in FY02; however, contaminant concentrations in river water remained low and were far below standards. Carbon tetrachloride and associated organic constituents form a relatively large plume beneath the central portion of the Site. Hexavalent chromium is present in smaller plumes beneath the reactor areas along the river and beneath the central portion of the Site. Sr90 exceeds standards beneath each of the reactor areas, and Tc-99 and uranium are present in the 200 Areas. Other minor contaminant plumes are also noted. Interim groundwater remediation in the 100 and 200 Areas continued in 2002. The objective of the two interim remediation (P&T) systems in the 200-ZP-1 and 200-UP-1 Groundwater OUs in the 200 West Area is to prevent the spread of carbon tetrachloride and Tc-99/uranium plumes. This annual report presents groundwater contours and the perimeter of the carbon tetrachloride, chloroform, and trichloroethylene plumes within the 200-ZP-1 Groundwater OU, as well as groundwater contours and the perimeter of the Tc-99 and uranium plumes within the 200-UP-1 Groundwater OU. Maps are also provided showing the location of sampled groundwater wells and identifying the frequency at which wells are sampled, the depth of well screens, and so forth. A set of computer models known as the SAC (System Assessment Capability) simulates movement of contaminants from waste sites through the vadose zone and groundwater. In FY02, modelers completed an initial assessment of 10 contaminants, simulating their movement over the years 1944 through 3050. Specific modeling of plume movements in the 200 Areas and local-scale modeling of the 200 Area P&T IRMs were reported.

Table B. Bibliography

Reference	Summary
DOE/RL-2002-67, 2003, *Fiscal Year 2002 Annual/Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations, Rev. 0*	Interim RODs were issued for the 200-UP-1 and 200-ZP-1 Groundwater OUs in 1997 and 1995. The RODs require remediation of the area of highest contaminant concentrations of the baseline target plumes. The RAOs specified are the following: • Hydraulically contain the central area of the plume. • Reduce contaminant mass in the aquifer. • Protect HHE. • Gather data that will support a final remedy. • The COCs for each P&T system are as follows: – Tc-99 and uranium for the 200-UP-1 Groundwater OU (secondarily, carbon tetrachloride and nitrate). – Carbon tetrachloride for the 200-ZP-1 Groundwater OU (secondarily, chloroform and trichloroethylene). – The document summarizes performance of the groundwater P&T systems in FY02 and discusses the changes that have been observed in plume shape and concentration during the reporting period. – The two 200-UP-1 extraction wells operated at an average annual rate of 197 L/min, exceeding the ROD operational requirement of 189 L/min (50 gal/min). The amount of contaminant mass removed in FY02 was as follows: o Technetium-99: 14.5 g o Uranium: 26.4 kg o Carbon tetrachloride: 2.75 kg o Nitrate: 3,686 kg The 200-UP-1 hydraulic conditions did not change significantly in FY02. Based on field measurements and numerical modeling, hydraulic capture of the baseline plume area was maintained, meeting the RAO to prevent further migration of the baseline plume area. Water levels continued to decline at an estimated rate of 0.36 m/year, compared to 0.4 m/year in FY01. The water level decline has left the monitoring network without coverage in the south, southeast, or southwest portions of the 200-UP-1 plume. Additional monitoring wells planned for installation in future years will fill some of these monitoring gaps. Overall 200-UP-1 plume configurations for both Tc-99 and uranium are similar to those of past years, with two distinct high-concentration areas (one near each extraction well). As discussed in the IRM conceptual plan (BHI, 1996), there were four RAOs: • Maintain hydraulic control and contain the high-concentration area of the plume. • Prevent uranium and Tc-99 concentration from increasing downgradient from the containment zone. • Reduce uranium, Tc-99, and carbon tetrachloride to MCLs prior to reinjection or disposal of treated groundwater. • Obtain data to support a final remedy.
	Three of the four RAOs were met; however, the objective to reduce concentrations below the MCLs for Tc-99 and uranium was not achieved. It is reported that the RAO for Tc-99 may be achieved in the next 1 or 2 years, however, methods of enhancing reductions in uranium concentrations should be investigated. Other recommendations in the report included the following: • Replacing dry monitoring wells for plume tracking • Decommissioning dry monitoring wells to prevent recharge • Converting well 299-W19-43 from a monitoring well to an extraction well to reduce high-contamination concentrations

Table B. Bibliography

Reference	Summary
Modeling	
PNNL-14027, 2002, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*	This document contains an explanation of the SAC framework and the results of recent runs. In 1999, DOE initiated the development of an assessment tool that will enable the users to model the movement of contaminants from all waste sites at Hanford through the vadose zone, groundwater, and the Columbia River and estimate the impact of contaminants on human health, ecology, and the local cultures and economy. An assessment was recently completed with the SAC demonstrating that it is a functional assessment capability. Future modifications to the tool will be driven by the requirements of specific assessments. Results will continue to improve as input data are refined through characterization and scientific research. The results of the first runs performed with SAC were presented to the Integration Project Expert Panel in September 2000. Analysis performed on these early results identified a number of issues that needed to be addressed before the tool could be considered useful. The major issues were addressed by replacing a simple two-dimensional groundwater model in the SAC with the three-dimensional Hanford Sitewide groundwater model, correcting the quantity of contaminant assigned to several waste sites, and obtaining more efficient hardware for performing analyses. Following the implementation of those changes, the assessment was re-run. The assessment included the following: • Modeled the movement of contaminants from more than 500 locations throughout the Site representing 890 waste sites through the vadose zone, groundwater, and Columbia River. • Incorporated data on 10 radioactive and chemical contaminants (carbon tetrachloride, Cs-137, chromium, I-129, Pu-239/240, Sr-90, Tc-99, tritium, total uranium, and U-238). • Focused on subsurface transport, the Columbia River, and risks to human and ecological health, and the economy and culture. See Section 5.3.1 of this document for an additional discussion of the anticipated use of the SAC in the 200-UP-1 Groundwater OU.
PNNL-11800, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*	A composite analysis was prepared for the Site considering only sources in the 200 Area Plateau. Estimating doses to hypothetical members of the public for the composite analysis was a multi-step process involving the estimation or simulation of inventories; waste release to the environment; migration through the vadose zone, groundwater, and atmospheric pathways; and exposure and dose. Doses were estimated for scenarios based on agriculture, residential, industrial, and recreational land uses. The radionuclides included in the vadose zone and groundwater pathway analyses of future releases were C-14, Cl-36, Se-79, Tc-99, I-129, and uranium isotopes. In addition, tritium and Sr-90 were included because they exist in groundwater plumes. Radionuclides considered in the atmospheric pathway included tritium and C-14. The analysis indicated that most of the radionuclide inventory in past-practice liquid discharge and solid waste burial sites on the 200 Area plateau was projected to be released in the first several hundred years following Site closure. The radionuclide doses for all of the exposure scenarios outside of a defined buffer zone were all <3 mrem/year, which is well below the performance objectives of 100 mrem/year or the ALARA objective of 30 mrem/year.

Table B. Bibliography

Reference	Summary
	Several sources of uncertainty were noted in the first iteration of the composite analysis, with the largest uncertainty associated with the inventories of key mobile radionuclides. Other sources of uncertainty in the analysis arose from the conceptual and numerical models of contaminant migration and fate in the vadose zone and assumption regarding source-term release models and end states. The composite analysis demonstrated a significant separation in time between past-practice discharges and disposals, and active and planned disposal of solid waste, environment restoration waste, and immobilized low-activity waste. The higher integrity disposal facilities and surface covers of these active and planned disposal delay releases and the releases do not superimpose on the plumes from the near-term past-practice disposals. See Section 5.3.1 of this document for an additional discussion of the anticipated use of the SAC in the 200-UP-1 Groundwater OU.
HNF-45099, 2010, *Development of a Geochemical Model for Uranium Transport in the Unsaturated and Saturated Sediments at the 200 West Area of the Department of Energy Hanford Site, Washington*	The document provides discussion of initial work to develop a geochemical model for transport of uranium through the unsaturated and saturated zone in the 200-UP-1 Groundwater OU. The distribution of contaminants (uranium) in the soil profile depends on the physical properties of the waste stream, which provides the transport medium (water) and the chemical properties of the contaminant. Other characteristics affecting the contaminant soil interaction include the geologic and geochemical properties of the soil column and the composition of soil moisture and soil gases. The major modeling assumptions presented in the document include the following: • The primary sorbents of uranium are Fe(III) and Al oxyhydroxides, clays, zeolites, phosphate minerals, and organic matter. Previous studies cited in the document have indicated that iron-hydroxide surface sites (FeOM) dominate UO2+2 complexation in Hanford soils. MSE assumed that the primary sorbent of uranium in soils was FeOH. • MSE chose to use a diffuse layer surface complexation model for the geochemical modeling efforts. The primary parameters of interest for the modeling included the concentration of available sorbing sites in a given volume of the soil matrix, the surface area of the sorbents exposed to the groundwater, and the thermodynamic equilibrium constants for reactions involving surface sites and aqueous components. The results of the initial geochemical model and the results from batch testing are presented in this report. The results are presented as plots of the percent of uranium adsorbed as a function of the pH under which the adsorption occurred for both the model predictions and observed data. The results indicated poor agreement between the modeled and observed values for adsorption; however, it was reported that the general shape of the of the modeled and observed sorption curves was, in most cases, promising. Additional work to resolve discrepancies between the model and batch testing is in progress.
WHC-EP-0133, 1988, *U1/U2 Uranium Plume Characterization, Remedial Action Review and Recommendation for Future Action*	This document notes the following: • The contaminant plume below the 216-U-1 and 216-U-2 Cribs is moving slowly, so delay of remediation by up to 10 years will not significantly increase time and cost of cleanup. • Pumping commenced on June 13, 1985, and continued until November 26, 1985. A total of 8 million gal of groundwater were pumped and treated to remove 687 kg of uranium via an ion-exchange column. The maximum uranium concentration was reduced from about 72,000 to 17,000 pCi/L.

Table B. Bibliography

Reference	Summary
	It is recommended that: • Additional multi-level sampling devices should be installed to characterize the horizontal and vertical extent of the plume. • Aquifer test should be performed to determine hydraulic properties of the U1 and U2 Sites. • Using the additional characterization data obtained above, three-dimensional flow and transport models should be developed to evaluate the vertical extent of contaminant migration under no action and pumping scenarios. • Before resuming groundwater pumping for cleanup, transport simulations should be performed to evaluate the effect that pumping would have on other groundwater contamination (the carbon tetrachloride contamination from the PFP). • Additional contamination may be introduced into the aquifer below the 216-U-1 and 216-U-2 Cribs by discharge of treated groundwater. The treated groundwater contains some residual contamination because the ion-column treatment system cannot be 100% efficient, and additional contamination may be transported from the unsaturated portion of the flow system to the water table. This should continue to be considered when planning for remediation. • The nitrate contamination in the groundwater below the 216-U-1 and 216-U-2 Cribs is also characterized in this document.
WHC-EP-0342, Addendum 19, 1990, *UO_3 Plant Process Condensate Stream-Specific Report*	This document notes that the proposed waste stream designation for the UO_3 Plant process condensate waste stream is that this stream is not a dangerous waste, as defined by WAC 173-303, "Dangerous Waste Regulations." A combination of process knowledge and sampling data was used to make this determination. Traces of butanol, acetone, and 2-butanone were identified as process impurities sent with uranyl nitrate hexahydrate from the PUREX Plant.
DOE/RL-2002-10, 2002, *Sampling and Analysis Plan for the 200-UP-1 Groundwater Monitoring Well Network, Rev. 0*	
DOE/RL-91-52, 1992, *U Plant Source Aggregate Area Management Study Report, Rev. 0*	The 216-U-1 and 216-U-2 Cribs are located 61 m (200 ft) north of 16th Street and 205 m (1,000 ft) east of the 207-U retention basins. Each crib is composed of a 3.6 m by 3.6 m by 1.2 m (12 ft by 12 ft by 4 ft) deep wooden structure constructed of 15 cm by 15 cm (6 in. by 6 in.) timbers on undisturbed soil at the bottom of 6.1 m (20 ft) deep backfilled excavations, with 1:1 side slopes. The cribs were backfilled with native soil. The cribs are 18 m (60 ft) apart and are connected by a 8.9 cm (3.5 in.) diameter, stainless-steel pipe. Overflow from the 216-U-1 Crib flows to the 216-U-2 Crib. All wastes flowed to the 216-U-1 and 216-U-2 Cribs from the 241-U-361 settling tank, which is 24 m (80 ft) east of the 216-U-1 Crib. Reportedly, 4,000 kg (8,900 lb) of uranium were discharged to the cribs between 1957 and 1967 (WHC-EP-0400, 1991, *200-UP-2 Operable Unit Technical Baseline Report*). The uranium reacted with the sediments to form carbonate-phosphate compounds. After 1967, other cribs (notably 216-U-12) were used to dispose this wastewater.

Table B. Bibliography

Reference	Summary
	The 216-U-4 reverse well is the only reverse well in the U Plant aggregate area and is located 5.2 m (17 ft) west and 0.6 m (2 ft) north of the west corner of the 222-U Laboratory building. This State of Washington-registered underground injection well is a 7.6 cm (3 in.) diameter steel pipe, extending 23 m (75 ft) beneath the surface. The bottom 2.4 m (8 ft) is perforated. From 1947 to 1955, the 216-U-4 reverse well received 300,000 L (80,000 gal) of decontamination waste from the 222-U Laboratory hood sinks (acidic plutonium and fission product waste). In 1955, when the 216-U-4 reverse well began to plug, it was deactivated and an overflow line was installed to the new 216-U-4A French drain. It is documented that the well was sealed off (WHC-EP-0400). The 216-U-4A French drain was installed to receive 222-U Laboratory hood sink wastes when the 215-U-4 reverse well began to plug in 1955. The drain was installed 2.4 m (8 ft) north of the well, and the 216-U-4A French drain and well were connected by an overflow line. The 216-U-4A French drain is a 130 cm (51 in.) diameter concrete pipe extending downward at least 1.2 m (4 ft), and the upper surface is 1.5 m (5 ft) below grade. The drain rests on undisturbed soil and is not gravel-filled. From 1955 to 1970, the 216-U-4A French drain received 545,000 L (144,000 gal) of acidic plutonium and fission product decontamination waste. The 216-U-8 Crib consists of three underground timber crib structures within a north/south-oriented trench that is approximately 49 m by 15.2 m (160 ft by 50 ft), backfilled with gravel. Each crib is a 4.9 m by 4.9 m by 3 m (16 ft by 16 ft by 10 ft) box, constructed of 0.15 m by 0.2 m (6 in. by 8 in.) Douglas fir timbers resting on a 0.9 m (3 ft) thick gravel bed, about 9.4 m (31 ft) below grade. The 216-U-8 Crib is located 137 m (450 ft) west of Beloit Avenue and 229 m (750 ft) south of 16th Street. Approximately 379,000 L (100,000 gal) of acidic process condensate from the 221-U and 224-U Buildings and the 291-U stack drainage system were discharged to the crib. In 1960, the surface above the 216-U-8 Crib began to subside. In response to this subsidence, the incoming line was blanked off and the waste was diverted to the 215-U-12 Crib (RHO-CD-673, 1979, *Handbook 200 Areas Waste Site*). The 216-U-8 Crib reportedly holds the largest inventory of waste uranium of any 200 West Area crib.
WHC-EP-0287, 1989, *Waste Stream Characterization Report, Vols. 2 and 3*	The principal source of waste to the S Plant wastewater is overflow of raw water from the fire protection water tank. Cooling water from REDOX and steam condensate are minor contributors. In addition, the 222-S Laboratory discharged wastewater into the 216-SS-10 Ditch on a temporary basis. Radionuclides previously detected include Sr-89/90 and Cs-137. The UO_3 Plant process condensate is obtained from plant overheads. Plant campaigns are conducted for several week intervals, several times a year, to calcine that is contained in aqueous solutions of uranyl nitrate. Since January 1988, the condensate has been collected and neutralized batch-wise prior to discharge, which has had significant impact on the pH data collected after this date. The waste stream is evaluated as two discharges: the first is associated with plant operation, and the second is generated when the plant is in standby status. Radionuclides previously detected include hydrogen-3 and uranium. The UO_3 Plant and U Plant wastewater contains process cooling water and steam condensate, aqueous makeup waste, sink and floor drain waste from the UO_3 Plant, facility cooling water and steam condensate from both plants, and yard drainage associated with nitric acid loadout activities. Aqueous makeup and nitric acid loadout activities are controlled by procedures to reduce the risk of the introduction of chemicals into this waste stream through floor drains. Seasonal variation of this waste stream is possible. Radionuclides previously detected include hydrogen-3, uranium, and Tc-99.

Table B. Bibliography

Reference	Summary
PNNL-14301, 2003, *Monitoring Plan for RCRA Groundwater Assessment at the 216-U-12 Crib*	The 216-U-12 Crib received process waste from U Plant and the 224 Building, which has impacted the unconfined aquifer. This document provides information on the monitoring well network design, monitoring constituents, sampling and analysis protocols and frequency, quality assurance, data management, site hydrogeology, a conceptual model of the RCRA facility, and an integrated CERCLA/RCRA final status post-closure monitoring plan. The document notes that the 216-U-12 Crib was built in 1960 to replace the 216-U-8 Crib when it showed signs of potential cave-in. The 216-U-12 Crib was operational until 1988, when the pipeline was cut and capped. The retired 216-U-12 Crib was replaced by the 216-U-17 Crib, which operated from 1988 to 1994. The crib is located downgradient of several other liquid waste disposal cribs in the 200 West Area. These cribs received large volumes of liquid effluent containing radioactive and hazardous waste at various times during the operational history of the U and S Plants.
PNL-6456, 1988, *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford, Volume 1 – Evaluation Methods and Results and Volume 2 – Engineered-Facility Sites (HISS Data Base)*	Based on volume of waste disposed at each REDOX waste site, a calculation was made to determine if the volume disposed exceeded the volume necessary to cause groundwater contamination as result of its operation. At total of 13 inactive waste sites exceeded the volume criteria. Seven of the sites (216-S-3, 216-S-4, 216-S-5, 216-S-6, 216-S-16D, 216-S-16P, and 216-S-17) received steam condensate and cooling water with little or no chemical or radiological content and, therefore, are not of much concern (primarily the S-ponds and ditches). The other six sites (216-S-1 and 2, 216-S-7, 216-S-9, 216-S-11, 216-S-20, and 216-S-21) were either process condensate wastes or process wastes that would contain sufficient chemical and radionuclide contamination to cause groundwater impacts. The process condensate sites 216-S-1 and 2, 216-S-7, 216-S-9, and 216-S-21 have the greatest volume. Sites 216-S-1 and 2, 216-S-7, and 216-S-9 are REDOX process condensate sites, which means they received liquids generated due to the dissolution of nuclear fuel elements in nitric acid. The primary contaminants in these streams are nitrate, tritium, and I-129. These sources are all located in the region north of REDOX and represent the origin of the large plume of the previously mentioned contaminants. Site 216-S-21 is from 241-SX Tank Farm, which contained a number of tanks of self-boiling wastes that produced large volumes of condensate. These wastes were much less concentrated than the REDOX dissolver condensate described previously. The last two sites considered potentially significant were 216-S-20 and 216-S-11. Site 216-S-20 received process waste from the 222-S Laboratory, also a far less concentrated waste stream, and it is in a location downgradient from the previously mentioned, more significant sources that could easily mask the impact of this site. Site 216-S-11, on the other hand, only received a relatively small volume of process waste and very large volume of cooling water, leaving little chance for any measurable groundwater impact.

Table B. Bibliography

Reference		Summary
AAMS	=	Aggregate Area Management Study
AAMSR	=	Aggregate Area Management Study Report
AEA	=	*Atomic Energy Act of 1954*
ALARA	=	as low as reasonably achievable
ARAR	=	applicable or relevant and appropriate requirement
CERCLA	=	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	=	*Code of Federal Regulations*
COC	=	contaminant of concern
DOE	=	U.S. Department of Energy
DQO	=	data quality objective
DWS	=	drinking water standard
Ecology	=	Washington State Department of Ecology
EPA	=	U.S. Environmental Protection Agency
ERA	=	expedited response action
ERDF	=	Environmental Restoration Disposal Facility
ETF	=	Effluent Treatment Facility
FY	=	fiscal year
HHE	=	human health and the environment
IRM	=	interim remedial measure
LFI	=	limited field investigation
MCL	=	maximum contaminant level
MNA	=	monitored natural attenuation
MSE	=	MSE Technology Applications, Inc.
NCP	=	*National Oil and Hazardous Substances Pollution Contingency Plan*
N&E	=	nature and extent
OU	=	operable unit
P&T	=	pump-and-treat
PFP	=	Plutonium Finishing Plant
PUREX	=	Plutonium-Uranium Extraction (Plant)
RA	=	Remedial Action
RAO	=	remedial action objective
RCRA	=	*Resource Conservation and Recovery Act of 1976*
REDOX	=	Reduction-Oxidation (Plant)
RI/FS	=	remedial investigation/feasibility study
RFI/CMS	=	RCRA facility investigation/corrective measures study
ROD	=	record of decision
SAC	=	system assessment capability
SARA	=	*Superfund Amendments and Reauthorization Act of 1986*
Tri-Party Agreement	=	*Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989)
TSD	=	treatment, storage, and disposal
WAC	=	*Washington Administrative Code*

Appendix C

Geological Cross Sections

This page intentionally let blank.

