

VET-1405-RPT-001

US Ecology Low-Level Radioactive Waste Disposal Site

Final Remedial Investigation Report

Revision: 0

Issue Date: July 14, 2010

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Executive Summary

The Data Quality Objective (DQO) Summary Report communicated the preliminary conceptual site model thus guiding the development of the Scope of Work (SOW) and the Sampling and Analysis Plan (SAP). Generally, this conceptual site model suggests that chemical contaminants in waste emplaced prior to 1985 may have leaked from packaging and contaminated the vadose zone and groundwater. Additionally, discharges or leaks from the resin tanks may also have contaminated the vadose zone and groundwater. This Remedial Investigation (RI) segregates the US Ecology Site (USE Site) into three decision units to aid the planning and implementation of the investigation:

- The Pre-1985 Trench Area
- The Resin Tank Area
- Groundwater

These three units are potential source areas for contamination, and the division of the USE Site into three areas presents a method for evaluating investigational data and forming a context for describing the nature and extent of contamination.

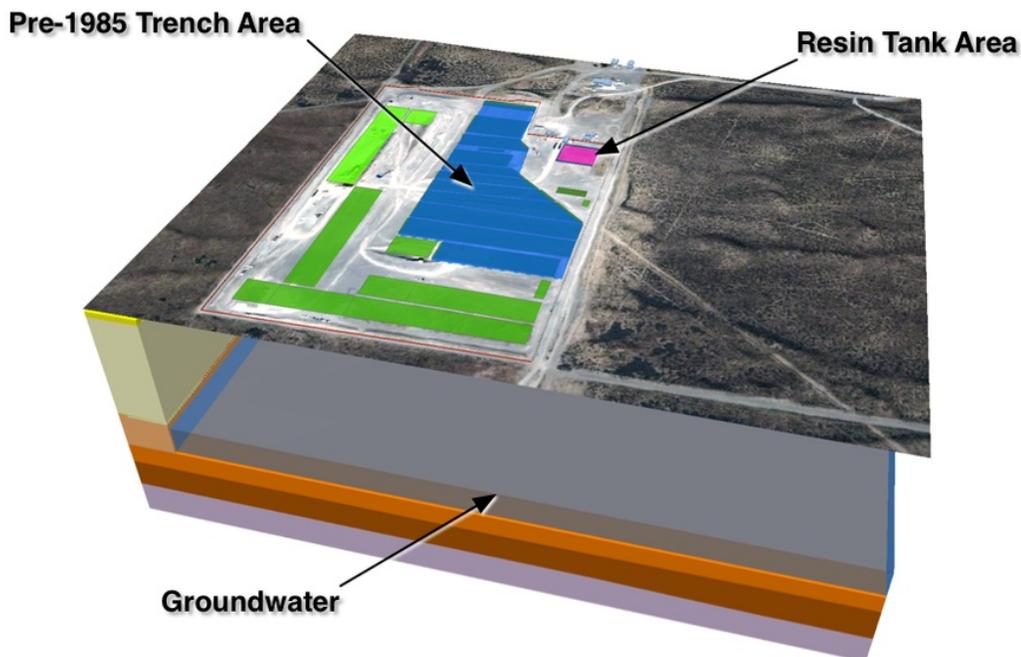


Figure ES - I USE Site Decision Units

The pre-1985 Trench Area consists of those specific trenches receiving waste prior to 1985. This pre-1985 waste may have included mixtures of hazardous chemical constituents. Specifically, the Chemical Trench received approximately 481 cubic meters (m³) (17,000 cubic feet [ft³]) of waste. The Chemical Trench closed in 1970. Early disposal practices within these trenches included emplacement of waste in fiberboard, wood, and cardboard, as well as metal containers.

The Resin Tank Area consisted of five underground storage tanks installed for treatment of liquid low-level radioactive waste (LLRW) resins. The tanks provided storage for LLRW treated by solar evaporation. The LLRW was likely from laundering activities (potentially used protective clothing) and ion-exchange resins from U.S. Navy nuclear power plants. A rapid snowmelt in 1985 generated large quantities of surface water runoff and pooled water entered one of the tanks. This water filled the tank to the riser. In 1985-86, liquids from the tanks were removed, stabilized, and disposed of within Trench 11-A. The stabilization process potentially involved the solidification of liquids using Aquaset/Petraset based upon historical practices. The remaining tank bottom liquids were sampled and characterized as an extremely hazardous waste. The two smaller tanks were removed and the remaining three tanks were closed in place after being filled with concrete. The tank area was covered with soil on August 12, 1988.