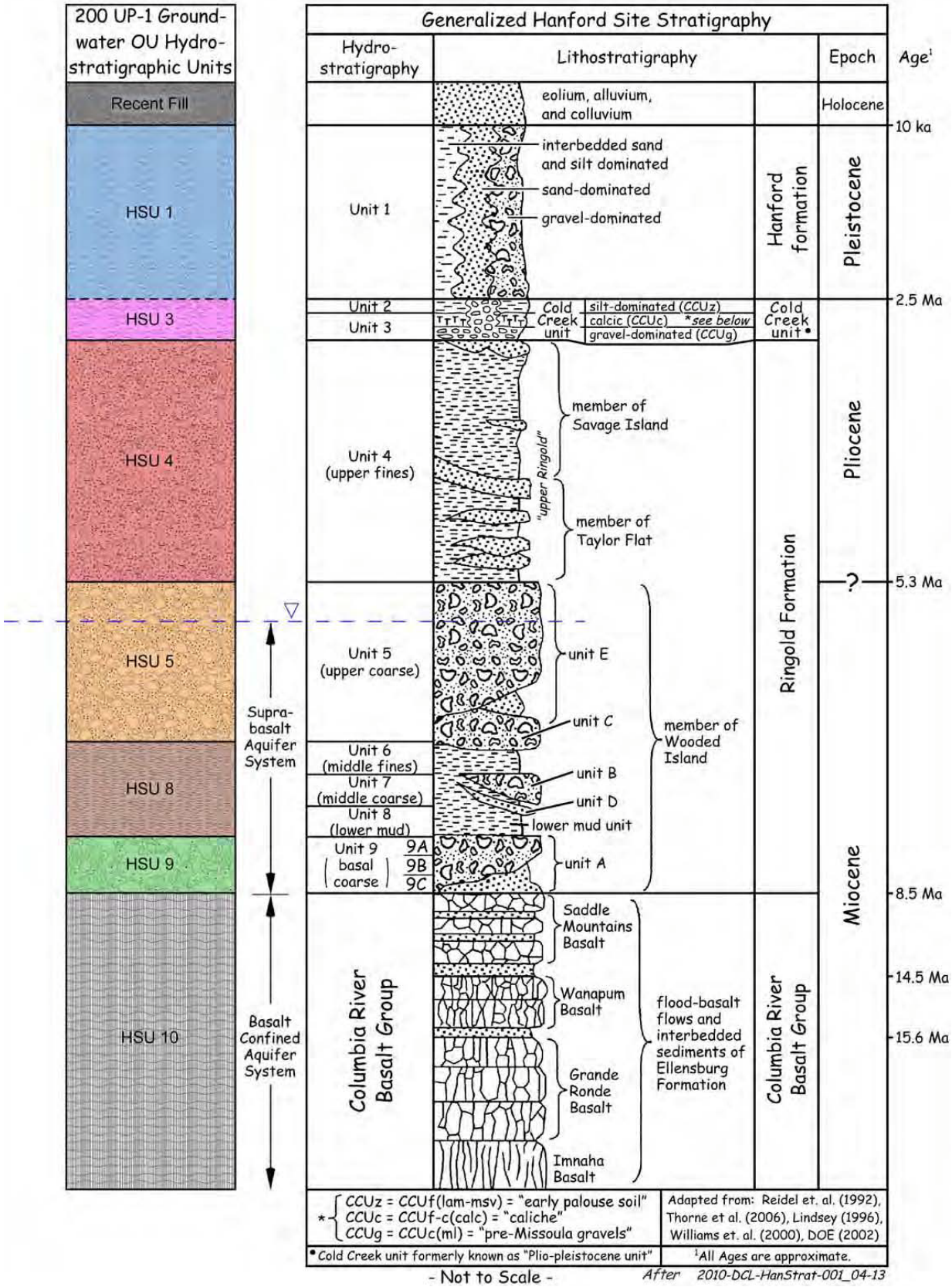


Figure C-1. Hydrogeologic Nomenclature Comparison for the 200-UP-1 Groundwater Operable Unit

This page intentionally let blank.

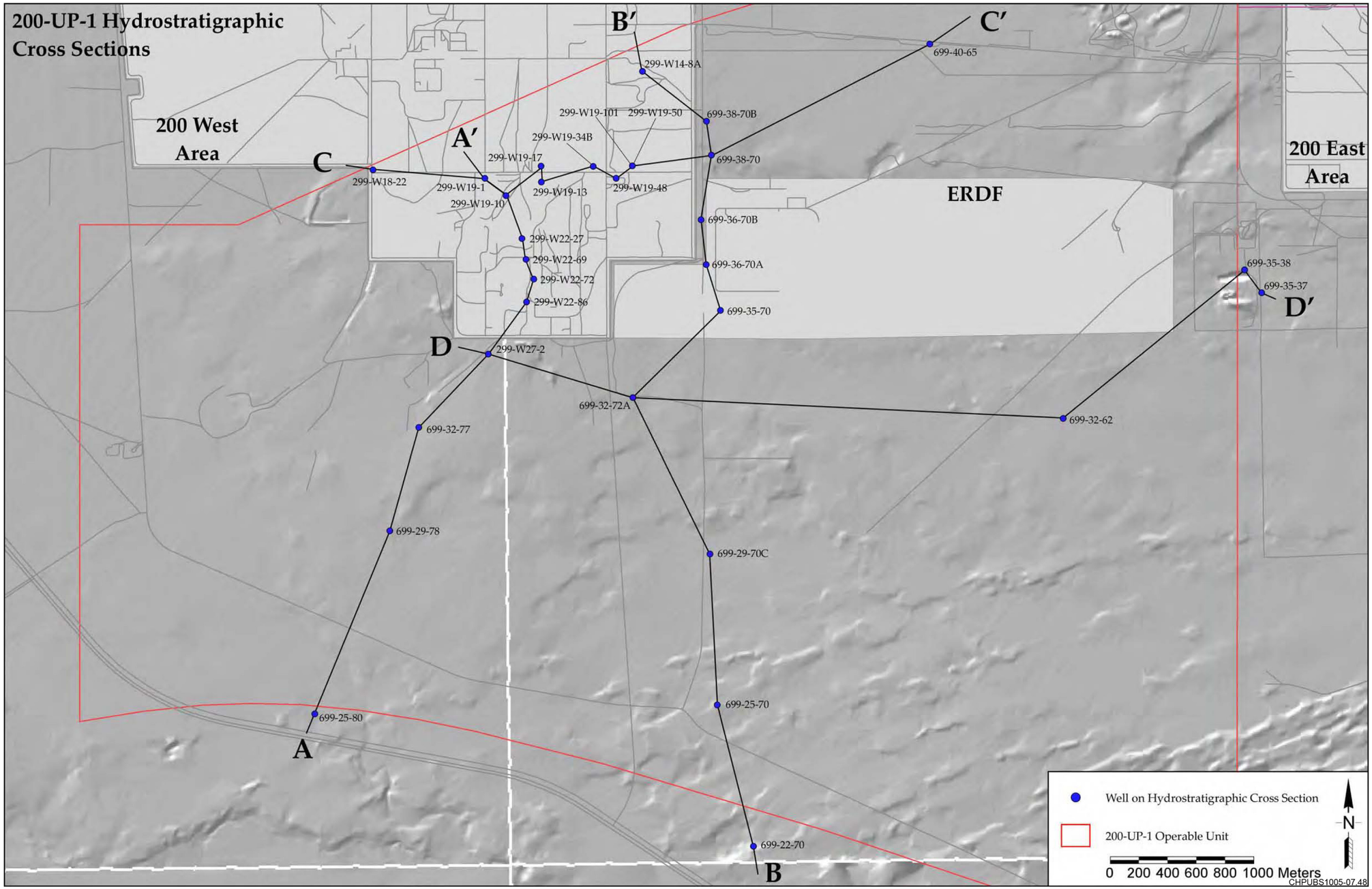


Figure C-2. 200-UP-1 Hydrostratigraphic Cross Sections

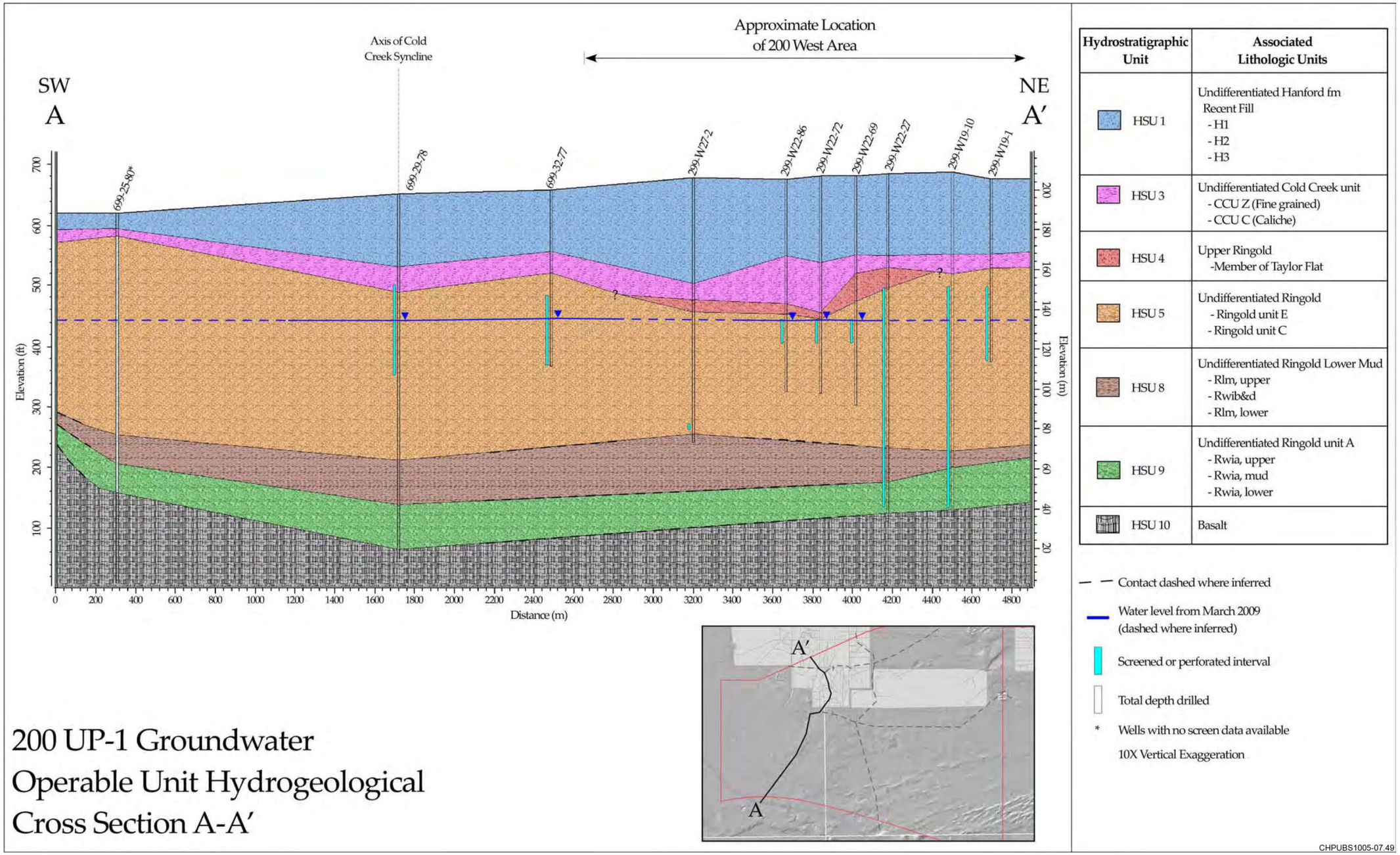


Figure C-3. 200-UP-1 Groundwater Operable Unit Hydrogeological Cross Section A-A'

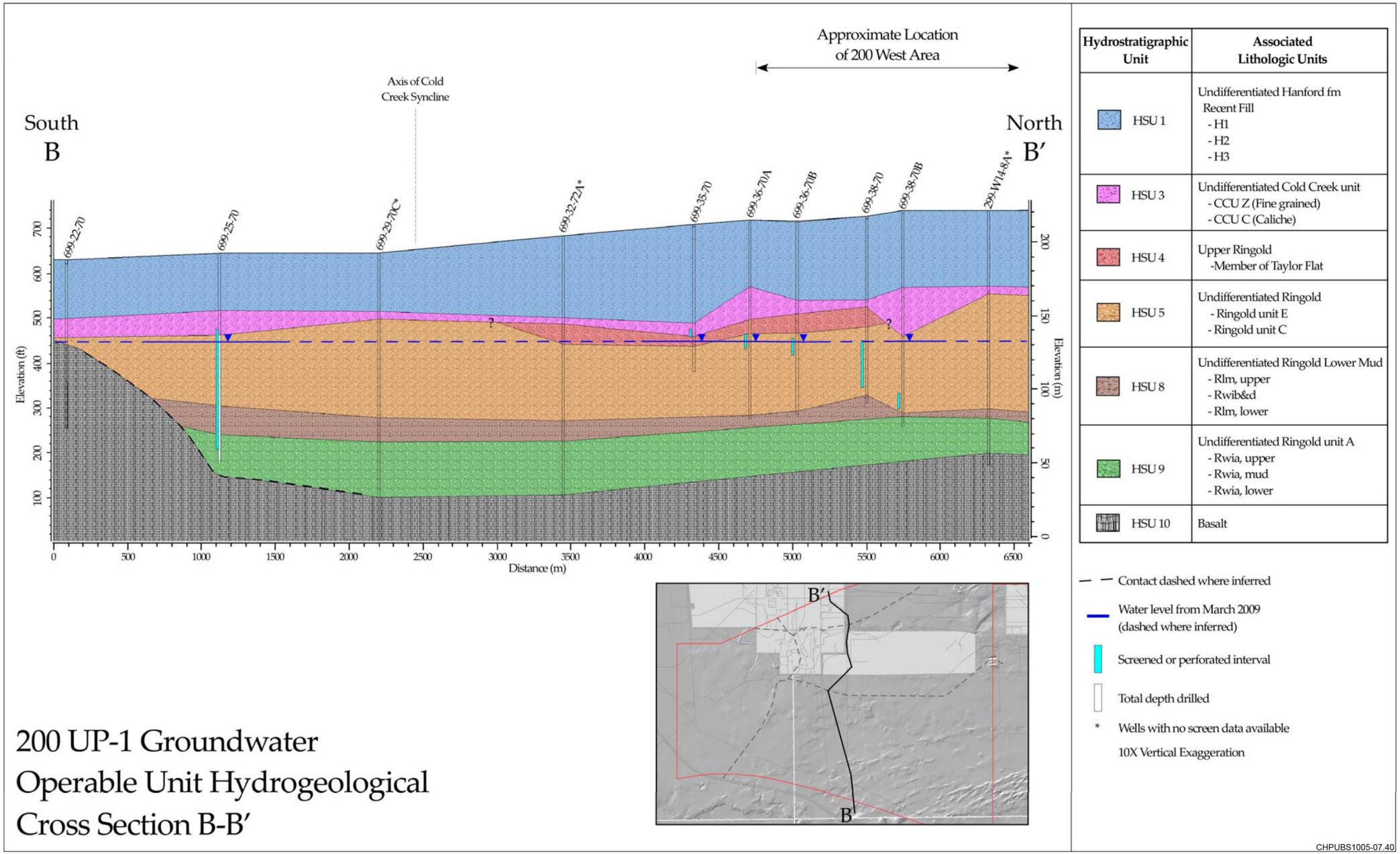


Figure C-4. 200-UP-1 Groundwater Operable Unit Hydrogeological Cross Section B-B'

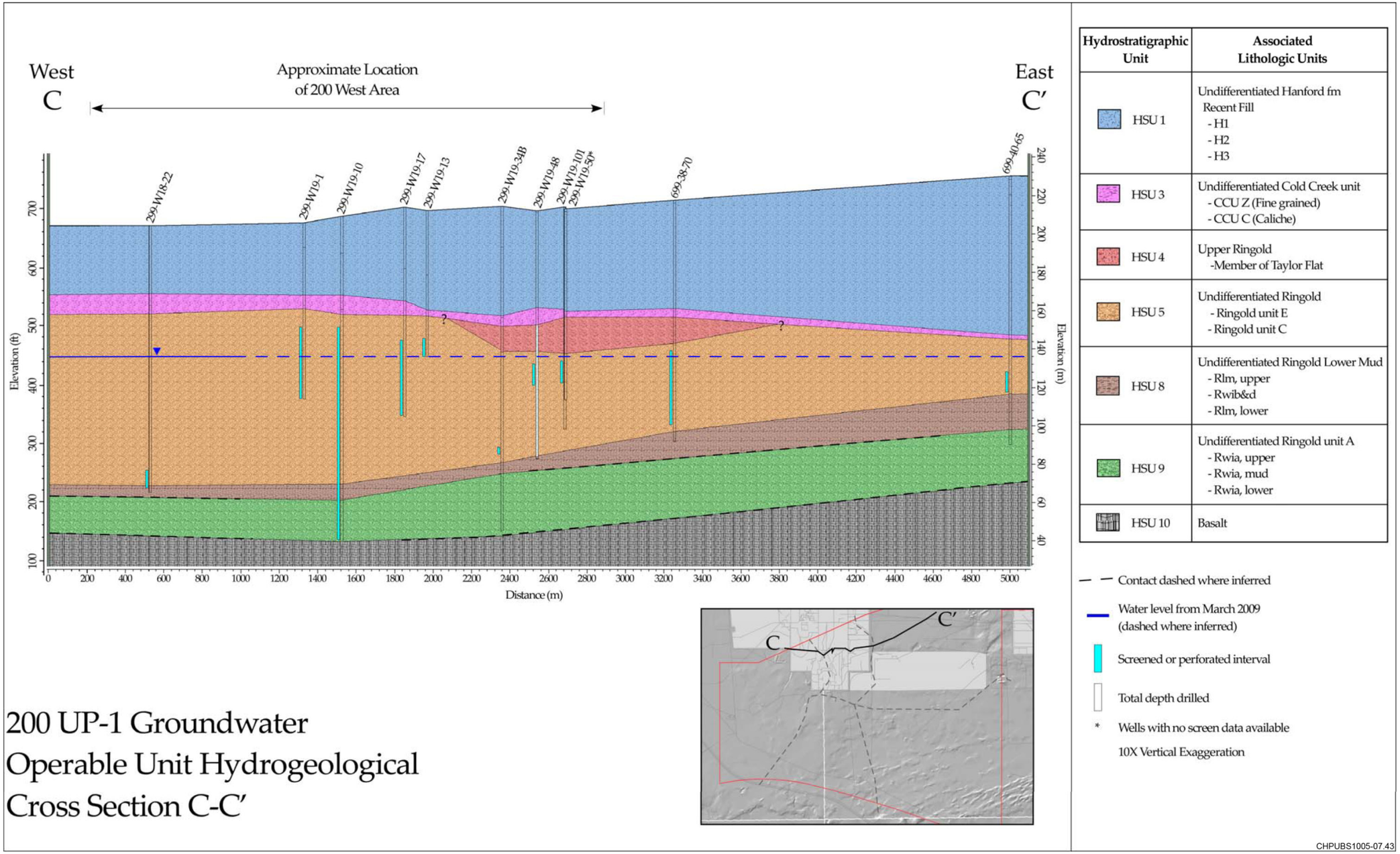


Figure C-5. 200-UP-1 Groundwater Operable Unit Hydrogeological Cross Section C-C'

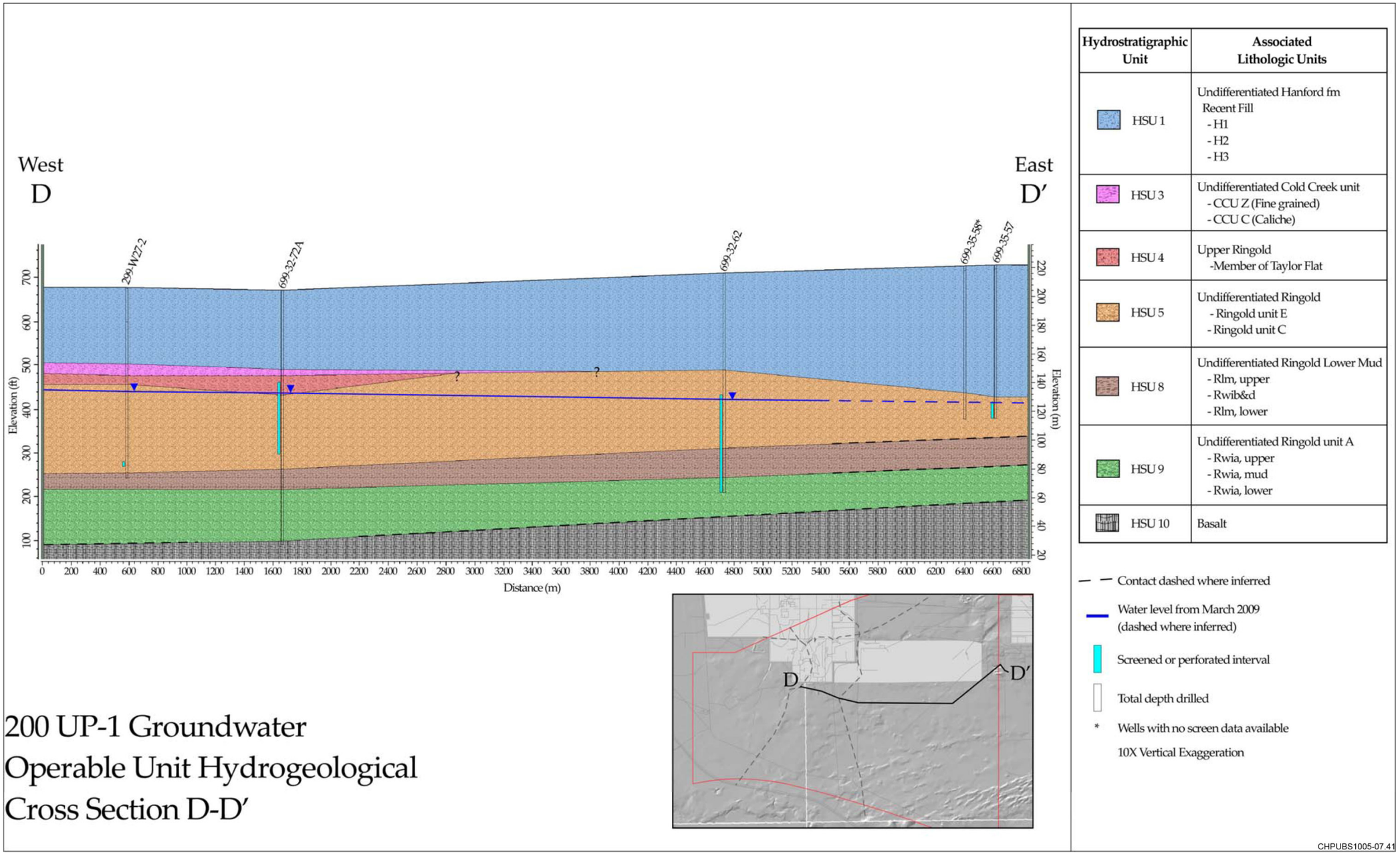


Figure C-6. 200-UP-1 Groundwater Operable Unit Hydrogeological Cross Section D-D'