The water table at the site is positioned in the upper part of the Middle Ringold Formation (typically Unit E of the Wood Island Member) at a depth that varies from 98.1 m (322 ft) to 103.3 m (339 ft). The saturated thickness of the unconfined aquifer is between 27.4 to 30 m (90 to 100 ft). The bottom of the unconfined aquifer is the low-permeability silty-sand in the Lower Mud Member of the Ringold Formation. Groundwater was investigated during fieldwork (as part of a long-term monitoring program) due to the potential for releases related to the site's pre-1985 waste disposal.

Remedial Investigation

An RI assessment was conducted at the USE Low-Level Radioactive Waste (LLRW) Disposal Site in accordance with the requirements of *Washington Administrative Code (WAC) 173-340-350*. In early to mid 2008, a field investigation (Section 3.0) was completed to characterize the nature and extent of soil contamination in the pre-1985 Trench Area and Resin Tank Area Decision Units. Other activities included the installation of thirty vadose zone soil gas-monitoring wells, and the completion of civil, borehole camera, and well deviation surveys in USE groundwater monitoring wells. Long-term monitoring activities (Section 4.0) included collecting groundwater and soil-vapor samples for eight consecutive quarters.

The RI also included an evaluation of site characteristics including physiographic setting, geology, climate, and hydrostratigraphy. Groundwater flow was evaluated for both the USE Site and regional area. The groundwater contour maps for the USE Site were prepared using results from the well deviation and civil surveys. The RI information will be incorporated and referenced within the Model Toxics Control Act (MTCA) Feasibility Study (FS).

Data Quality

The RI report includes more than 70,000 analytical results for the field investigation and long-term monitoring activities. Of these results, less than 8 percent have been qualified as estimated measurements, and less than 0.5 percent of the project results have been rejected. Of the results reported by the laboratories as quantifiable measurements, less than 0.03 percent were qualified during data validation as non-detects due to quality control (QC) issues. The two-tiered data validation approach was effective to implement the Level A and C data validation required by the Quality Assurance Project Plan (QAPjP). The data are well formed and appropriate; meeting project data quality objectives. The dataset is usable and sufficient for project decision-making purposes.

Identification of Hazardous Substances Requiring Further Evaluation

Using data from the MTCA investigation, human health and ecological screening assessments were completed to identify hazardous substances, which required further evaluation as part of the RI. The first step of the assessment was to compare site soil concentrations to background concentrations. Analytes with concentrations consistent with background levels were not carried forward in the RI screening assessment.

The screening assessments compared an exposure point concentration (EPC) to the appropriate screening levels. The EPCs were calculated using ProUCL-based decision logic in accordance with guidance provided by the Washington State Department of Ecology. The methods selected for the MTCA investigation were chosen based upon their capability to produce reliable and robust results, and are similar in nature to the methods implemented for the Hanford River Corridor Baseline Risk Assessment (RCBRA).

In groundwater, 1,2-dichloroethane-d4, antimony, arsenic, bromofluorobenzene, fluoride, hexavalent chromium, molybdenum, nitrate, toluene-d8, trichloroethene, uranium, and vanadium were identified as hazardous substances exceeding the MTCA Method B screening levels.

In soil, hexavalent chromium, nitrate, nitrite, and methylene chloride were identified as substances exceeding the MTCA Method B screening levels for protection of groundwater. No analytes exceeded the MTCA Method B screening levels for soil direct contact.

In soil vapor, 1,1-dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, dichlorofluoromethane, tetrachloroethene, and trichloroethene exceeded the MTCA Method B screening levels.

The ecological screen utilized shallow soil samples (from the surface to a maximum depth of fifteen feet) since these are the samples that are relevant for wildlife exposure. No analytes failed the ecological screening assessment.

Contaminants of Potential Concern

The MTCA investigation evaluated soil, soil-vapor, and groundwater for potential contamination related to USE Site activities associated with the pre-1985 trenches and the resin tank area. The MTCA RI identifies contaminants of potential concern (COPCs) for groundwater, soil, and soil vapor with detailed discussion of magnitude and extent in Section 7.0 of this report.