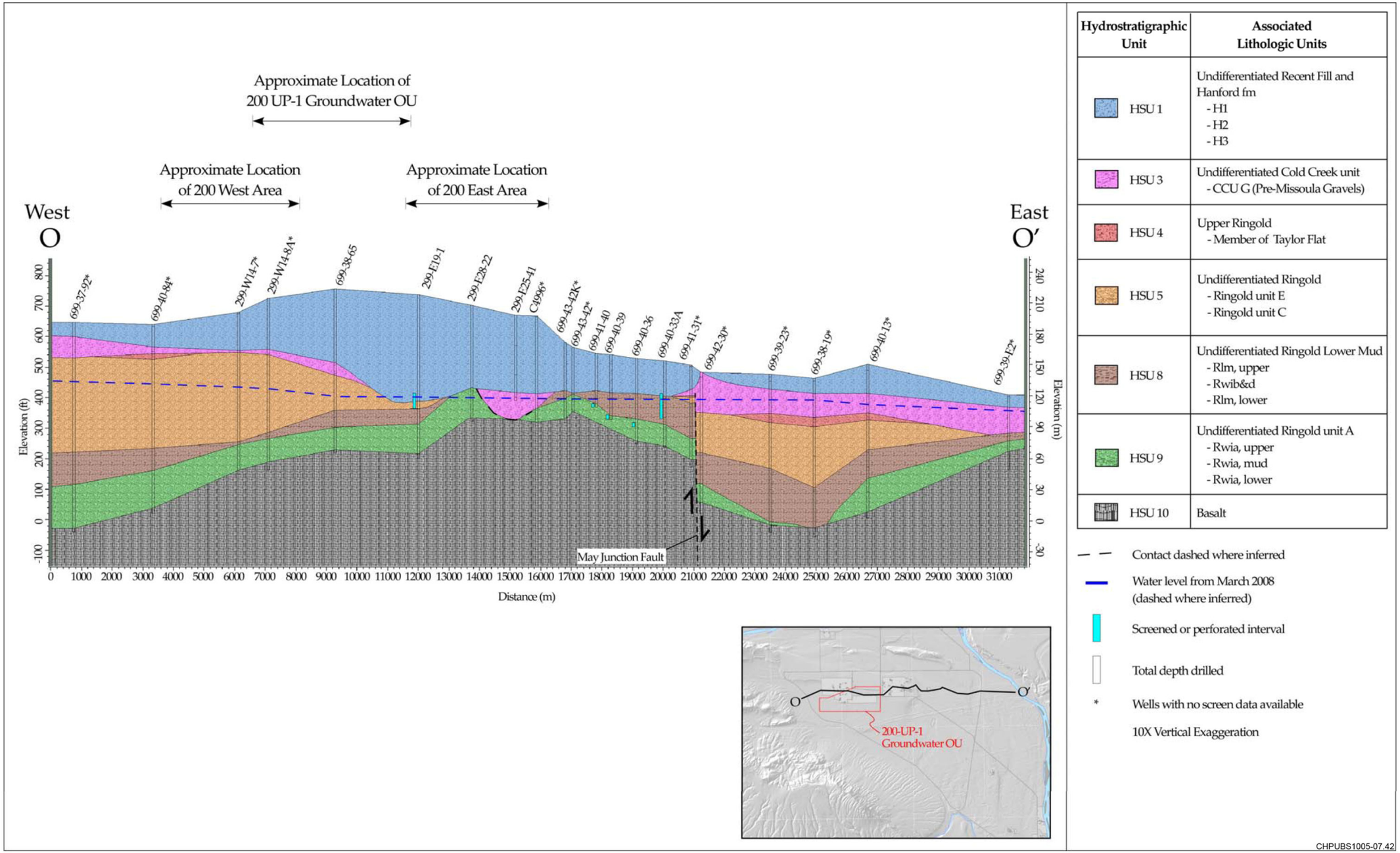


Figure C-7. 200-UP-1 Groundwater Operable Unit Hydrogeological Cross Section O-O'

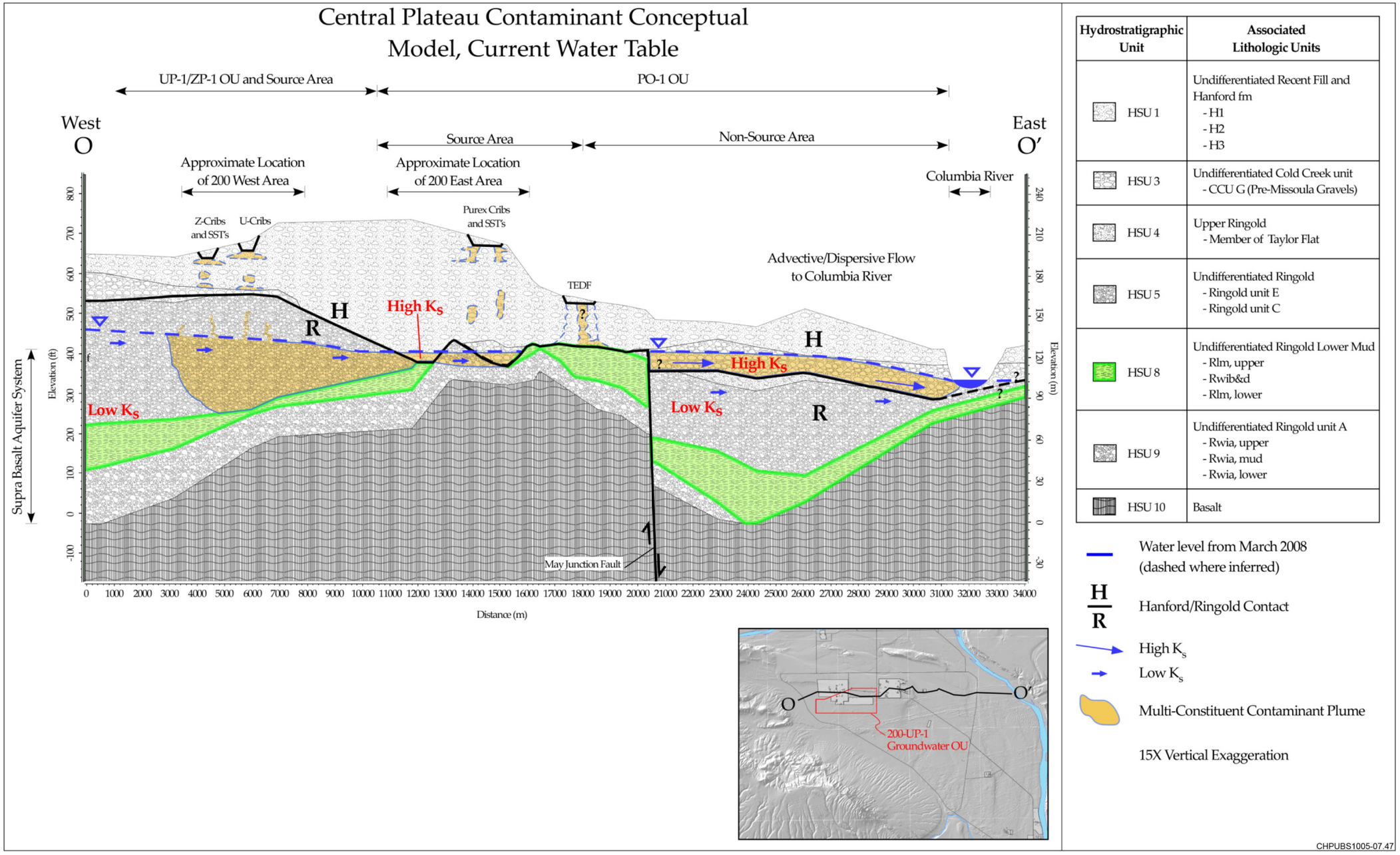


Figure C-8. Central Plateau Contaminant Conceptual Model, Current Water Table

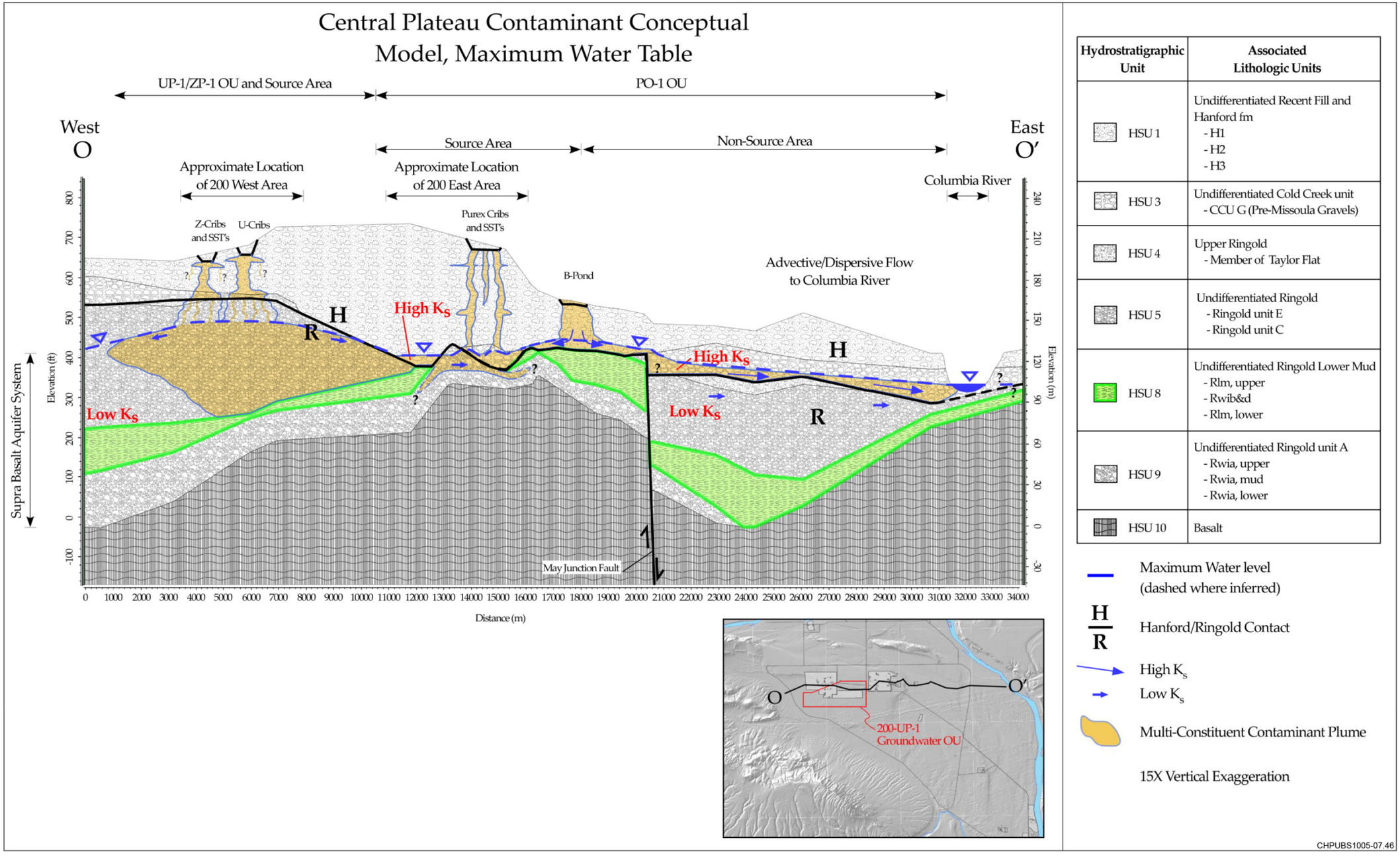


Figure C-9. Central Plateau Contaminant Conceptual Model, Maximum Water Table

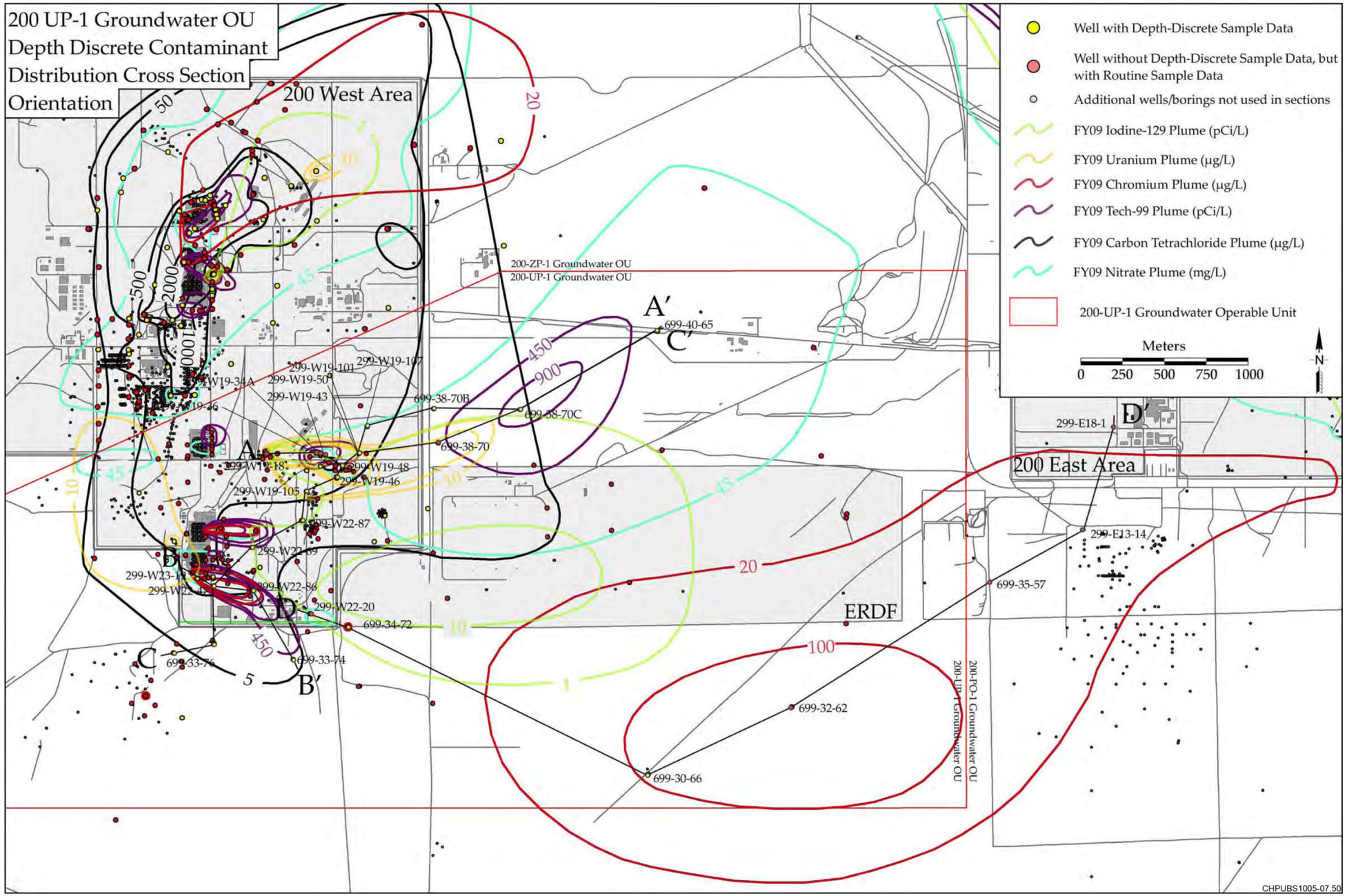


Figure C-10. 200-UP-1 Groundwater OU Depth Discrete Contaminant Distribution Cross Section Orientation

This page intentionally left blank.

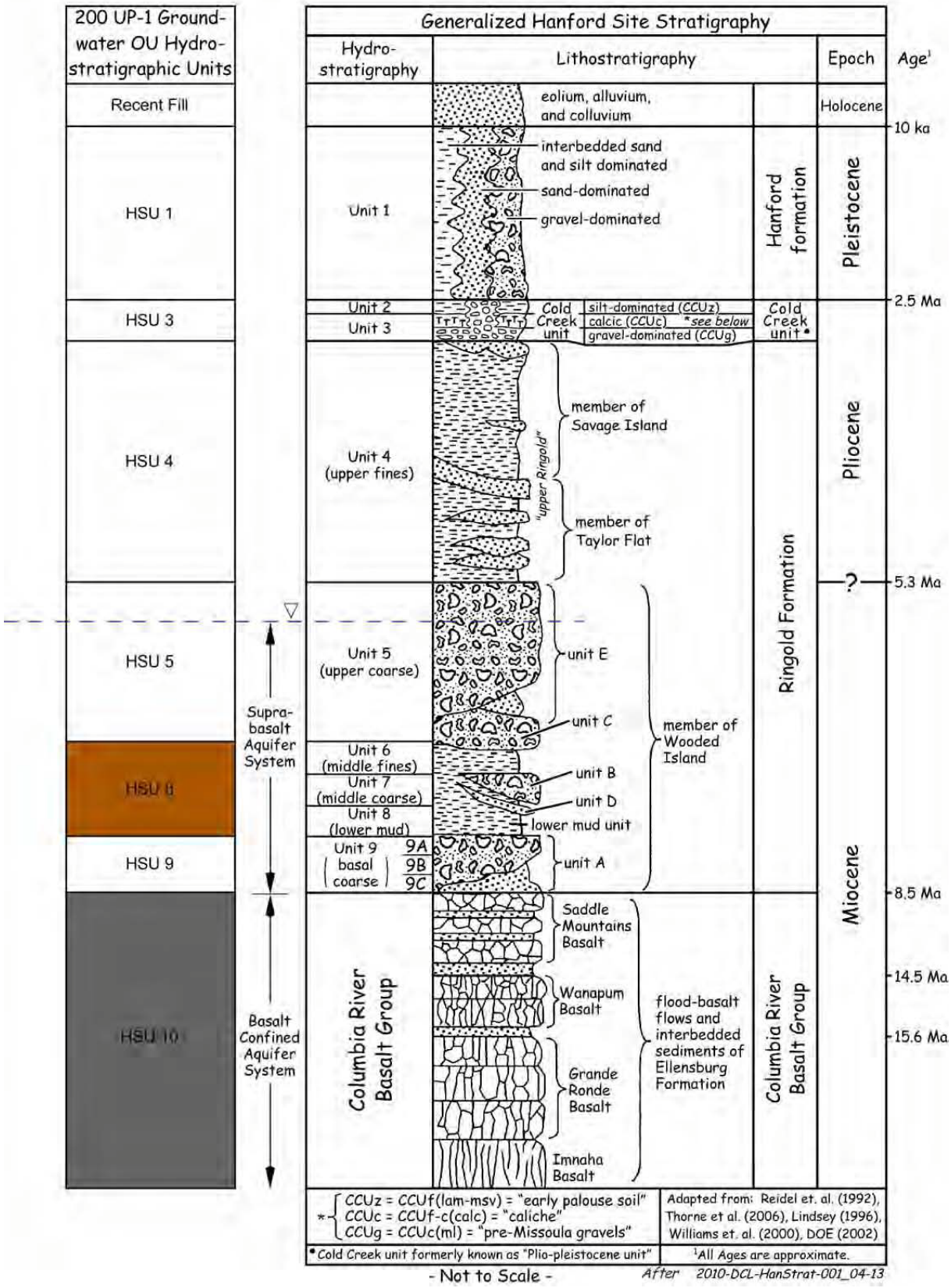


Figure C-11. 200 UP-1 Groundwater Operable Unit Hydrostratigraphic Nomenclature

This page intentionally left blank.

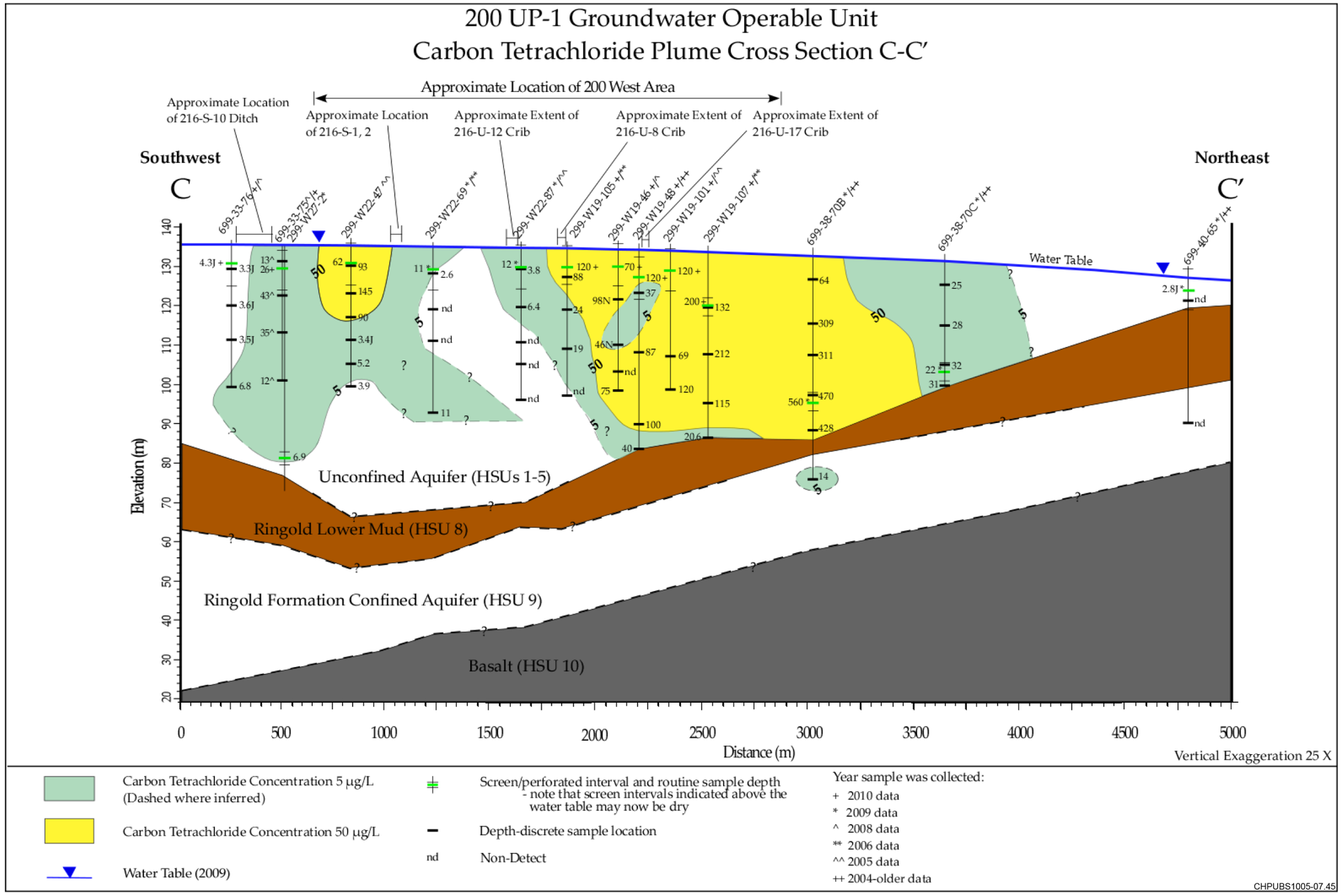


Figure C-12. 200-UP-1 Groundwater Operable Unit Carbon Tetrachloride Plume Cross Section A-A'

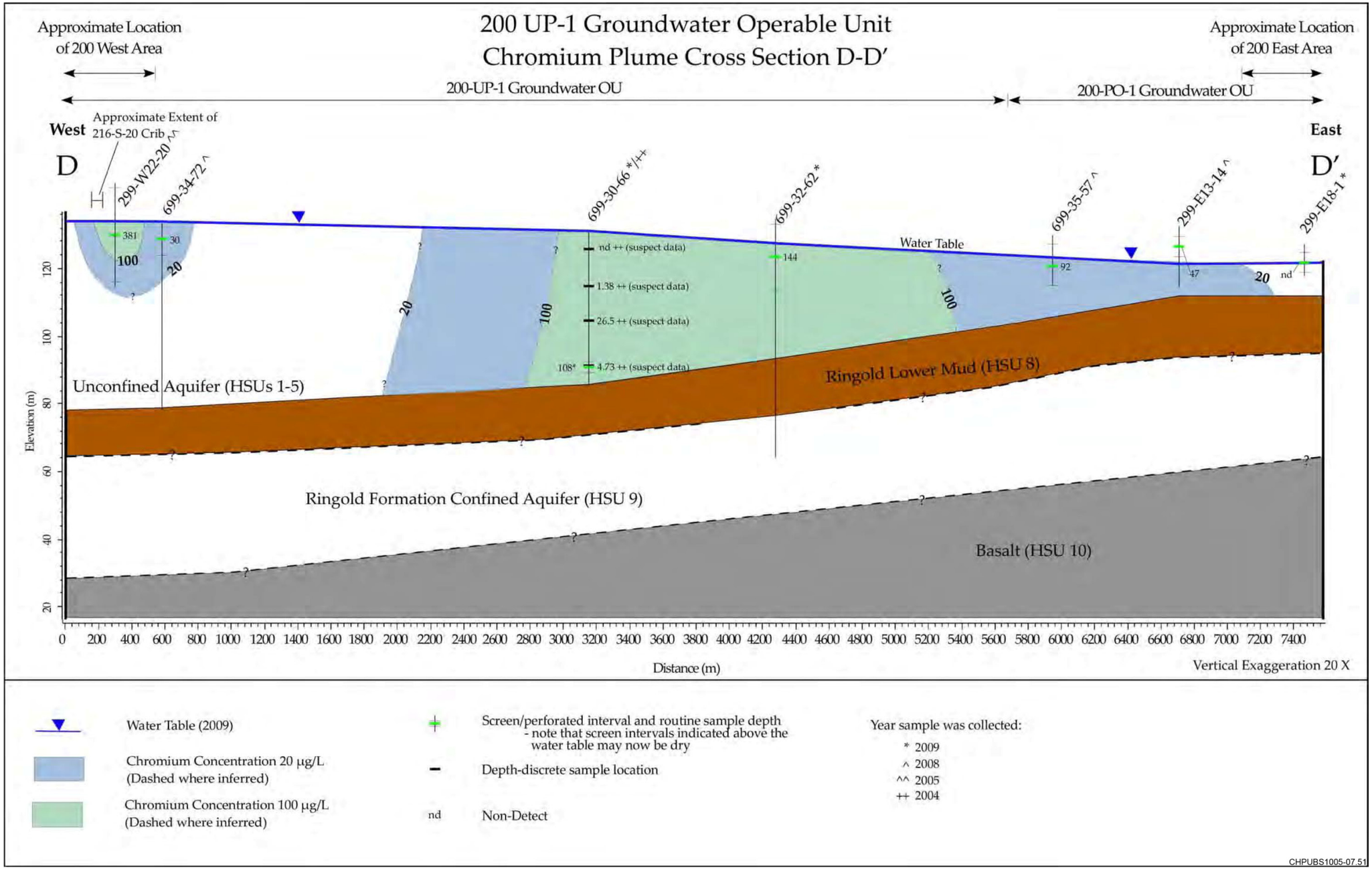


Figure C-13. 200-UP-1 Groundwater Operable Unit Chromium Plume Cross Section D-D'

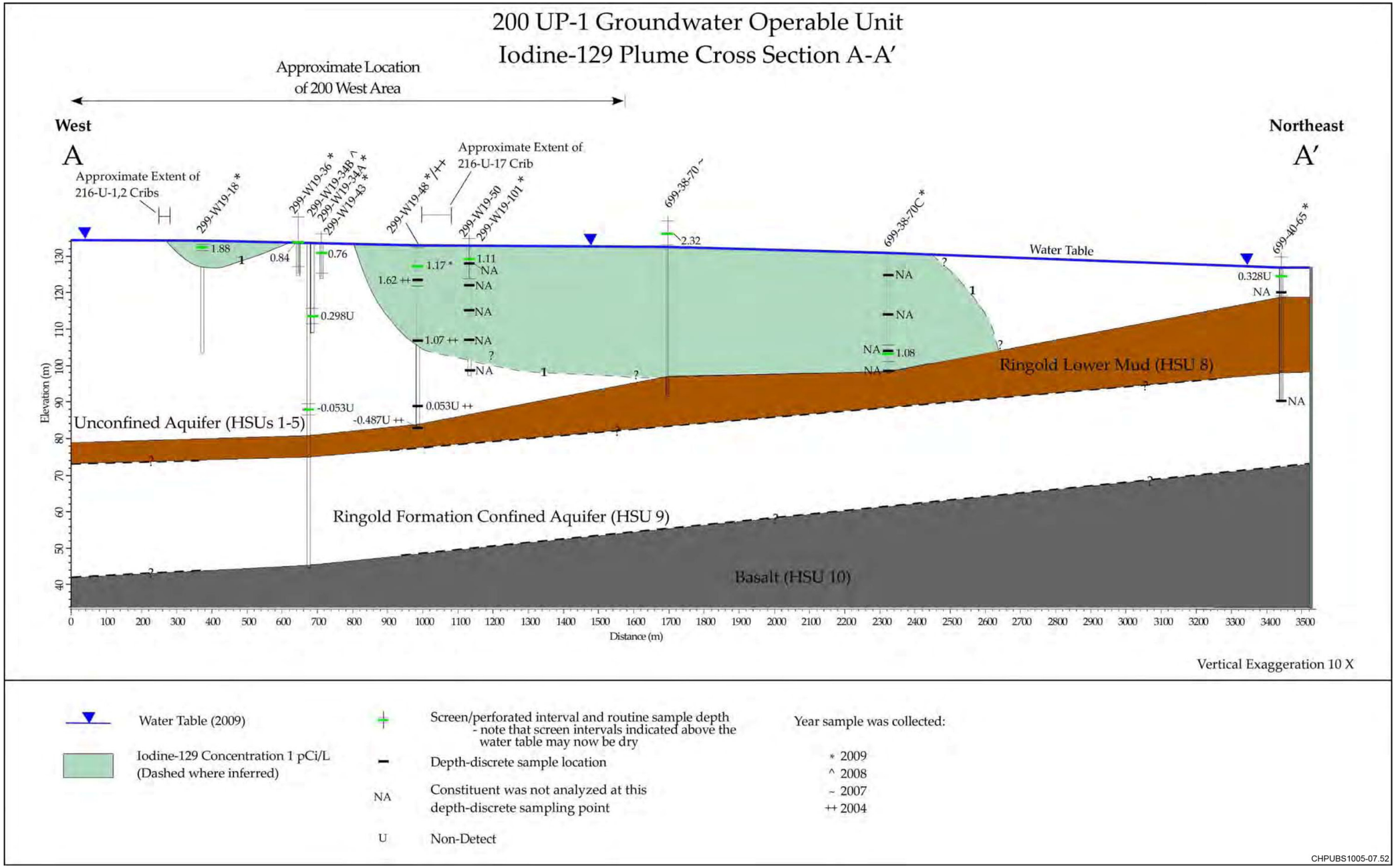


Figure C-14. 200-UP-1 Groundwater Operable Unit Iodine-129 Plume Cross Section A-A'

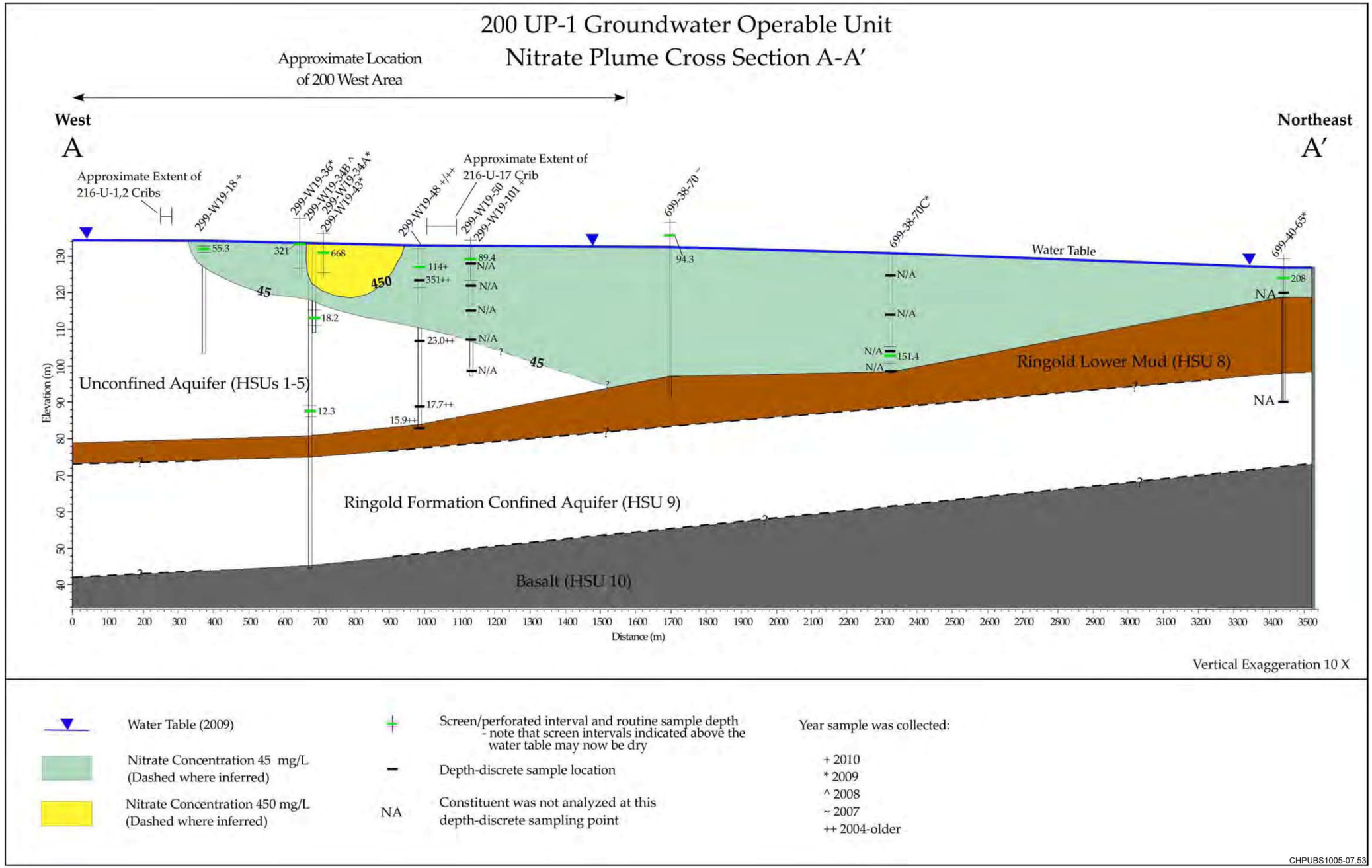


Figure C-15. 200-UP-1 Groundwater Operable Unit Nitrate Plume Cross Section A-A'

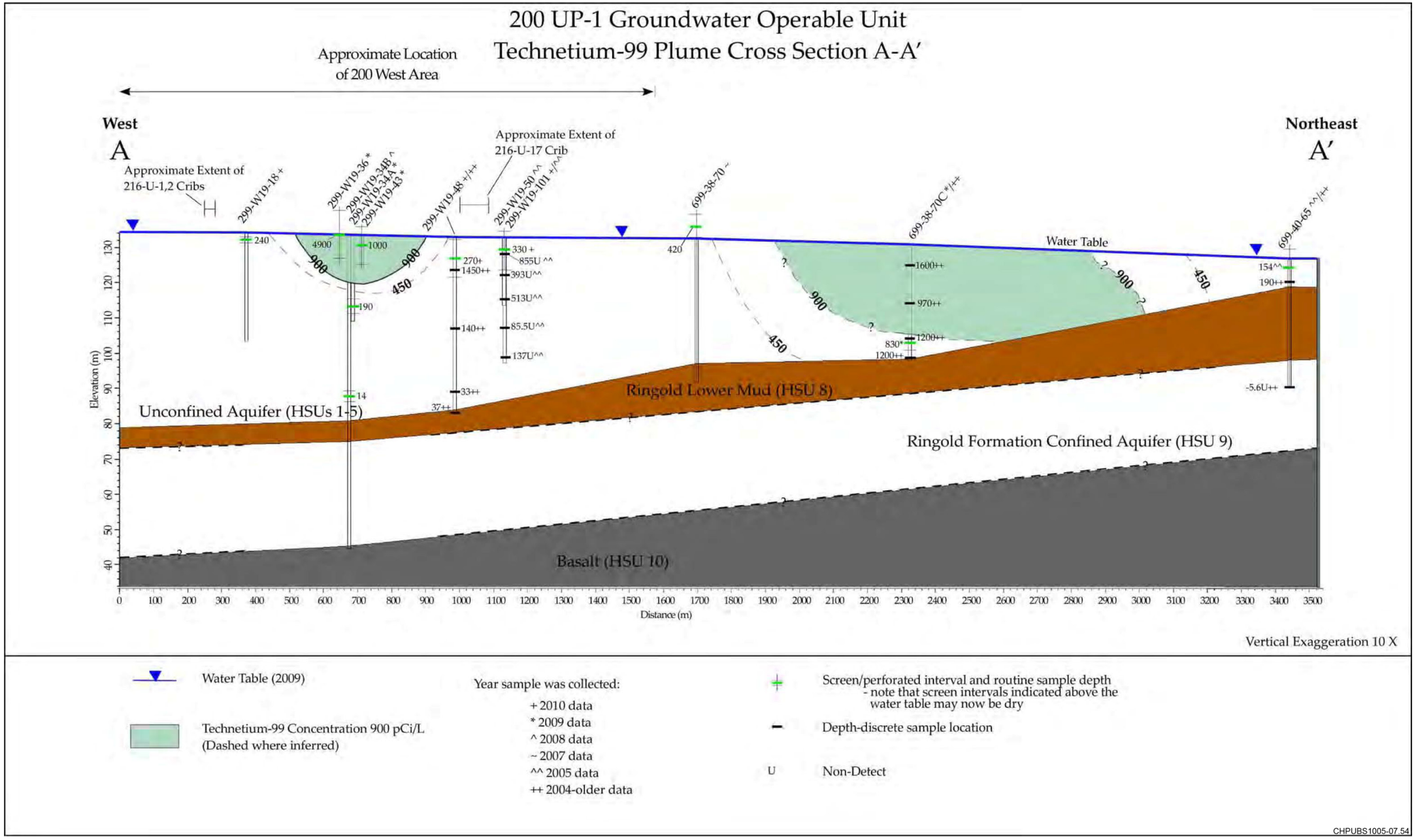


Figure C-16. 200-UP-1 Groundwater Operable Unit Technetium-99 Plume Cross Section A-A'

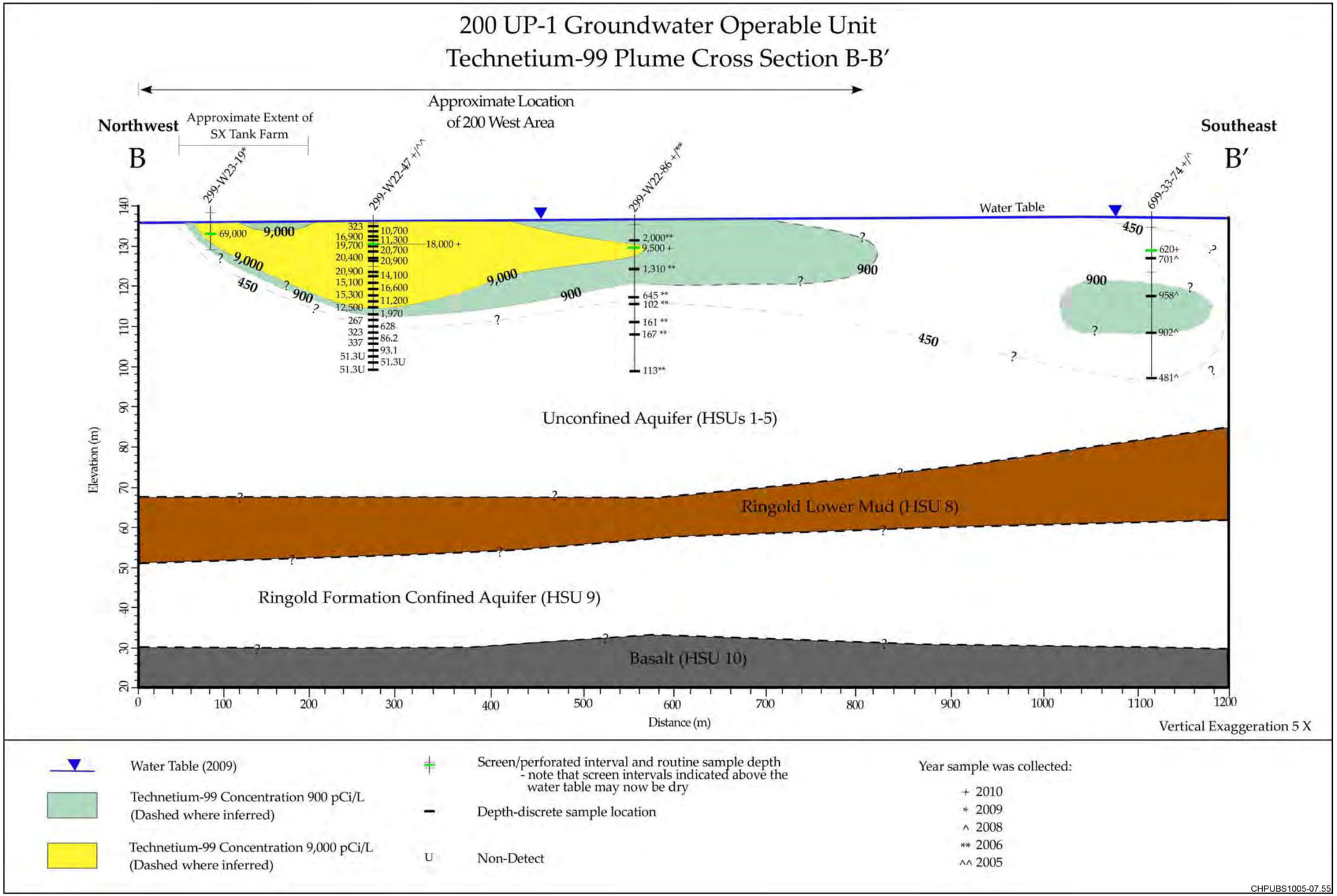


Figure C-17. 200-UP-1 Groundwater Operable Unit Technetium-99 Plume Cross Section B-B'