The twelve groundwater COPCs identified by this RI are:

- Arsenic
- Uranium
- Hexavalent chromium
- Trichloroethene
- Antimony
- Fluoride
- Molybdenum
- Nitrate
- Vanadium
- 1,2-Dichloroethane-d4
- Bromofluorobenzene
- Toluene-d8

Arsenic and uranium will continue to be monitored; however, Vista Engineering suggests that these two analytes are anomalous and should not be considered in the FS. This reasoning is based upon: 1) the arsenic Method B screening level calculated for the MTCA investigation is one order of magnitude less than the MTCA Method A screening level for unrestricted site use, and 2) The single detection of uranium coincided with a detection of uranium within the laboratory blank. 1,2-dichloroethane-d4, bromofluorobenzene, and toluene-d8, are not associated with previous site operations and the nature and extent is limited to a single detection. These three analytes will be further evaluated in the FS, and may be included in long-term monitoring to further determine their role in selecting site cleanup actions. The remaining seven COPCs will undergo detailed evaluation and consideration for active remediation in the MTCA investigation FS.

The four soil COPCs identified by this RI are:

- Hexavalent Chromium
- Methylene Chloride
- Nitrate
- Nitrite

Vista Engineering suggests that nitrite and methylene chloride are anomalous and should not drive future remediation efforts; however, the evaluation of remedial alternatives in the FS will consider the efficacy of cleanup for each of these analytes.

The soil vapor COPCs identified by this RI are:

- 1,1-Dichloroethane
- 1,3-Butadiene
- Benzene
- Carbon Tetrachloride
- Chloroform
- Cis-1,2-Dichloroethene
- Dichlorofluoromethane
- Tetrachloroethene
- Trichloroethene

These COPCs are based upon indoor air concentrations calculated using the Johnson and Ettinger Model (Section 6.4.4). The nature and extent of soil vapor COPCs is evaluated using chloroform and

trichloroethene since these two analytes have relatively high concentrations and a greater number of detections among soil vapor constituents. The alternatives evaluated in the FS will include consideration of efficacy for the cleanup of each of the COPCs.

Nature and Extent of Contamination

Hazardous substances have been contributed or released during operation of the USE Site and contaminated soil and groundwater. Contamination is also present in the form of vapor within vadose zone soil.

Hexavalent chromium and nitrate were potentially released during leaks or discharges from the resin tanks. The data suggest that the release mechanism is not the sudden snowmelt events since the shallow soil samples did not contain detectable quantities of hexavalent chromium.

The trichloroethene detected in groundwater was potentially released from waste emplaced in the trenches prior to 1985. The pre-1985 trench waste is also a potential source for hexavalent chromium and nitrate in groundwater. Soil samples collected within the pre-1985 Trench Area Decision Unit contain hexavalent chromium and nitrate, but at concentrations that are lower than those observed within similar samples from the Resin Tank Area Decision Unit. This suggests that the primary source for hexavalent chromium and nitrate in groundwater is potentially from releases associated with the resin tanks.

The most likely sources for the chloroform and trichloroethene detected within soil vapor are the waste packages used in the pre-1985 Trench Area. The relatively stable monitoring trends suggest source materials are not currently contributing to groundwater contamination. Soil vapor, however, may be a mechanism for additional groundwater contamination. The FS will evaluate whether soil vapor and groundwater concentrations are in equilibrium.

Conclusions

The MTCA RI presents data collected during an initial field investigation together with eight quarters (two years) of long-term monitoring that included soil-vapor and groundwater. Evaluation of the dataset and validation results shows that project data are of sufficient quality to support a feasibility study (FS). These results indicate concentrations of hazardous substances in soil and groundwater related to discharges from the resin tanks and wastes emplaced in the pre-1985 trenches. Since these substances are present at concentrations greater than the human health-based and ecological screening levels, it is necessary to conduct a FS to evaluate the potential for future cleanup actions.

The MTCA FS will further evaluate the COPCs identified in this RI and establish a list of contaminants of concern (COC) in order to evaluate remedial alternatives that may potentially be used for site cleanup in accordance with MTCA and the MTCA Cleanup Regulation.