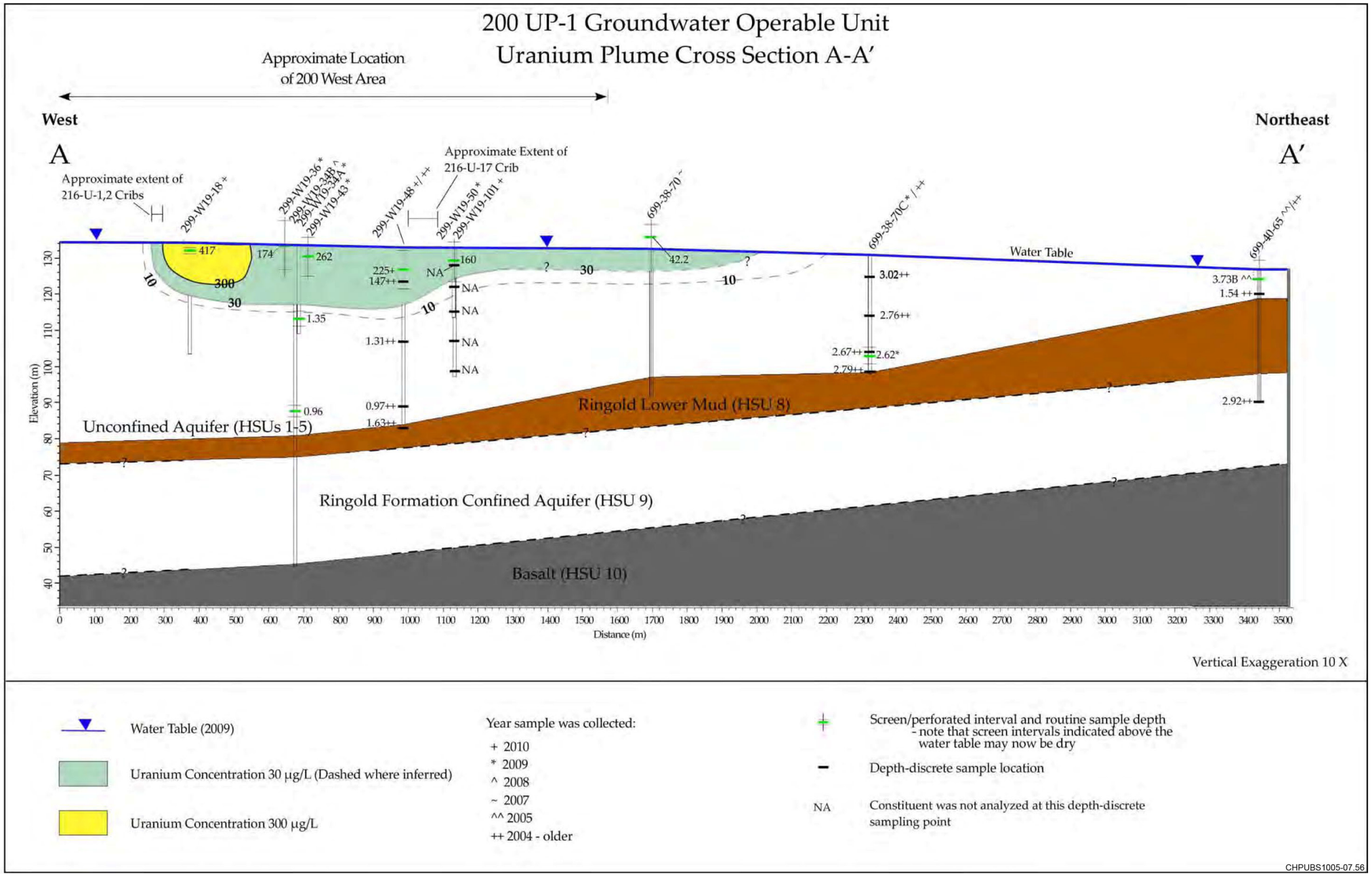


Figure C-18. 200-UP-1 Groundwater Operable Unit Uranium Plume Cross Section A-A'

This page intentionally left blank.

Appendix E

Summary of the Native American Risk Assessments

This page intentionally left blank.

E1 Summary of the Native American Risk Assessments

Several local and regional Tribes have ancestral ties to the Hanford Reach of the Columbia River and surrounding lands. DOE has requested that each Tribe provide an exposure scenario that reflects their traditional activities. At this time, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways* (Harris and Harper, 2004) and *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments* (Harris, 2008) have been provided by the CTUIR, and *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment* (Ridolfi, 2007) has been provided by the Yakama Nation.

The CTUIR and Yakama Nation scenarios reflect exposure conditions that assume groundwater from the 200-UP-1 Groundwater OU is restored to its highest beneficial use and is used as a drinking water source and to generate steam in a sweat lodge. Use of groundwater to irrigate crops and water livestock is not evaluated in this risk evaluation because those exposure pathways, although potentially complete, are considered insignificant and secondary to the drinking water and sweat lodge exposure pathways. Food chain pathways are generally evaluated quantitatively in the source area OUs because the RESRAD model (ANL, 2009) estimates exposure from these pathways. Contact with contaminated drill cuttings is not addressed because this assessment includes only groundwater pathway exposures.

Potentially complete exposure routes for adult and child Tribal members associated with use of groundwater as a drinking water source are as follows:

- Ingestion of drinking water
- Inhalation of volatiles when showering and other domestic purposes
- Dermal contact with skin while showering and using groundwater for other domestic purposes (such as, washing dishes)

Potentially complete exposure routes for adult Tribal members associated with the use of groundwater to generate steam in a sweat lodge are as follows:

- Inhalation of tritium, volatiles, and semivolatiles as vapors while in a sweat lodge
- Inhalation of aerosolized nonvolatiles while spending time in a sweat lodge
- Dermal contact with vapors from volatile and semivolatile compounds while in a sweat lodge
- Dermal contact with vapor and aqueous condensate while in a sweat lodge

A complete description of each of the Tribal use exposure scenarios is provided in Appendix D (ECF-200UP1-10-0250). This calculation describes the methodology, assumptions, and inputs, and the calculation of risks and hazards, and discusses the results of the risk assessment for each of the Native American scenarios.

E1.1 Summary of the CTUIR Risk Assessment

This section summarizes the results for each of the exposures associated with use of groundwater as a drinking water source and use of groundwater to generate steam in a sweat lodge.

E1.1.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact,[1] and inhalation of volatiles during

[1] The dermal contact exposure route is only evaluated for nonradionuclide COPCs.

household activities. Table E-1 provides a summary of the risk estimates by exposure route for the 200-UP-1 Groundwater OU. Additional detail including COPC-specific risk contributions is provided in Appendix D (ECF-200UP1-10-0250).

Table E-1. Confederated Tribes of the Umatilla Indian Reservation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source

Exposure Route	ELCR	HI
Nonradionuclide COPCs		
Ingestion	2.1×10^{-3}	30
Dermal	2.2×10^{-4}	2.4
Inhalation	3.9×10^{-5}	0.87
Total	**2.4×10^{-3}**	**34**
Radionuclide COPCs		
Ingestion	1.6×10^{-3}	--
Inhalation	2.3×10^{-5}	--
Total	**1.6×10^{-3}**	**--**
Total ELCR*	**3.9×10^{-3}**	**--**

* Sum of total ELCR values for nonradionuclides and radionuclides.

-- = HI is not applicable

COPC = contaminant of potential concern

ELCR = excess lifetime cancer risk

HI = hazard index

The cumulative ELCR is 2.4×10^{-3} for nonradiological COPCs and 1.6×10^{-3} for radiological COPCs, which is greater than the EPA upper target risk threshold of 1×10^{-4} (see Table E-2) Results in Table E-2 show the major contributors to ELCR are carbon tetrachloride (1.7×10^{-3}; 42 percent contribution), technentium-99 (1.1×10^{-3}; 28 percent contribution), tritium (2.7×10^{-4}; 6.9 percent contribution), iodine-129 (4.9×10^{-5}; 1.2 percent contribution), tetrachloroethene (4.1×10^{-5}; 1.1 percent contribution); which have been identified as final COPCs in Section 6.1 of the RI report. Additional analytes that contribute greater than one percent of the ELCR include U-234 (9.6×10^{-5}; 2.5 percent contribution) and Se-79 (3.9×10^{-5}; 1.0 percent contribution). Se-79 and U-234 are not identified as final COPCs, however total uranium is identified as a final COPC and is discussed below. In addition, contribution to ELCR are elevated for arsenic (5.8×10^{-4}; 15 percent contribution), where measured concentrations are within natural background values. Contributions from 1,4-dioxane (3.8×10^{-6}; 0.1 percent contribution), chloroform (1.6×10^{-5}; 0.39 percent contribution), and trichloroethene (1.9×10^{-5}; 0.49 percent contribution) fall below 1 percent but they are indentified as final COPCs in Section 6.1 of the RI report based on their action levels and the localized measurements.

The HI is 34, which is greater than the EPA target HI of 1.0. Result in Table E-3 show the major contributors to HI are carbon tetrachloride (HQ = 17; 52 percent contribution), uranium (HQ = 3.9; 12 percent contribution), hexavalent chromium (HQ = 1.2; 3.5 percent contribution), and nitrate

(HQ = 1.1; 3.2 percent contribution); which have been identified as final COPCs in Section 6.1. Additional analytes that contribute greater than 1 percent of the HI include acrolein (HQ = 1.0; 3.0 percent contribution), antimony (HQ = 4.1; 12 percent contribution), arsenic (HQ = 1.3; 3.8 percent contribution), cobalt (HQ = 0.52; 1.6 percent contribution), fluoride (HQ = 0.45; 1.3 percent contribution), molybdenum (HQ = 0.69; 2.0 percent contribution), and vanadium (HQ = 0.42; 1.3 percent contribution). Some of the metals concentrations (arsenic and cobalt) and fluoride are within natural background values. For antimony, the analytical method used for the measurements has a high MDL, making the data unreliable for risk characterization. As discussed In Section 6.1 of the RI report, acrolein is considered to be an anomalous measurement (one detection in 122 measurements; with about 5 years of non-detections at the same well where that detection was measured). Measurements of molybdenum greater than the action level (discussed in Section 6.1) are not associated with a trend or an exposure point. All detected vanadium concentrations and MDLs are consistently less than the action level.

Table E-2. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,1,2-Trichloroethane	5.00E-04	Yes	1.65E-06	8.36E-08	9.67E-08	1.83E-06	0.047
1,1-Dichloroethane	5.00E-04	Yes	--	--	--	--	--
1,1-Dichloroethene	5.00E-04	Yes	--	--	--	--	--
1,2-Dichloroethane	5.00E-04	Yes	2.64E-06	6.97E-08	1.57E-07	2.86E-06	0.073
1,4-Dichlorobenzene	5.00E-04	Yes	1.56E-07	5.66E-08	6.65E-08	2.79E-07	0.0071
1,4-Dioxane	0.0060	--	3.83E-06	7.40E-09	--(b)	3.83E-06	0.098
2,3,4,6-Tetrachlorophenol	0.0014	--	--	--	--(b)	--	--
2-Butanone	9.00E-04	Yes	--	--	--	--	--
2-Butoxyethanol	0.066	--	--	--	--(b)	--	--
2-Pentanone, 4-Methyl	5.00E-04	Yes	--	--	--	--	--
4-Nitrophenol	0.0014	--	--	--	--(b)	--	--
Acetone	0.0031	Yes	--	--	--	--	--
Acrolein	0.0014	Yes	--	--	--	--	--
Aluminum	0.096	--	--	--	--(b)	--	--
Antimony	0.028	--	--	--	--(b)	--	--
Arsenic	0.0066	--	5.74E-04	1.66E-06	--(b)	5.75E-04	15
Barium	0.069	--	--	--	--(b)	--	--
Benzene	5.00E-04	Yes	1.59E-06	1.31E-07	4.71E-08	1.77E-06	0.045
Beryllium	0.0020	--	--	--	--(b)	--	--
Bis(2-ethylhexyl)	0.0018	--	1.46E-06	1.22E-06	--(b)	2.68E-06	0.068

Table E-2. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
phthalate							
Boron	0.055	--	--	--	--(b)	--	--
Bromodichloromethane	0.0025	Yes	8.98E-06	3.96E-07	1.12E-06	1.05E-05	0.27
Bromoform	0.0025	--	1.14E-06	4.30E-08	--(b)	1.19E-06	0.030
Bromomethane	0.0050	Yes	--	--	--	--	--
Cadmium	0.0020	--	--	--	--(b)	--	--
Carbon disulfide	5.00E-04	Yes	--	--	--	--	--
Carbon tetrachloride	0.19	Yes	1.42E-03	2.05E-04	3.42E-05	1.66E-03	42
Chloride	31	--	--	--	--(b)	--	--
Chlorobenzene	0.0025	Yes	--	--	--	--	--
Chloroform	0.0072	Yes	1.28E-05	6.31E-07	1.99E-06	1.55E-05	0.39
Chromium	0.099	--	--	--	--(b)	--	--
cis-1,2-Dichloroethylene	5.00E-04	Yes	--	--	--	--	--
Cobalt	0.0028	--	--	--	--(b)	--	--
Copper	0.0050	--	--	--	--(b)	--	--
Cyanide	0.0024	Yes	--	--	--	--	--
Ethylbenzene	5.00E-04	Yes	3.19E-07	1.03E-07	1.51E-08	4.37E-07	0.011
Fluoride	0.47	--	--	--	--(b)	--	--
Hexavalent Chromium	0.052	--	--	--	--(b)	--	--
Iron	0.41	--	--	--	--(b)	--	--
Isobutyl alcohol	0.015	Yes	--	--	--	--	--
Lead	0.0037	--	--	--	--(b)	--	--
Lithium	0.0089	--	--	--	--(b)	--	--
Manganese	0.018	--	--	--	--(b)	--	--
Mercury	5.00E-05	--	--	--	--(b)	--	--
Methylene chloride	0.0011	Yes	4.56E-07	9.23E-09	5.96E-09	4.72E-07	0.012
Molybdenum	0.060	--	--	--	--(b)	--	--
Nickel	0.018	--	--	--	--(b)	--	--
Nitrate	133	--	--	--	--(b)	--	--

Table E-2. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Nitrite	0.11	--	--	--	--(b)	--	--
Phenol	0.0020	--	--	--	--(b)	--	--
Selenium	0.023	--	--	--	--(b)	--	--
Silver	0.0053	--	--	--	--(b)	--	--
Strontium	0.26	--	--	--	--(b)	--	--
Styrene	0.0025	Yes	--	--	--	--	--
Sulfate	39	--	--	--	--(b)	--	--
Tetrachloroethene	0.0010	Yes	3.13E-05	1.01E-05	7.13E-08	4.14E-05	1.1
Thallium	0.0050	--	--	--	--(b)	--	--
Tin	0.0036	--	--	--	--(b)	--	--
Toluene	5.00E-04	Yes	--	--	--	--	--
trans-1,3-Dichloropropene	0.0025	Yes	1.45E-05	4.27E-07	1.21E-07	1.50E-05	0.38
Tributyl phosphate	6.50E-04	--	3.47E-07	--	--(b)	3.47E-07	0.0088
Trichloroethene	0.0033	Yes	1.68E-05	1.56E-06	9.82E-07	1.93E-05	0.49
Uranium	0.21	--	--	--	--(b)	--	--
Vanadium	0.037	--	--	--	--(b)	--	--
Xylenes (total)	5.00E-04	Yes	--	--	--	--	--
Zinc	0.027	--	--	--	--(b)	--	--
Carbon-14	14	--	2.05E-06		--(b)	2.05E-06	0.052
Gross alpha	4.1	--	--		--(b)	--	--
Iodine-129	3.5	--	4.89E-05		--(b)	4.89E-05	1.2
Neptunium-237	0.039	--	2.32E-07		--(b)	2.32E-07	0.0059
Protactinium-231	0.15	--	2.48E-06		--(b)	2.48E-06	0.063
Selenium-79	56	--	3.93E-05		--(b)	3.93E-05	1.0
Strontium-90	0.66	--	3.52E-06		--(b)	3.52E-06	0.090
Technetium-99	4,150	--	1.09E-03		--(b)	1.09E-03	28
Tritium	51,150	Yes	2.48E-04		2.28E-05	2.71E-04	6.9
Uranium-234	14	--	9.63E-05		--(b)	9.63E-05	2.4
Uranium-235	0.68	--	4.52E-06		--(b)	4.52E-06	0.12

Table E-2. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Uranium-238	2.4	--	1.48E-05		--(b)	1.48E-05	0.38
Total Cumulative ELCR			3.64E-03	2.21E-04	6.16E-05	3.93E-03	100

Table E-3. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Noncancer Hazard Results forRadiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
1,1,2-Trichloroethane	5.00E-04	Yes	7.14E-03	3.35E-04	--	7.48E-03	0.022
1,1-Dichloroethane	5.00E-04	Yes	1.43E-04	5.59E-06	8.63E-06	1.57E-04	4.68E-04
1,1-Dichloroethene	5.00E-04	Yes	5.71E-04	3.95E-05	3.02E-05	6.41E-04	0.0019
1,2-Dichloroethane	5.00E-04	Yes	1.43E-03	3.50E-05	2.52E-06	1.47E-03	0.0044
1,4-Dichlorobenzene	5.00E-04	Yes	4.08E-04	1.37E-04	7.55E-06	5.53E-04	0.0016
1,4-Dioxane	0.0060	--	3.43E-03	6.16E-06	--(b)	3.43E-03	0.010
2,3,4,6-Tetrachlorophenol	0.0014	--	2.67E-03	--	--(b)	2.67E-03	0.0079
2-Butanone	9.00E-04	Yes	8.57E-05	4.05E-07	2.18E-06	8.83E-05	2.63E-04
2-Butoxyethanol	0.066	--	7.54E-03	6.00E-05	--(b)	7.60E-03	0.023
2-Pentanone, 4-Methyl	5.00E-04	Yes	3.57E-04	5.70E-06	2.01E-06	3.65E-04	0.0011
4-Nitrophenol	0.0014	--	1.00E-02	3.64E-04	--(b)	1.04E-02	0.031
Acetone	0.0031	Yes	1.94E-04	--	1.19E-06	1.95E-04	5.80E-04
Acrolein	0.0014	Yes	1.60E-01	4.77E-04	8.46E-01	1.01E+00	3.0
Aluminum	0.096	--	5.50E-03	1.44E-05	--(b)	5.51E-03	0.016
Antimony	0.028	--	4.00E+00	6.96E-02	--(b)	4.07E+00	12
Arsenic	0.0066	--	1.26E+00	3.28E-03	--(b)	1.26E+00	3.8
Barium	0.069	--	1.97E-02	7.33E-04	--(b)	2.04E-02	0.061
Benzene	5.00E-04	Yes	7.14E-03	5.47E-04	2.01E-04	7.89E-03	0.023
Beryllium	0.0020	--	5.71E-02	2.13E-02	--(b)	7.84E-02	0.23