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1.0 Introduction

This Remedial Investigation (RI) Report presents data gathered and evaluated to support the development and analysis of remedial alternatives for cleanup action for the U.S. Ecology, Inc. (USE) Low-Level Radioactive Waste (LLRW) Disposal Site located in Benton County, Washington (USE Site). The USE Site is situated near the center of the U.S. Department of Energy (DOE) Hanford Facility (Hanford Site) and is approximately 37 kilometers (km) [23 miles (mi)] northwest of Richland, Washington.

The USE facility occupies approximately 0.4 km² (100 acres) of federal land leased to the State of Washington and sublet to USE. Figure 1 illustrates the location of the USE Site and the area of this investigation.

The *Low Level Radioactive Waste Site (LLRW) Agreed Order – Scope of Work* (SOW, USE, 2006) outlines the SOW for this RI. The scope of this RI (as stated in the SOW), includes chemical contamination associated with potential LLRW site disposal operations.

The *Remedial Investigation Work Plan for US Ecology Site RI/FS* (Work Plan, VET-1405-PLN-01) provides the approach, rationale, and framework for the RI Report. The *Sampling and Analysis Plan for the US Ecology RI/FS* (SAP, VET-1405-PLN-03) describes the sample collection, handling, and analysis procedures used at the site during RI sampling and long-term monitoring.

The *Quality Assurance Project Plan for the US Ecology Site RI/FS* (QAPjP, VET-1405-PLN-02) presents the quality assurance (QA) and quality control (QC) requirements for this RI.

The *Washington Administrative Code* (WAC) (specifically WAC 173-340-350[7][a]) allows for the integration of topics between the RI and the feasibility study (FS). This RI will present data associated with the investigation of the USE Site. However, a certain measure of evaluation will be taken into account when dealing with the overall context of the data in order to fully characterize the site in accordance with WAC 173-340-350(6) through 173-340-350(7)(a) together with the substantive requirements of the Model Toxics Control Act (MTCA) and the MTCA Cleanup Regulations.

This RI will also evaluate the conceptual site model presented in the Data Quality Objective (DQO) Report by EQM (*Data Quality Objectives Summary Report to Support the Model Toxics Control Act Remedial Investigation/Feasibility Study for the Low-Level Radioactive Waste Disposal Site*, EQM 2003). The evaluation of the conceptual model following site characterization will consider if the conceptual site model holds true once the site has been sufficiently characterized under the requirements of the MTCA, specifically WAC 173-340-350.

This RI Report is organized in the following manner:

- **Section 1.0**, Introduction (this section) presents an introduction to the report, and provides an overview of the USE Site.
- **Section 2**, General Facility Information provides specific details of the USE Site including the conceptual site model.
- **Section 3.0**, Field Investigation details the activities conducted to support the field investigation and long-term monitoring phases of the project.
- **Section 4.0**, Long-Term Monitoring details the remedial investigation long term monitoring activities.
- **Section 5.0**, Data Validation describes the data validation process and summarizes the results of data validation.
- **Section 6.0**, Identification of Hazardous Substances Requiring Further Evaluation presents the results of the target analyte screening process and identifies contaminants of potential concern.
- **Section 7.0** Nature and Extent of Contamination describes the nature and extent of hazardous substance contamination in the decision units.
- **Section 8.0**, Conclusions details the conclusions of the remedial investigation and describes the need for further action.

Ten appendices of additional information supplement the body of this report:

- Appendix A: Final Field Locations presents the final field locations of the soil borings, vadose zone wells, and groundwater wells.
- Appendix B: Field Activity Reports presents the Field Activity Reports.
- Appendix C: Ground Penetrating Radar Report presents the Ground Penetrating Radar Report of the Resin Tank Area.
- Appendix D: Soil Sample Results presents the chemical soil sample results collected as part of this RI.
- Appendix E: Physical Soil Sample Results presents the physical soil sample results collected as part of this RI.
- Appendix F: Soil Gas Sample Results presents the soil gas sample results collected as part of this RI.
- Appendix G: Gyroscopic Groundwater Well Deviation Report presents the Gyroscopic Groundwater Well Deviation Report.
- Appendix H: Groundwater Sample Results presents the groundwater sample results collected as part of this RI.
- Appendix I: Data Validation Reports presents the Data Validation Reports for the chemical soil, soil gas and groundwater samples collected and analyzed for this RI.

- Appendix J: Summary Tables Supporting the Screening of Target Analytes presents the summary tables used to perform the screening of contaminants to identify hazardous substances requiring further evaluation.