Table E-3. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Noncancer Hazard Results forRadiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
Bis(2-ethylhexyl) phthalate	0.0018	--	5.14E-03	3.97E-03	--(b)	9.12E-03	0.027
Boron	0.055	--	1.58E-02	4.13E-05	--(b)	1.59E-02	0.047
Bromodichloromethane	0.0025	Yes	7.14E-03	2.92E-04	--	7.43E-03	0.022
Bromoform	0.0025	--	7.14E-03	2.49E-04	--(b)	7.39E-03	0.022
Bromomethane	0.0050	Yes	2.04E-01	3.25E-03	1.21E-02	2.19E-01	0.65
Cadmium	0.0020	--	2.29E-01	1.19E-02	--(b)	2.41E-01	0.72
Carbon disulfide	5.00E-04	Yes	2.86E-04	2.52E-05	8.63E-06	3.20E-04	9.52E-04
Carbon tetrachloride	0.19	Yes	1.54E+01	2.06E+00	1.20E-02	1.75E+01	52
Chloride	31	--	--	--	--(b)	--	
Chlorobenzene	0.0025	Yes	7.14E-03	1.28E-03	6.04E-04	9.03E-03	0.027
Chloroform	0.0072	Yes	4.09E-02	1.86E-03	8.82E-04	4.36E-02	0.13
Chromium	0.099	--	3.78E-03	7.58E-04	--(b)	4.54E-03	0.014
cis-1,2-Dichloroethylene	5.00E-04	Yes	2.86E-03	1.27E-04	--	2.98E-03	0.0089
Cobalt	0.0028	--	5.24E-01	5.47E-04	--(b)	5.24E-01	1.6
Copper	0.0050	--	7.14E-03	1.86E-05	--(b)	7.16E-03	0.021
Cyanide	0.0024	Yes	6.71E-03	1.75E-05	--	6.73E-03	0.020
Ethylbenzene	5.00E-04	Yes	2.86E-04	8.59E-05	6.04E-06	3.78E-04	0.0011
Fluoride	0.47	--	4.48E-01	1.17E-03	--(b)	4.49E-01	1.3
Hexavalent Chromium	0.052	--	9.86E-01	2.06E-01	--(b)	1.19E+00	3.5
Iron	0.41	--	3.31E-02	8.64E-05	--(b)	3.32E-02	0.099
Isobutyl alcohol	0.015	Yes	2.76E-03	--	--	2.76E-03	0.0082
Lead	0.0037	--	--	--	--(b)	--	
Lithium	0.0089	--	2.53E-01	6.60E-04	--(b)	2.54E-01	0.75
Manganese	0.018	--	4.30E-02	2.80E-03	--(b)	4.58E-02	0.14
Mercury	5.00E-05	--	9.52E-03	3.55E-04	--(b)	9.88E-03	0.029
Methylene chloride	0.0011	Yes	1.00E-03	1.88E-05	1.27E-05	1.03E-03	0.0031
Molybdenum	0.060	--	6.85E-01	1.79E-03	--(b)	6.86E-01	2.0

Table E-3. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Drinking Water Scenario Noncancer Hazard Results forRadiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
Nickel	0.018	--	5.03E-02	6.56E-04	--(b)	5.09E-02	0.15
Nitrate	133	--	1.07E+00	2.79E-03	--(b)	1.07E+00	3.2
Nitrite	0.11	--	2.00E-02	5.22E-05	--(b)	2.01E-02	0.060
Phenol	0.0020	--	3.81E-04	9.31E-06	--(b)	3.90E-04	0.0012
Selenium	0.023	--	2.64E-01	6.90E-04	--(b)	2.65E-01	0.79
Silver	0.0053	--	6.00E-02	2.35E-03	--(b)	6.23E-02	0.19
Strontium	0.26	--	2.47E-02	6.44E-05	--(b)	2.47E-02	0.074
Styrene	0.0025	Yes	7.14E-04	1.60E-04	3.02E-05	9.05E-04	0.0027
Sulfate	39	--	--	--	--(b)	--	
Tetrachloroethene	0.0010	Yes	5.71E-03	1.70E-03	4.48E-05	7.46E-03	0.022
Thallium	0.0050	--	--	--	--(b)	--	
Tin	0.0036	--	3.43E-04	8.95E-07	--(b)	3.44E-04	0.0010
Toluene	5.00E-04	Yes	3.57E-04	6.20E-05	1.21E-06	4.20E-04	0.0013
trans-1,3-Dichloropropene	0.0025	Yes	4.76E-03	1.30E-04	1.51E-03	6.40E-03	0.019
Tributyl phosphate	6.50E-04	--	1.86E-04	--	--(b)	1.86E-04	5.53E-04
Trichloroethene	0.0033	Yes	--	--	1.12E-03	1.12E-03	0.0033
Uranium	0.21	--	3.91E+00	1.02E-02	--(b)	3.92E+00	12
Vanadium	0.037	--	4.19E-01	1.09E-03	--(b)	4.21E-01	1.3
Xylenes (total)	5.00E-04	Yes	1.43E-04	4.65E-05	6.04E-05	2.50E-04	7.44E-04
Zinc	0.027	--	5.14E-03	8.05E-06	--(b)	5.15E-03	0.015
Hazard Index			**30**	**2.4**	**0.87**	**34**	**100**

E1.1.2 Use of Groundwater to Generate Steam for Sweat Lodge Use

Potential exposure to groundwater as steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater include inhalation of vaporized volatiles and semivolatiles and aerosolized nonvolatiles and dermal contact with vaporized volatiles, semivolatiles, and nonvolatiles and condensed liquid while spending time in a sweat lodge. Table E-4 provides a summary of the risk estimates by exposure route and exposure area. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in ECF-200UP1-10-0250.

The cumulative ELCR for the 200-UP-1 Groundwater OU is 3.6×10^{-2} for nonradiological COPCs and 1.2×10^{-3} for radiological COPCs, which is greater than the EPA upper target risk threshold of 1×10^{-4}.

Results in Table E-5 show the major contributors to ELCR are hexavalent chromium (3.5×10^{-2}; 95 percent contribution) and U-234 (6.9×10^{-4}; 1.8 percent contribution). Additional analytes that contribute less than one percent of the ELCR include technentium-99 (2.5×10^{-4}; 0.67 percent contribution), cobalt (2.1×10^{-4}; 0.55 percent contribution), carbon tetrachloride (1.4×10^{-4}; 0.37 percent contribution), U-238 (9.5×10^{-5}; 0.26 percent contribution), tritium (7.1×10^{-5}; 0.19 percent contribution), beryllium (4.0 x 10-5; 0.11 percent contribution) and nickel (3.8×10^{-5}; 0.10 percent contribution). In addition, contribution to ELCR are elevated for arsenic (2.4×10^{-4}; 0.64 percent contribution), where measured concentrations are within natural background values.

Table E-4. CTUIR Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge

Exposure Route	ELCR	HI
Nonradionuclide COPCs		
Inhalation in Sweat Lodge		
Volatile and Semivolatile (vapor)	1.6×10^{-4}	3.6
Nonvolatile (aerosol)	3.6×10^{-2}	27
Total	**3.6×10^{-2}**	**31**
Dermal Exposure in Sweat Lodge		
Volatile and Semivolatile (vapor only)	1.0×10^{-7}	<0.01
Nonvolatile (vapor and aqueous condensate)	2.5×10^{-6}	0.58
Total	**2.6×10^{-6}**	**0.59**
Total Nonradionuclide COPCs	**3.6×10^{-2}**	**31**
Radionuclide COPCs		
Inhalation in Sweat Lodge		
Volatile and Semivolatile (vapor)	7.1×10^{-5}	--
Nonvolatile (aerosol)	1.1×10^{-3}	--
Total Radionuclide COPCs	**1.2×10^{-3}**	--
Total ELCR*	**3.7×10^{-2}**	

* Sum of total ELCR values for nonradionuclide and radionuclide COPCs.

-- = HI is not applicable

COPC = contaminant of potential concern

ELCR = excess lifetime cancer risk

HI = hazard index

The HI is 31, which is greater than the EPA target HI of 1.0. Results in Table E-6 show the major contributors to HI are uranium (HQ = 5.9; 19 percent contribution), hexavalent chromium (HQ = 4.8;

15 percent contribution), cobalt (HQ = 3.9; 13 percent contribution), arsenic (HQ = 3.8; 12 percent contribution), acrolein (HQ = 3.5; 11 percent contribution), manganese (HQ = 3.1; 9.9 percent contribution),cadmium (HQ = 1.7; 5.6 percent contribution), nickel (HQ = 1.7; 5.4 percent contribution), and barium (HQ = 1.2; 3.8 percent contribution). Some of the metals concentrations (arsenic and cobalt) are within natural background values.

Table E-5. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,1,2-Trichloroethane	5.00E-04	VOC	3.87E-07	--	4.35E-11	--	--	3.87E-07	0.0010
1,1-Dichloroethane	5.00E-04	VOC	--	--	--	--	--	--	--
1,1-Dichloroethene	5.00E-04	VOC	--	--	--	--	--	--	--
1,2-Dichloroethane	5.00E-04	VOC	6.28E-07	--	4.56E-11	--	--	6.28E-07	0.0017
1,4-Dichlorobenzene	5.00E-04	VOC	2.66E-07	--	2.71E-11	--	--	2.66E-07	0.00071
1,4-Dioxane	0.0060	SVOC	2.23E-06	--	5.20E-12	--	--	2.23E-06	0.0060
2,3,4,6-Tetrachlorophenol	0.0014	SVOC	--	--	--	--	--	--	--
2-Butanone	9.00E-04	VOC	--	--	--	--	--	--	--
2-Butoxyethanol	0.066	SVOC	--	--	--	--	--	--	--
2-Pentanone, 4-Methyl	5.00E-04	VOC	--	--	--	--	--	--	--
4-Nitrophenol	0.0014	SVOC	--	--	--	--	--	--	--
Acetone	0.0031	VOC	--	--	--	--	--	--	--
Acrolein	0.0014	VOC	--	--	--	--	--	--	--
Aluminum	0.096	--	--	--	--	--	--	--	--
Antimony	0.028	--	--	--	--	--	--	--	--
Arsenic	0.0066	--	--	2.35E-04	--	2.47E-06	4.05E-10	2.38E-04	0.64
Barium	0.069	--	--	--	--	--	--	--	--
Benzene	5.00E-04	VOC	1.88E-07	--	9.84E-11	--	--	1.89E-07	0.00051

Table E-5. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Beryllium	0.0020	--	--	3.98E-05	--	--	--	3.98E-05	0.11
Bis(2-ethylhexyl) phthalate	0.0018	SVOC	2.09E-07	--	1.50E-10	--	--	2.09E-07	0.00056
Boron	0.055	--	--	--	--	--	--	--	--
Bromodichloromethane	0.0025	VOC	4.47E-06	--	1.70E-10	--	--	4.47E-06	0.012
Bromoform	0.0025	SVOC	1.33E-07	--	1.04E-11	--	--	1.33E-07	0.00036
Bromomethane	0.0050	VOC	--	--	--	--	--	--	--
Cadmium	0.0020	--	--	2.98E-05	--	--	--	2.98E-05	0.080
Carbon disulfide	5.00E-04	VOC	--	--	--	--	--	--	
Carbon tetrachloride	0.19	VOC	1.37E-04	--	9.35E-08	--	--	1.37E-04	0.37
Chloride	31	--	--	--	--	--	--	--	--
Chlorobenzene	0.0025	VOC	--	--	--	--	--	--	--
Chloroform	0.0072	VOC	7.95E-06	--	--	--	--	7.95E-06	0.021
Chromium	0.099	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethylene	5.00E-04	VOC	--	--	--	--	--	--	--
Cobalt	0.0028	--	--	2.05E-04	--	--	--	2.05E-04	0.55
Copper	0.0050	--	--	--	--	--	--	--	--
Cyanide	0.0024	VOC	--	--	--	--	--	--	--
Ethylbenzene	5.00E-04	VOC	6.04E-08	--	6.43E-11	--	--	6.05E-08	0.00016

Table E-5. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Fluoride	0.47	--	--	--	--	--	--	--	--
Hexavalent Chromium	0.052	--	--	3.54E-02	--	--	--	3.54E-02	95
Iron	0.41	--	--	--	--	--	--	--	--
Isobutyl alcohol	0.015	VOC	--	--	--	--	--	--	--
Lead	0.0037	--	--	--	--	--	--	--	--
Lithium	0.0089	--	--	--	--	--	--	--	--
Manganese	0.018	--	--	--	--	--	--	--	--
Mercury	5.00E-05	--	--	--	--	--	--	--	--
Methylene chloride	0.0011	VOC	2.38E-08	--	6.57E-12	--	--	2.38E-08	0.00006
Molybdenum	0.060	--	--	--	--	--	--	--	--
Nickel	0.018	--	--	3.79E-05	--	--	--	3.79E-05	0.10
Nitrate	133	--	--	--	--	--	--	--	--
Nitrite	0.11	--	--	--	--	--	--	--	--
Phenol	0.0020	SVOC	--	--	--	--	--	--	--
Selenium	0.023	--	--	--	--	--	--	--	--
Silver	0.0053	--	--	--	--	--	--	--	--
Strontium	0.26	--	--	--	--	--	--	--	--
Styrene	0.0025	VOC	--	--	--	--	--	--	--

Table E-5. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Sulfate	39	--	--	--	--	--	--	--	--
Tetrachloroethene	0.0010	VOC	2.85E-07	--	4.25E-09	--	--	2.89E-07	0.00078
Thallium	0.0050	--	--	--	--	--	--	--	--
Tin	0.0036	--	--	--	--	--	--	--	--
Toluene	5.00E-04	VOC	--	--	--	--	--	--	--
trans-1,3-Dichloropropene	0.0025	VOC	4.83E-07	--	2.56E-10	--	--	4.83E-07	0.0013
Tributyl phosphate	6.50E-04	SVOC	--	--	3.25E-11	--	--	3.25E-11	0.00000009
Trichloroethene	0.0033	VOC	3.93E-06	--	8.28E-10	--	--	3.93E-06	0.011
Uranium	0.21	--	--	--	--	--	--	--	--
Vanadium	0.037	--	--	--	--	--	--	--	--
Xylenes (total)	5.00E-04	VOC	--	--	--	--	--	--	--
Zinc	0.027	--	--	--	--	--	--	--	--
Carbon-14	14	--	--	4.13E-07			--	4.13E-07	0.0011
Gross alpha	4.1	--	--	--			--	--	--
Iodine-129	3.5	--	--	8.88E-07			--	8.88E-07	0.0024
Neptunium-237	0.039	--	--	2.94E-06			--	2.94E-06	0.0079
Protactinium-231	0.15	--	--	2.89E-05			--	2.89E-05	0.078
Selenium-79	56	--	--	7.95E-07			--	7.95E-07	0.0021

Table E-5. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Strontium-90	0.66	--	--	2.93E-07			--	2.93E-07	0.0008
Technetium-99	4,150	--	--	2.48E-04			--	2.48E-04	0.67
Tritium	51,150	VOC	7.10E-05	--			--	7.10E-05	0.19
Uranium-234	14	--	--	6.88E-04			--	6.88E-04	1.8
Uranium-235	0.68	--	--	2.91E-05			--	2.91E-05	0.078
Uranium-238	2.4	--	--	9.54E-05			--	9.54E-05	0.26
Total Cumulative ELCR			2.29E-04	3.70E-02	9.95E-08	2.47E-06	4.05E-10	3.73E-02	100

Table E-6. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
1,1,2-Trichloroethane	5.00E-04	VOC	--	--	1.96E-07	--	--	1.96E-07	6.31E-07
1,1-Dichloroethane	5.00E-04	VOC	3.55E-05	--	4.11E-09	--	--	3.55E-05	1.14E-04
1,1-Dichloroethene	5.00E-04	VOC	1.24E-04	--	2.95E-08	--	--	1.24E-04	4.00E-04
1,2-Dichloroethane	5.00E-04	VOC	1.04E-05	--	2.58E-08	--	--	1.04E-05	3.34E-05
1,4-Dichlorobenzene	5.00E-04	VOC	3.11E-05	--	7.37E-08	--	--	3.12E-05	1.00E-04
1,4-Dioxane	0.0060	SVOC	8.29E-05	--	4.86E-09	--	--	8.29E-05	2.66E-04
2,3,4,6-Tetrachlorophenol	0.0014	SVOC	--	--	8.14E-07	--	--	8.14E-07	2.61E-06
2-Butanone	9.00E-04	VOC	8.95E-06	--	3.54E-10	--	--	8.95E-06	2.88E-05
2-Butoxyethanol	0.066	SVOC	2.53E-04	--	3.89E-08	--	--	2.53E-04	8.12E-04
2-Pentanone, 4-Methyl	5.00E-04	VOC	8.29E-06	--	4.14E-09	--	--	8.29E-06	2.67E-05
4-Nitrophenol	0.0014	SVOC	--	--	2.06E-07	--	--	2.06E-07	6.63E-07
Acetone	0.0031	VOC	4.89E-06	--	4.26E-10	--	--	4.89E-06	1.57E-05
Acrolein	0.0014	VOC	3.48E+00	--	4.47E-07	--	--	3.48E+00	11
Aluminum	0.096	--	--	1.64E-01	--	2.48E-05	4.06E-09	1.64E-01	0.53
Antimony	0.028	--	--	--	--	1.20E-01	1.97E-05	1.20E-01	0.39
Arsenic	0.0066	--	--	3.76E+00	--	5.66E-03	9.27E-07	3.76E+00	12
Barium	0.069	--	--	1.17E+00	--	1.26E-03	2.07E-07	1.18E+00	3.8
Benzene	5.00E-04	VOC	8.29E-04	--	4.60E-07	--	--	8.29E-04	0.0027

Table E-6. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Beryllium	0.0020	--	--	8.53E-01	--	3.67E-02	6.02E-06	8.90E-01	2.9
Bis(2-ethylhexyl) phthalate	0.0018	SVOC	--	--	5.52E-07	--	--	5.52E-07	1.78E-06
Boron	0.055	--	--	2.36E-02	--	7.12E-05	1.17E-08	2.37E-02	0.076
Bromodichloromethane	0.0025	VOC	--	--	1.41E-07	--	--	1.41E-07	4.54E-07
Bromoform	0.0025	SVOC	--	--	6.75E-08	--	--	6.75E-08	2.17E-07
Bromomethane	0.0050	VOC	4.97E-02	--	2.46E-06	--	--	4.97E-02	0.16
Cadmium	0.0020	--	--	1.71E+00	--	2.06E-02	3.37E-06	1.73E+00	5.6
Carbon disulfide	5.00E-04	VOC	3.55E-05	--	2.09E-08	--	--	3.55E-05	1.14E-04
Carbon tetrachloride	0.19	VOC	4.93E-02	--	1.06E-03	--	--	5.04E-02	0.16
Chloride	31	--	--	--	--	--	--	--	
Chlorobenzene	0.0025	VOC	2.49E-03	--	8.59E-07	--	--	2.49E-03	0.0080
Chloroform	0.0072	VOC	3.63E-03	--	1.19E-06	--	--	3.63E-03	0.012
Chromium	0.099	--	--	--	--	1.31E-03	2.14E-07	1.31E-03	0.0042
cis-1,2-Dichloroethylene	5.00E-04	VOC	--	--	9.45E-08	--	--	9.45E-08	3.04E-07
Cobalt	0.0028	--	--	3.91E+00	--	9.43E-04	1.54E-07	3.91E+00	13
Copper	0.0050	--	--	--	--	3.21E-05	5.27E-09	3.21E-05	1.03E-04
Cyanide	0.0024	VOC	--	--	2.89E-08	--	--	2.89E-08	9.27E-08
Ethylbenzene	5.00E-04	VOC	2.49E-05	--	6.02E-08	--	--	2.49E-05	8.01E-05

Table E-6. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Fluoride	0.47	--	--	3.09E-01	--	2.01E-03	3.30E-07	3.11E-01	1.0
Hexavalent Chromium	0.052	--	--	4.42E+00	--	3.55E-01	5.81E-05	4.77E+00	15
Iron	0.41	--	--	--	--	1.49E-04	2.44E-08	1.49E-04	4.79E-04
Isobutyl alcohol	0.015	VOC	--	--	2.28E-08	--	--	2.28E-08	7.32E-08
Lead	0.0037	--	--	--	--	--	--	--	--
Lithium	0.0089	--	--	--	--	1.14E-03	1.86E-07	1.14E-03	0.0037
Manganese	0.018	--	--	3.08E+00	--	4.83E-03	7.92E-07	3.09E+00	9.9
Mercury	5.00E-05	--	--	1.42E-02	--	6.12E-04	1.00E-07	1.48E-02	0.048
Methylene chloride	0.0011	VOC	5.22E-05	--	1.50E-08	--	--	5.22E-05	1.68E-04
Molybdenum	0.060	--	--	--	--	3.08E-03	5.05E-07	3.08E-03	0.010
Nickel	0.018	--	--	1.67E+00	--	1.13E-03	1.85E-07	1.67E+00	5.4
Nitrate	133	--	--	--	--	4.82E-03	7.89E-07	4.82E-03	0.015
Nitrite	0.11	--	--	--	--	9.00E-05	1.47E-08	9.00E-05	2.89E-04
Phenol	0.0020	SVOC	4.97E-04	--	7.04E-09	--	--	4.97E-04	0.0016
Selenium	0.023	--	--	9.87E-03	--	1.19E-03	1.95E-07	1.11E-02	0.036
Silver	0.0053	--	--	--	--	4.05E-03	6.64E-07	4.05E-03	0.013
Strontium	0.26	--	--	--	--	1.11E-04	1.82E-08	1.11E-04	3.57E-04
Styrene	0.0025	VOC	1.24E-04	--	1.14E-07	--	--	1.24E-04	4.00E-04

Table E-6. 200-UP-1 OU Native American Risk Assessment--Summary of CTUIR Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Sulfate	39	--	--	--	--	--	--	--	--
Tetrachloroethene	0.0010	VOC	1.84E-04	--	8.10E-07	--	--	1.85E-04	5.95E-04
Thallium	0.0050	--	--	--	--	--	--	--	--
Tin	0.0036	--	--	--	--	1.54E-06	2.53E-10	1.54E-06	4.96E-06
Toluene	5.00E-04	VOC	4.97E-06	--	4.76E-08	--	--	5.02E-06	1.61E-05
trans-1,3-Dichloropropene	0.0025	VOC	6.22E-03	--	8.80E-08	--	--	6.22E-03	0.020
Tributyl phosphate	6.50E-04	SVOC	--	--	1.82E-08	--	--	1.82E-08	5.85E-08
Trichloroethene	0.0033	VOC	4.62E-03	--	--	--	--	4.62E-03	0.015
Uranium	0.21	--	--	5.85E+00	--	1.76E-02	2.89E-06	5.86E+00	19
Vanadium	0.037	--	--	--	--	1.89E-03	3.09E-07	1.89E-03	0.0061
Xylenes (total)	5.00E-04	VOC	2.49E-04	--	3.25E-08	--	--	2.49E-04	7.99E-04
Zinc	0.027	--	--	--	--	1.39E-05	2.28E-09	1.39E-05	4.46E-05
Total Hazard Index			3.6	27	0.0010	0.58	9.57E-05	31	100

E1.2 Summary of the Yakama Nation Risk Assessment

This section summarizes the results for each of the exposures associated with use of groundwater as a drinking water source and use of groundwater to generate steam in a sweat lodge.

E1.2.1 Use of Groundwater as a Potential Drinking Water Source

Potential exposure to groundwater as a drinking water source is evaluated under this scenario. Potential routes of exposure to groundwater include ingestion, dermal contact,[2] and inhalation of volatiles during household activities. Table E-7 provides a summary of the risk estimates by exposure route for the 200-UP-1 Groundwater OU. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in ECF-200UP1-10-0250.

Table E-7. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater as a Potential Drinking Water Source

Exposure Route	ELCR	HI
Nonradionuclide COPCs		
Ingestion	2.3×10^{-3}	30
Dermal	2.2×10^{-4}	2.4
Inhalation	3.9×10^{-5}	0.87
Total	**2.5×10^{-3}**	**34**
Radionuclide COPCs		
Ingestion	1.6×10^{-3}	--
Inhalation	2.4×10^{-5}	--
Total	**1.6×10^{-3}**	**--**
Total ELCR*	**4.1×10^{-3}**	**--**

* Sum of total ELCR values for nonradionuclides and radionuclides.

-- = HI is not applicable

COPC = contaminant of potential concern

ELCR = excess lifetime cancer risk

HI = hazard index

The cumulative ELCR is 2.5×10^{-3} for nonradiological COPCs and 1.6×10^{-3} for radiological COPCs, which is greater than the EPA upper target risk threshold of 1×10^{-4} (see Table E-8). Results in Table E-8 show the major contributors to ELCR are carbon tetrachloride (1.8×10^{-3}; 43 percent contribution), technetium-99 (1.1×10^{-3}; 27 percent contribution), tritium (2.8×10^{-4}; 6.7 percent contribution), iodine-129 (5.0×10^{-5}; 1.2 percent contribution), and tetrachloroethene (4.4×10^{-5}; 1.1 percent contribution); which have been identified as final COPCs in Section 6.1 of the RI report. Additional analytes that contribute greater than one percent of the ELCR include U-234 (9.9×10^{-5}; 2.4 percent contribution) and Se-79 (4.0×10^{-5}; 0.97 percent contribution). Se-79 and U-234 are not identified as final COPCs, however total uranium is identified as a final COPC and is discussed below. In addition,

[2] The dermal contact exposure route is only evaluated for nonradionuclide COPCs

contributions to ELCR are elevated for arsenic (6.3 x 10^{-4}; 15 percent contribution), where measured concentrations are within natural background values. Contributions from 1,4-dioxane (4.2 x 10^{-6}; 0.1 percent contribution), chloroform (1.7 x 10^{-5}; 0.4 percent contribution), and trichloroethene (2.1 x 10^{5}; 0.5 percent contribution) fall below 1 percent but they are indentified as final COPCs in Section 6.1 of the RI report based on their action levels and the localized measurements.

The HI is 34, which is greater than the EPA target HI of 1.0. Result in Table E-9 show the major contributors to HI are carbon tetrachloride (HQ = 17; 52 percent contribution), uranium (HQ = 3.9; 12 percent contribution), hexavalent chromium (HQ = 1.2; 3.5 percent contribution), and nitrate (HQ = 1.1; 3.2 percent contribution); which have been identified as final COPCs in Section 6.1 of the RI report. Additional analytes that contribute greater than 1 percent of the HI include acrolein (HQ = 1.0; 3.0 percent contribution), antimony (HQ = 4.1; 12 percent contribution), arsenic (HQ = 1.3; 3.8 percent contribution), cobalt (HQ = 0.52; 1.6 percent contribution), fluoride (HQ = 0.45; 1.3 percent contribution), molybdenum (HQ = 0.69; 2.0 percent contribution), and vanadium (HQ = 0.42; 1.3 percent contribution). Some of the metals concentrations (arsenic and cobalt) and fluoride are within natural background values. For antimony, the analytical method used for the measurements has a high MDL, making the data unreliable for risk characterization. As discussed In Section 6.1 of the RI report, acrolein is considered to be an anomalous measurement (one detection in 122 measurements; with about 5 years of non-detections at the same well where that detection was measured). Measurements of molybdenum greater than the action level (discussed in Section 6.1) are not associated with a trend or an exposure point. All detected vanadium concentrations and MDLs are consistently less than the action level.

Table E-8. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
1,1,2-Trichloroethane	5.00E-04	Yes	1.79E-06	8.29E-08	9.67E-08	1.97E-06	0.048
1,1-Dichloroethane	5.00E-04	Yes	--	--	--	--	--
1,1-Dichloroethene	5.00E-04	Yes	--	--	--	--	--
1,2-Dichloroethane	5.00E-04	Yes	2.86E-06	6.91E-08	1.57E-07	3.09E-06	0.075
1,4-Dichlorobenzene	5.00E-04	Yes	1.70E-07	5.61E-08	6.65E-08	2.93E-07	0.007
1,4-Dioxane	0.0060	--	4.16E-06	7.34E-09	--(b)	4.16E-06	0.10
2,3,4,6-Tetrachlorophenol	0.0014	--	--	--	--(b)	--	--
2-Butanone	9.00E-04	Yes	--	--	--	--	--
2-Butoxyethanol	0.066	--	--	--	--(b)	--	--
2-Pentanone, 4-Methyl	5.00E-04	Yes	--	--	--	--	--
4-Nitrophenol	0.0014	--	--	--	--(b)	--	--
Acetone	0.0031	Yes	--	--	--	--	--

Table E-8. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Acrolein	0.0014	Yes	--	--	--	--	--
Aluminum	0.096	--	--	--	--(b)	--	--
Antimony	0.028	--	--	--	--(b)	--	--
Arsenic	0.0066	--	6.23E-04	1.65E-06	--(b)	6.25E-04	15
Barium	0.069	--	--	--	--(b)	--	--
Benzene	5.00E-04	Yes	1.73E-06	1.30E-07	4.71E-08	1.91E-06	0.046
Beryllium	0.0020	--	--	--	--(b)	--	--
Bis(2-ethylhexyl) phthalate	0.0018	--	1.59E-06	1.21E-06	--(b)	2.79E-06	0.067
Boron	0.055	--	--	--	--(b)	--	--
Bromodichloromethane	0.0025	Yes	9.76E-06	3.92E-07	1.12E-06	1.13E-05	0.27
Bromoform	0.0025	--	1.24E-06	4.26E-08	--(b)	1.29E-06	0.031
Bromomethane	0.0050	Yes	--	--	--	--	--
Cadmium	0.0020	--	--	--	--(b)	--	--
Carbon disulfide	5.00E-04	Yes	--	--	--	--	--
Carbon tetrachloride	0.19	Yes	1.54E-03	2.03E-04	3.42E-05	1.78E-03	43
Chloride	31	--	--	--	--(b)	--	--
Chlorobenzene	0.0025	Yes	--	--	--	--	--
Chloroform	0.0072	Yes	1.40E-05	6.25E-07	1.99E-06	1.66E-05	0.40
Chromium	0.099	--	--	--	--(b)	--	--
cis-1,2-Dichloroethylene	5.00E-04	Yes	--	--	--	--	--
Cobalt	0.0028	--	--	--	--(b)	--	--
Copper	0.0050	--	--	--	--(b)	--	--
Cyanide	0.0024	Yes	--	--	--	--	--
Ethylbenzene	5.00E-04	Yes	3.46E-07	1.02E-07	1.51E-08	4.64E-07	0.011
Fluoride	0.47	--	--	--	--(b)	--	--
Hexavalent Chromium	0.052	--	--	--	--(b)	--	--

Table E-8. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Iron	0.41	--	--	--	--(b)	--	--
Isobutyl alcohol	0.015	Yes	--	--	--	--	--
Lead	0.0037	--	--	--	--(b)	--	--
Lithium	0.0089	--	--	--	--(b)	--	--
Manganese	0.018	--	--	--	--(b)	--	--
Mercury	5.00E-05	--	--	--	--(b)	--	--
Methylene chloride	0.0011	Yes	4.96E-07	9.15E-09	5.96E-09	5.11E-07	0.012
Molybdenum	0.060	--	--	--	--(b)	--	--
Nickel	0.018	--	--	--	--(b)	--	--
Nitrate	133	--	--	--	--(b)	--	--
Nitrite	0.11	--	--	--	--(b)	--	--
Phenol	0.0020	--	--	--	--(b)	--	--
Selenium	0.023	--	--	--	--(b)	--	--
Silver	0.0053	--	--	--	--(b)	--	--
Strontium	0.26	--	--	--	--(b)	--	--
Styrene	0.0025	Yes	--	--	--	--	--
Sulfate	39	--	--	--	--(b)	--	--
Tetrachloroethene	0.0010	Yes	3.40E-05	9.97E-06	7.13E-08	4.40E-05	1.1
Thallium	0.0050	--	--	--	--(b)	--	--
Tin	0.0036	--	--	--	--(b)	--	--
Toluene	5.00E-04	Yes	--	--	--	--	--
trans-1,3-Dichloropropene	0.0025	Yes	1.57E-05	4.23E-07	1.21E-07	1.63E-05	0.39
Tributyl phosphate	6.50E-04	--	3.76E-07	--	--(b)	3.76E-07	0.009
Trichloroethene	0.0033	Yes	1.82E-05	1.55E-06	9.82E-07	2.07E-05	0.50
Uranium	0.21	--	--	--	--(b)	--	--
Vanadium	0.037	--	--	--	--(b)	--	--
Xylenes (total)	5.00E-04	Yes	--	--	--	--	--

Table E-8. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Zinc	0.027	--	--	--	--(b)	--	--
Carbon-14	14	--	2.09E-06		--(b)	2.09E-06	0.051
Gross alpha	4.1	--	--		--(b)	--	--
Iodine-129	3.5	--	5.00E-05		--(b)	5.00E-05	1.2
Neptunium-237	0.039	--	2.37E-07		--(b)	2.37E-07	0.006
Protactinium-231	0.15	--	2.54E-06		--(b)	2.54E-06	0.061
Selenium-79	56	--	4.02E-05		--(b)	4.02E-05	0.97
Strontium-90	0.66	--	3.60E-06		--(b)	3.60E-06	0.087
Technetium-99	4,150	--	1.12E-03		--(b)	1.12E-03	27
Tritium	51,150	Yes	2.54E-04		2.37E-05	2.77E-04	6.7
Uranium-234	14	--	9.86E-05		--(b)	9.86E-05	2.38
Uranium-235	0.68	--	4.63E-06		--(b)	4.63E-06	0.11
Uranium-238	2.4	--	1.51E-05		--(b)	1.51E-05	0.37
Total Cumulative ELCR			3.86E-03	2.19E-04	6.25E-05	4.14E-03	100

Table E-9. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
1,1,2-Trichloroethane	5.00E-04	Yes	7.14E-03	3.35E-04	--	7.48E-03	0.022
1,1-Dichloroethane	5.00E-04	Yes	1.43E-04	5.59E-06	8.63E-06	1.57E-04	4.68E-04
1,1-Dichloroethene	5.00E-04	Yes	5.71E-04	3.95E-05	3.02E-05	6.41E-04	0.0019
1,2-Dichloroethane	5.00E-04	Yes	1.43E-03	3.50E-05	2.52E-06	1.47E-03	0.0044

Table E-9. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
1,4-Dichlorobenzene	5.00E-04	Yes	4.08E-04	1.37E-04	7.55E-06	5.53E-04	0.0016
1,4-Dioxane	0.0060	--	3.43E-03	6.16E-06	--(b)	3.43E-03	0.010
2,3,4,6-Tetrachlorophenol	0.0014	--	2.67E-03	--	--(b)	2.67E-03	0.0079
2-Butanone	9.00E-04	Yes	8.57E-05	4.05E-07	2.18E-06	8.83E-05	2.63E-04
2-Butoxyethanol	0.066	--	7.54E-03	6.00E-05	--(b)	7.60E-03	0.023
2-Pentanone, 4-Methyl	5.00E-04	Yes	3.57E-04	5.70E-06	2.01E-06	3.65E-04	0.0011
4-Nitrophenol	0.0014	--	1.00E-02	3.64E-04	--(b)	1.04E-02	0.031
Acetone	0.0031	Yes	1.94E-04	--	1.19E-06	1.95E-04	5.80E-04
Acrolein	0.0014	Yes	1.60E-01	4.77E-04	8.46E-01	1.01E+00	3.0
Aluminum	0.096	--	5.50E-03	1.44E-05	--(b)	5.51E-03	0.016
Antimony	0.028	--	4.00E+00	6.96E-02	--(b)	4.07E+00	12
Arsenic	0.0066	--	1.26E+00	3.28E-03	--(b)	1.26E+00	3.8
Barium	0.069	--	1.97E-02	7.33E-04	--(b)	2.04E-02	0.061
Benzene	5.00E-04	Yes	7.14E-03	5.47E-04	2.01E-04	7.89E-03	0.023
Beryllium	0.0020	--	5.71E-02	2.13E-02	--(b)	7.84E-02	0.23
Bis(2-ethylhexyl) phthalate	0.0018	--	5.14E-03	3.97E-03	--(b)	9.12E-03	0.027
Boron	0.055	--	1.58E-02	4.13E-05	--(b)	1.59E-02	0.047
Bromodichloromethane	0.0025	Yes	7.14E-03	2.92E-04	--	7.43E-03	0.022
Bromoform	0.0025	--	7.14E-03	2.49E-04	--(b)	7.39E-03	0.022
Bromomethane	0.0050	Yes	2.04E-01	3.25E-03	1.21E-02	2.19E-01	0.65
Cadmium	0.0020	--	2.29E-01	1.19E-02	--(b)	2.41E-01	0.72
Carbon disulfide	5.00E-04	Yes	2.86E-04	2.52E-05	8.63E-06	3.20E-04	9.52E-04
Carbon tetrachloride	0.19	Yes	1.54E+01	2.06E+00	1.20E-02	1.75E+01	52
Chloride	31	--	--	--	--(b)	--	
Chlorobenzene	0.0025	Yes	7.14E-03	1.28E-03	6.04E-04	9.03E-03	0.027

Table E-9. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
Chloroform	0.0072	Yes	4.09E-02	1.86E-03	8.82E-04	4.36E-02	0.13
Chromium	0.099	--	3.78E-03	7.58E-04	--(b)	4.54E-03	0.014
cis-1,2-Dichloroethylene	5.00E-04	Yes	2.86E-03	1.27E-04	--	2.98E-03	0.0089
Cobalt	0.0028	--	5.24E-01	5.47E-04	--(b)	5.24E-01	1.6
Copper	0.0050	--	7.14E-03	1.86E-05	--(b)	7.16E-03	0.021
Cyanide	0.0024	Yes	6.71E-03	1.75E-05	--	6.73E-03	0.020
Ethylbenzene	5.00E-04	Yes	2.86E-04	8.59E-05	6.04E-06	3.78E-04	0.0011
Fluoride	0.47	--	4.48E-01	1.17E-03	--(b)	4.49E-01	1.3
Hexavalent Chromium	0.052	--	9.86E-01	2.06E-01	--(b)	1.19E+00	3.5
Iron	0.41	--	3.31E-02	8.64E-05	--(b)	3.32E-02	0.099
Isobutyl alcohol	0.015	Yes	2.76E-03	--	--	2.76E-03	0.0082
Lead	0.0037	--	--	--	--(b)	--	
Lithium	0.0089	--	2.53E-01	6.60E-04	--(b)	2.54E-01	0.75
Manganese	0.018	--	4.30E-02	2.80E-03	--(b)	4.58E-02	0.14
Mercury	5.00E-05	--	9.52E-03	3.55E-04	--(b)	9.88E-03	0.029
Methylene chloride	0.0011	Yes	1.00E-03	1.88E-05	1.27E-05	1.03E-03	0.0031
Molybdenum	0.060	--	6.85E-01	1.79E-03	--(b)	6.86E-01	2.0
Nickel	0.018	--	5.03E-02	6.56E-04	--(b)	5.09E-02	0.15
Nitrate	133	--	1.07E+00	2.79E-03	--(b)	1.07E+00	3.2
Nitrite	0.11	--	2.00E-02	5.22E-05	--(b)	2.01E-02	0.060
Phenol	0.0020	--	3.81E-04	9.31E-06	--(b)	3.90E-04	0.0012
Selenium	0.023	--	2.64E-01	6.90E-04	--(b)	2.65E-01	0.79
Silver	0.0053	--	6.00E-02	2.35E-03	--(b)	6.23E-02	0.19
Strontium	0.26	--	2.47E-02	6.44E-05	--(b)	2.47E-02	0.074
Styrene	0.0025	Yes	7.14E-04	1.60E-04	3.02E-05	9.05E-04	0.0027

Table E-9. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Drinking Water Scenario Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile[a]	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
Sulfate	39	--	--	--	--(b)	--	
Tetrachloroethene	0.0010	Yes	5.71E-03	1.70E-03	4.48E-05	7.46E-03	0.022
Thallium	0.0050	--	--	--	--(b)	--	
Tin	0.0036	--	3.43E-04	8.95E-07	--(b)	3.44E-04	0.0010
Toluene	5.00E-04	Yes	3.57E-04	6.20E-05	1.21E-06	4.20E-04	0.0013
trans-1,3-Dichloropropene	0.0025	Yes	4.76E-03	1.30E-04	1.51E-03	6.40E-03	0.019
Tributyl phosphate	6.50E-04	--	1.86E-04	--	--(b)	1.86E-04	5.53E-04
Trichloroethene	0.0033	Yes	--	--	1.12E-03	1.12E-03	0.0033
Uranium	0.21	--	3.91E+00	1.02E-02	--(b)	3.92E+00	12
Vanadium	0.037	--	4.19E-01	1.09E-03	--(b)	4.21E-01	1.3
Xylenes (total)	5.00E-04	Yes	1.43E-04	4.65E-05	6.04E-05	2.50E-04	7.44E-04
Zinc	0.027	--	5.14E-03	8.05E-06	--(b)	5.15E-03	0.015
Hazard Index			**30**	**2.4**	**0.87**	**34**	**100**

E1.2.2 Use of Groundwater to Generate Steam for Sweat Lodge Use

Potential exposure to groundwater as steam in a sweat lodge is evaluated under this scenario. Potential routes of exposure to steam generated from groundwater include inhalation of vaporized volatiles and semivolatiles and aerosolized nonvolatiles and dermal contact with vaporized volatiles, semivolatiles, and nonvolatiles and condensed liquid while spending time in a sweat lodge. Table E-10 provides a summary of the risk estimates by exposure route and exposure area. Additional detail including COPC-specific risk contributions is provided in the calculation spreadsheets presented in ECF-200UP1-10-0250.

The cumulative ELCR for the 200-UP-1 Groundwater OU is 7.4×10^{-2} for nonradiological COPCs and 2.4×10^{-3} for radiological COPCs, which is greater than the EPA upper target risk threshold of 1×10^{-4}. Results in Table E-11 show the major contributors to ELCR are hexavalent chromium (7.2×10^{-2}; 95 percent contribution) and U-234 (1.4×10^{-3}; 1.9 percent contribution). Additional analytes that contribute less than one percent of the ELCR include technetium-99 (5.2×10^{-4}; 0.68 percent contribution), cobalt (4.3×10^{-4}; 0.56 percent contribution), carbon tetrachloride (2.8×10^{-4}; 0.37 percent contribution), U-238 (2.0×10^{-4}; 0.26 percent contribution), tritium (1.5×10^{-3}; 0.19 percent contribution), beryllium (8.3×10^{5}; 0.11 percent contribution) and nickel (7.9×10^{-5}; 0.10 percent contribution). In addition, contribution to

ELCR are elevated for arsenic (4.9×10^{-4}; 0.65 percent contribution), where measured concentrations are within natural background values.

The HI is 65, which is greater than the EPA target HI of 1.0. Results in Table E-12 show the major contributors to HI are uranium (HQ = 12; 19 percent contribution), hexavalent chromium (HQ = 9.9; 15 percent contribution), cobalt (HQ = 8.1; 13 percent contribution), arsenic (HQ = 7.8; 12 percent contribution), acrolein (HQ = 7.2; 11 percent contribution), manganese (HQ = 6.4; 9.9 percent contribution), cadmium (HQ = 3.6; 5.6 percent contribution), nickel (HQ = 3.5; 5.4 percent contribution), and barium (HQ = 2.4; 3.8 percent contribution). Some of the metals concentrations (arsenic and cobalt) are within natural background values.