The RI Report provides data to complete a FS that will develop and evaluate cleanup alternatives that may be selected for the USE Site. WAC 173-340-350(a) stipulates that cleanup actions are required except in circumstances when the concentration of hazardous substances do not exceed the cleanup level a standard point of compliance. Cleanup levels will be developed within the Draft Cleanup Action Plan.

The purpose for the RI/FS process at the USE Site is to collect data and evaluate cleanup options in order to select a final remedy/cleanup action [WAC 173-340-350(1)]. The complexity of the USE Site will rely on information being presented *both* in the RI and FS phases of this cleanup action in order to fully characterize the site and establish options under the substantive requirements of the MTCA.

This approach is allowed (as stated earlier) in WAC 173-340-350(7)(a), and while the intent is not to exclude and data during either the RI or FS phase, it shall be necessary to consider all aspects of site characterization including: the DQO (EQM, 2003), the USE Site Environmental Impact Statement (EIS) (WDOH, 2004) data collected from the RI, and interpretations of data based upon *both* regional and site conditions.

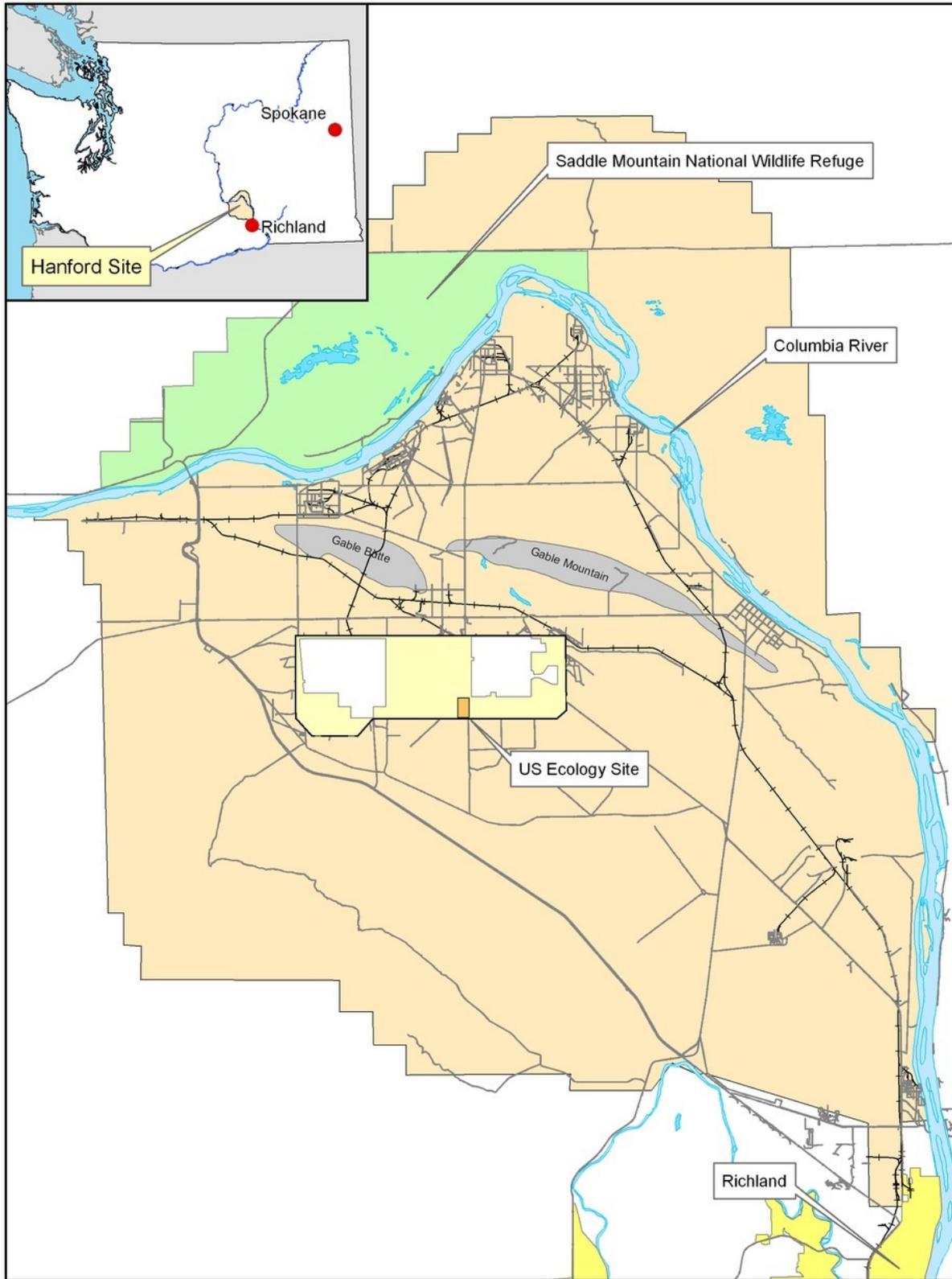


Figure 1 US Ecology Site, Near Richland Washington

I.1 Purpose

WAC 173-340-350(7) states “*The purpose and objective of the RI is to collect data necessary to adequately characterize the site for the purpose of developing and evaluating cleanup action alternatives.*” During this RI, data was collected that is representative of site conditions. These RI results will be used to characterize the nature and extent of contamination in the vicinity of the Pre-1985 Trench Area, the Resin Tank Area, and groundwater decision units.

This RI/FS process will determine if chemical contaminants associated with the USE Site pose potential risk (current or future) to human health or the environment. The RI will focus on combining information from the DQO (EQM, 2003), the final USE Site EIS (WDOH, 2004), and supplemental data collected during this RI. Interpretations from this RI will be carried forward into the FS for the subsequent development and evaluation of cleanup alternatives. This RI Report conforms to the requirements of WAC 173-340-350(7)(c), see Table 1.

Table 1 RI Report Conformance with WAC 173-340-350(7)(c)

(c) Content. A remedial investigation shall include the following information as appropriate:	Refer to Section
(i) General facility information. General information, including: Project title; name, address, and phone number of project coordinator; legal description of the facility location; dimensions of the facility; present owner and operator; chronological listing of past owners and operators and operational history; and other pertinent information.	1.0 and 2.0