Table E-10. Yakama Nation Exposure Scenario—Summary of Risk Estimates from Use of Groundwater in a Sweat Lodge

Exposure Route	ELCR	HI
Nonradionuclide COPCs		
Inhalation in Sweat Lodge		
Volatile and Semivolatile (vapor)	3.3×10^{-4}	7.5
Nonvolatile (aerosol)	7.3×10^{-2}	56
Total	**7.4×10^{-2}**	**64**
Dermal Exposure in Sweat Lodge		
Volatile and Semivolatile (vapor only)	2.0×10^{-7}	<0.01
Nonvolatile (vapor and aqueous condensate)	4.9×10^{-6}	1.2
Total	**5.1×10^{-6}**	**1.2**
Total Nonradionuclide COPCs	**7.4×10^{-2}**	**65**
Radionuclide COPCs		
Inhalation in Sweat Lodge		
Volatile and Semivolatile (vapor)	1.5×10^{-4}	--
Nonvolatile (aerosol)	2.3×10^{-3}	--
Total Radionuclide COPCs	**2.4×10^{-3}**	**--**
Total ELCR*	**7.6×10^{-2}**	**--**

* Sum of total ELCR values for nonradionuclide and radionuclide COPCs.

-- = HI is not applicable

COPC = contaminant of potential concern

ELCR = excess lifetime cancer risk

HI = hazard index

Table E-11. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
1,1,2-Trichloroethane	5.00E-04	VOC	8.04E-07	--	8.70E-11	--	--	8.04E-07	0.0011
1,1-Dichloroethane	5.00E-04	VOC	--	--	--	--	--	--	--
1,1-Dichloroethene	5.00E-04	VOC	--	--	--	--	--	--	--
1,2-Dichloroethane	5.00E-04	VOC	1.31E-06	--	9.12E-11	--	--	1.31E-06	0.0017
1,4-Dichlorobenzene	5.00E-04	VOC	5.53E-07	--	5.41E-11	--	--	5.53E-07	0.0007
1,4-Dioxane	0.0060	SVOC	4.64E-06	--	1.04E-11	--	--	4.64E-06	0.0061
2,3,4,6-Tetrachlorophenol	0.0014	SVOC	--	--	--	--	--	--	--
2-Butanone	9.00E-04	VOC	--	--	--	--	--	--	--
2-Butoxyethanol	0.066	SVOC	--	--	--	--	--	--	--
2-Pentanone, 4-Methyl	5.00E-04	VOC	--	--	--	--	--	--	--
4-Nitrophenol	0.0014	SVOC	--	--	--	--	--	--	--
Acetone	0.0031	VOC	--	--	--	--	--	--	--
Acrolein	0.0014	VOC	--	--	--	--	--	--	--
Aluminum	0.096	--	--	--	--	--	--	--	--
Antimony	0.028	--	--	--	--	--	--	--	--
Arsenic	0.0066	--	--	4.89E-04	--	4.95E-06	8.10E-10	4.94E-04	0.65
Barium	0.069	--	--	--	--	--	--	--	--
Benzene	5.00E-04	VOC	3.92E-07	--	1.97E-10	--	--	3.92E-07	0.0005
Beryllium	0.0020	--	--	8.28E-05	--	--	--	8.28E-05	0.11
Bis(2-ethylhexyl) phthalate	0.0018	SVOC	4.34E-07	--	3.01E-10	--	--	4.34E-07	0.0006

Table E-11. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Boron	0.055	--	--	--	--	--	--	--	--
Bromodichloromethane	0.0025	VOC	9.30E-06	--	3.40E-10	--	--	9.30E-06	0.012
Bromoform	0.0025	SVOC	2.76E-07	--	2.07E-11	--	--	2.76E-07	3.63E-04
Bromomethane	0.0050	VOC	--	--	--	--	--	--	--
Cadmium	0.0020	--	--	6.21E-05	--	--	--	6.21E-05	0.082
Carbon disulfide	5.00E-04	VOC	--	--	--	--	--	--	--
Carbon tetrachloride	0.19	VOC	2.84E-04	--	1.87E-07	--	--	2.84E-04	0.37
Chloride	31	--	--	--	--	--	--	--	--
Chlorobenzene	0.0025	VOC	--	--	--	--	--	--	--
Chloroform	0.0072	VOC	1.65E-05	--	--	--	--	1.65E-05	0.022
Chromium	0.099	--	--	--	--	--	--	--	--
cis-1,2-Dichloroethylene	5.00E-04	VOC	--	--	--	--	--	--	--
Cobalt	0.0028	--	--	4.27E-04	--	--	--	4.27E-04	0.56
Copper	0.0050	--	--	--	--	--	--	--	--
Cyanide	0.0024	VOC	--	--	--	--	--	--	--
Ethylbenzene	5.00E-04	VOC	1.26E-07	--	1.29E-10	--	--	1.26E-07	1.65E-04
Fluoride	0.47	--	--	--	--	--	--	--	--
Hexavalent Chromium	0.052	--	--	7.22E-02	--	--	--	7.22E-02	95
Iron	0.41	--	--	--	--	--	--	--	--
Isobutyl alcohol	0.015	VOC	--	--	--	--	--	--	--

Table E-11. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Lead	0.0037	--	--	--	--	--	--	--	--
Lithium	0.0089	--	--	--	--	--	--	--	--
Manganese	0.018	--	--	--	--	--	--	--	--
Mercury	5.00E-05	--	--	--	--	--	--	--	--
Methylene chloride	0.0011	VOC	4.96E-08	--	1.31E-11	--	--	4.96E-08	6.52E-05
Molybdenum	0.060	--	--	--	--	--	--	--	--
Nickel	0.018	--	--	7.89E-05	--	--	--	7.89E-05	0.10
Nitrate	133	--	--	--	--	--	--	--	--
Nitrite	0.11	--	--	--	--	--	--	--	--
Phenol	0.0020	SVOC	--	--	--	--	--	--	--
Selenium	0.023	--	--	--	--	--	--	--	--
Silver	0.0053	--	--	--	--	--	--	--	--
Strontium	0.26	--	--	--	--	--	--	--	--
Styrene	0.0025	VOC	--	--	--	--	--	--	--
Sulfate	39	--	--	--	--	--	--	--	--
Tetrachloroethene	0.0010	VOC	5.93E-07	--	8.50E-09	--	--	6.01E-07	0.0008
Thallium	0.0050	--	--	--	--	--	--	--	--
Tin	0.0036	--	--	--	--	--	--	--	--
Toluene	5.00E-04	VOC	--	--	--	--	--	--	--
trans-1,3-Dichloropropene	0.0025	VOC	1.00E-06	--	5.13E-10	--	--	1.01E-06	0.0013

Table E-11. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Results for Nonradiological and Radiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	Risk (Inhalation) (VOCs and SVOCs)	Risk (Inhalation) (Nonvolatiles)	Risk (Dermal, Vapor, VOCs and SVOCs)	Risk (Dermal, Liquid, Nonvolatiles)	Risk (Dermal, Vapor, Nonvolatiles)	Total Risk	% Contribution
Tributyl phosphate	6.50E-04	SVOC	--	--	6.50E-11	--	--	6.50E-11	8.55E-08
Trichloroethene	0.0033	VOC	8.17E-06	--	1.66E-09	--	--	8.17E-06	0.011
Uranium	0.21	--	--	--	--	--	--	--	--
Vanadium	0.037	--	--	--	--	--	--	--	--
Xylenes (total)	5.00E-04	VOC	--	--	--	--	--	--	--
Zinc	0.027	--	--	--	--	--	--	--	--
Carbon-14	14	--	--	8.60E-07	--	--	--	8.60E-07	0.0011
Gross alpha	4.1	--	--	--	--	--	--	--	--
Iodine-129	3.5	--	--	1.85E-06	--	--	--	1.85E-06	0.0024
Neptunium-237	0.039	--	--	6.12E-06	--	--	--	6.12E-06	0.0080
Protactinium-231	0.15	--	--	6.01E-05	--	--	--	6.01E-05	0.079
Selenium-79	56	--	--	1.65E-06	--	--	--	1.65E-06	0.0022
Strontium-90	0.66	--	--	6.09E-07	--	--	--	6.09E-07	0.0008
Technetium-99	4,150	--	--	5.16E-04	--	--	--	5.16E-04	0.68
Tritium	51,150	VOC	1.48E-04	--	--	--	--	1.48E-04	0.19
Uranium-234	14	--	--	1.43E-03	--	--	--	1.43E-03	1.9
Uranium-235	0.68	--	--	6.05E-05	--	--	--	6.05E-05	0.079
Uranium-238	2.4	--	--	1.98E-04	--	--	--	1.98E-04	0.26
Total Cumulative ELCR			4.76E-04	7.56E-02	1.99E-07	4.95E-06	8.10E-10	7.61E-02	100

Table E-12. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
1,1,2-Trichloroethane	5.00E-04	VOC	--	--	3.93E-07	--	--	3.93E-07	6.07E-07
1,1-Dichloroethane	5.00E-04	VOC	7.39E-05	--	8.23E-09	--	--	7.39E-05	1.14E-04
1,1-Dichloroethene	5.00E-04	VOC	2.59E-04	--	5.89E-08	--	--	2.59E-04	4.00E-04
1,2-Dichloroethane	5.00E-04	VOC	2.16E-05	--	5.16E-08	--	--	2.16E-05	3.34E-05
1,4-Dichlorobenzene	5.00E-04	VOC	6.47E-05	--	1.47E-07	--	--	6.48E-05	1.00E-04
1,4-Dioxane	0.0060	SVOC	1.72E-04	--	9.72E-09	--	--	1.72E-04	2.67E-04
2,3,4,6-Tetrachlorophenol	0.0014	SVOC	--	--	1.63E-06	--	--	1.63E-06	2.52E-06
2-Butanone	9.00E-04	VOC	1.86E-05	--	7.07E-10	--	--	1.86E-05	2.88E-05
2-Butoxyethanol	0.066	SVOC	5.25E-04	--	7.78E-08	--	--	5.25E-04	8.12E-04
2-Pentanone, 4-Methyl	5.00E-04	VOC	1.72E-05	--	8.29E-09	--	--	1.73E-05	2.67E-05
4-Nitrophenol	0.0014	SVOC	--	--	4.13E-07	--	--	4.13E-07	6.38E-07
Acetone	0.0031	VOC	1.02E-05	--	8.52E-10	--	--	1.02E-05	1.57E-05
Acrolein	0.0014	VOC	7.24E+00	--	8.94E-07	--	--	7.24E+00	11
Aluminum	0.096	--	--	0.34	--	4.95E-05	8.11E-09	3.42E-01	0.53
Antimony	0.028	--	--	--	--	2.40E-01	3.93E-05	2.40E-01	0.37
Arsenic	0.0066	--	--	7.81	--	1.13E-02	1.85E-06	7.82E+00	12
Barium	0.069	--	--	2.44	--	2.53E-03	4.14E-07	2.45E+00	3.8

Table E-12. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Benzene	5.00E-04	VOC	1.72E-03	--	9.21E-07	--	--	1.73E-03	0.0027
Beryllium	0.0020	--	--	1.78	--	7.35E-02	1.20E-05	1.85E+00	2.9
Bis(2-ethylhexyl) phthalate	0.0018	SVOC	--	--	1.10E-06	--	--	1.10E-06	1.71E-06
Boron	0.055	--	--	0.05	--	1.42E-04	2.33E-08	4.93E-02	0.076
Bromodichloromethane	0.0025	VOC	--	--	2.82E-07	--	--	2.82E-07	4.37E-07
Bromoform	0.0025	SVOC	--	--	1.35E-07	--	--	1.35E-07	2.09E-07
Bromomethane	0.0050	VOC	1.03E-01	--	4.91E-06	--	--	1.03E-01	0.16
Cadmium	0.0020	--	--	3.55	--	4.11E-02	6.74E-06	3.59E+00	5.6
Carbon disulfide	5.00E-04	VOC	7.39E-05	--	4.17E-08	--	--	7.39E-05	1.14E-04
Carbon tetrachloride	0.19	VOC	1.03E-01	--	2.12E-03	--	--	1.05E-01	0.16
Chloride	31	--	--	--	--	--	--	--	--
Chlorobenzene	0.0025	VOC	5.17E-03	--	1.72E-06	--	--	5.17E-03	0.0080
Chloroform	0.0072	VOC	7.55E-03	--	2.39E-06	--	--	7.55E-03	0.012
Chromium	0.099	--	--	--	--	2.61E-03	4.28E-07	2.62E-03	0.0040
cis-1,2-Dichloroethylene	5.00E-04	VOC	--	--	1.89E-07	--	--	1.89E-07	2.92E-07
Cobalt	0.0028	--	--	8.14	--	1.89E-03	3.09E-07	8.14E+00	13
Copper	0.0050	--	--	--	--	6.43E-05	1.05E-08	6.43E-05	9.94E-05

Table E-12. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Cyanide	0.0024	VOC	--	--	5.77E-08	--	--	5.77E-08	8.92E-08
Ethylbenzene	5.00E-04	VOC	5.17E-05	--	1.20E-07	--	--	5.18E-05	8.02E-05
Fluoride	0.47	--	--	0.64	--	4.03E-03	6.60E-07	6.46E-01	1.0
Hexavalent Chromium	0.052	--	--	9.19	--	7.10E-01	1.16E-04	9.90E+00	15
Iron	0.41	--	--	--	--	2.98E-04	4.88E-08	2.98E-04	4.61E-04
Isobutyl alcohol	0.015	VOC	--	--	4.56E-08	--	--	4.56E-08	7.05E-08
Lead	0.0037	--	--	--	--	--	--	--	--
Lithium	0.0089	--	--	--	--	2.28E-03	3.73E-07	2.28E-03	0.0035
Manganese	0.018	--	--	6.41	--	9.67E-03	1.58E-06	6.42E+00	9.9
Mercury	5.00E-05	--	--	0.03	--	1.22E-03	2.01E-07	3.08E-02	0.048
Methylene chloride	0.0011	VOC	1.09E-04	--	3.01E-08	--	--	1.09E-04	1.68E-04
Molybdenum	0.060	--	--	--	--	6.16E-03	1.01E-06	6.16E-03	0.010
Nickel	0.018	--	--	3.47	--	2.26E-03	3.71E-07	3.47E+00	5.4
Nitrate	133	--	--	--	--	9.63E-03	1.58E-06	9.64E-03	0.015
Nitrite	0.11	--	--	--	--	1.80E-04	2.95E-08	1.80E-04	2.78E-04
Phenol	0.0020	SVOC	1.03E-03	--	1.41E-08	--	--	1.03E-03	0.0016
Selenium	0.023	--	--	0.02	--	2.38E-03	3.90E-07	2.29E-02	0.035
Silver	0.0053	--	--	--	--	8.10E-03	1.33E-06	8.10E-03	0.013

Table E-12. 200-UP-1 OU Native American Risk Assessment--Summary of Yakama Nation Sweat Lodge Scenario Risk Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90th Percentile Concentration in Groundwater (mg/L or pCi/L)	VOC/SVOC	HQ (Inhalation) (VOCs and SVOCs)	HQ (Inhalation) (Nonvolatiles)	HQ (Dermal, Vapor, VOCs and SVOCs)	HQ (Dermal, Liquid, Nonvolatiles)	HQ (Dermal, Vapor, Nonvolatiles)	Total HI	% Contribution
Strontium	0.26	--	--	--	--	2.22E-04	3.64E-08	2.22E-04	3.43E-04
Styrene	0.0025	VOC	2.59E-04	--	2.27E-07	--	--	2.59E-04	4.00E-04
Sulfate	39	--	--	--	--	--	--	--	--
Tetrachloroethene	0.0010	VOC	3.83E-04	--	1.62E-06	--	--	3.85E-04	5.95E-04
Thallium	0.0050	--	--	--	--	--	--	--	--
Tin	0.0036	--	--	--	--	3.09E-06	5.06E-10	3.09E-06	4.77E-06
Toluene	5.00E-04	VOC	1.03E-05	--	9.52E-08	--	--	1.04E-05	1.61E-05
trans-1,3-Dichloropropene	0.0025	VOC	1.29E-02	--	1.76E-07	--	--	1.29E-02	0.020
Tributyl phosphate	6.50E-04	SVOC	--	--	3.64E-08	--	--	3.64E-08	5.63E-08
Trichloroethene	0.0033	VOC	9.61E-03	--	--	--	--	9.61E-03	0.015
Uranium	0.21	--	--	12.16	--	3.52E-02	5.77E-06	1.22E+01	19
Vanadium	0.037	--	--	--	--	3.77E-03	6.19E-07	3.78E-03	0.0058
Xylenes (total)	5.00E-04	VOC	5.17E-04	--	6.51E-08	--	--	5.17E-04	8.00E-04
Zinc	0.027	--	--	--	--	2.78E-05	4.55E-09	2.78E-05	4.29E-05
Total Hazard Index			7.5	56	0.0021	1.2	1.91E-04	65	100

E1.3 Comparison of Native American and EPA Tap Water Scenario Risk Estimates

A summary of the risk estimates and hazard indices for each of the Native American Scenarios and the EPA tap water scenario is provided in Table E-13. Results are provided for the ingestion, dermal contact, and inhalation of volatiles during household activities exposure routes.

Exposure parameters for the Native American exposure scenarios and the EPA tap water scenario differ in exposure frequency (Native American 365 day/yr; EPA tap water 350 day/yr); exposure duration (Native American 70 years; EPA tap water 30 years); drinking water ingestion rate (Native American 4 L/day [1 gal/day]; EPA tap water 2 L/day [0.5 gal/day]); and inhalation rate (CTUIR 25 m^3/day [883 ft^3/day], Yakama Nation 26 m^3/day [918 ft^3/day]; EPA tap water 20 m^3/day [706 ft^3/day]). As a result, the EPA tap water scenario has a lower total ELCR and HI than the Native American exposure scenarios.

The total cumulative ELCRs for the CTUIR and the Yakama Nation exposure scenarios are 3.9×10^{-3} and 4.1×10^{-3}, respectively. The total ELCR for the EPA tap water scenario is 9.7×10^{-4}. All scenarios are greater than the EPA upper target risk threshold of 1×10^{-4} (see Table E-13). Contributors to risk for the Native American scenarios and EPA tap water scenario are carbon tetrachloride, technentium-99, tritium, iodine-129, tetrachloroethene, U-234, Se-79, 1,4-dioxane, chloroform, and trichloroethene. The total HI is 34 for both the CTUIR and Yakama Nation exposure scenarios. The HI for the EPA tap water scenario is 18. Carbon tetrachloride, nitrate, and uranium are the primary contributors to the non-cancer HI for the Native American scenarios and the EPA tap water exposure scenario.

This page intentionally left blank.

Table E-13. Comparison of Risk Estimates and Hazard Indices for the CTUIR, Yakama Nation, and EPA Tap Water Equations

Exposure Scenario	COPC Type	Drinking Water Ingestion		Inhalation of Volatiles		Dermal Contact with Water		Total			
		ELCR	Hazard Index	ELCR	Hazard Index	ELCR	Hazard Index	ELCR	Primary Contributors to Risk	Hazard Index	Primary Contributors to Hazard Index
CTUIR	Nonradiological	2.1×10^{-3}	30	3.9×10^{-5}	0.87	2.2×10^{-4}	2.4	2.4×10^{-3}	1,4-Dioxane, **Carbon Tetrachloride**, Chloroform, I-129, Sr-90, **H3**, PCE,TCE, **Tc-99,** Se-79, U-234	**34**	**Carbon Tetrachloride, Cr(VI), Nitrate, Uranium**
	Radiological	1.6×10^{-3}	--	2.3×10^{-5}	--	--	--	1.6×10^{-3}		--	
	Total	3.6×10^{-3}	30	6.2×10^{-5}	0.87	2.2×10^{-4}	2.4	3.9×10^{-3}		**34**	
Yakama Nation	Nonradiological	2.3×10^{-3}	30	3.9×10^{-5}	0.87	2.2×10^{-4}	2.4	2.5×10^{-3}	1,4-Dioxane, **Carbon Tetrachloride**, Chloroform, I-129, Sr-90, **H3**, PCE,TCE, **Tc-99,** Se-79, U-234	**34**	**Carbon Tetrachloride, Cr(VI), Nitrate, Uranium**
	Radiological	1.6×10^{-3}	--	2.4×10^{-5}	--	--	--	1.6×10^{-3}		--	
	Total	3.9×10^{-3}	30	6.3×10^{-5}	0.87	2.4×10^{-4}	2.4	4.1×10^{-3}		**34**	
EPA Tap Water	Nonradiological	5.4×10^{-4}	15	1.6×10^{-5}	0.84	1.0×10^{-4}	2.3	6.5×10^{-4}	1,4-Dioxane, **Carbon Tetrachloride**, Chloroform, I-129, Sr-90, H3, PCE, TCE, **Tc-99,** Se-79, U-234	**18**	**Carbon Tetrachloride**
	Radiological	3.1×10^{-4}	--	7.5×10^{-6}	--	--	--	3.1×10^{-4}		--	
	Total	8.4×10^{-4}	15	2.3×10^{-5}	0.84	1.0×10^{-4}	2.3	9.7×10^{-4}		**18**	

Notes: Bolded COPCs indicate that the individual ELCR is greater than 1×10^{-4} or has a hazard quotient greater than 1.

COPC = contaminant of potential concern

CTUIR = Confederated Tribes of the Umatilla Indian Reservation

ELCR = excess lifetime cancer risk

EPA = U.S. Environmental Protection Agency

H_3 = tritium

PCE = tetrachloroethene

TCE = trichloroethene

This page intentionally left blank.