(ii) Site conditions map. An existing site conditions map that illustrates relevant current site features such as property boundaries, proposed facility boundaries, surface topography, surface and subsurface structures, utility lines, well locations, and other pertinent information.	1.0 and 2.0
(iii) Field investigations. Sufficient investigations to characterize the distribution of hazardous substances present at the site, and threat to human health and the environment. Where applicable to the site, these investigations shall address the following:	3.0
(A) Surface water and sediments. Investigations of surface water and sediments to characterize significant hydrologic features such as: Surface drainage patterns and quantities, areas of erosion and sediment deposition, surface waters, floodplains, and actual or potential hazardous substance migration routes towards and within these features. Sufficient surface water and sediment sampling shall be performed to adequately characterize the areal and vertical distribution and concentrations of hazardous substances. Properties of surface and subsurface sediments that are likely to influence the type and rate of hazardous substance migration, or are likely to affect the ability to implement alternative cleanup actions shall be characterized.	N/A
(B) Soils. Investigations to adequately characterize the areal and vertical distribution and concentrations of hazardous substances in the soil due to the release. Properties of surface and subsurface soils that are likely to influence the type and rate of hazardous substance migration, or which are likely to affect the ability to implement alternative cleanup actions shall be characterized.	3.2
(C) Geology and ground water system characteristics. Investigations of site geology and hydrogeology to adequately characterize the areal and vertical distribution and concentrations of hazardous substances in the ground water and those features which affect the fate and transport of these hazardous substances. This shall include, as appropriate, the description, physical properties and distribution of bedrock and unconsolidated materials; ground water flow rate and gradient for affected and potentially affected ground waters; ground water divides; areas of ground water recharge and discharge; location of public and private production wells; and ground water quality data.	2.5, 2.6 and 0

Table 1 RI Report Conformance with WAC 173-340-350(7)(c)

(c) Content. A remedial investigation shall include the following information as appropriate:	Refer to Section
(D) Air. An evaluation of air quality impacts, including sampling, where appropriate, and information regarding local and regional climatological characteristics which are likely to affect the hazardous substance migration such as seasonal patterns of rainfall, the magnitude and frequency of significant storm events, temperature extremes, prevailing wind direction, variations in barometric pressure, and wind velocity.	2.7
(E) Land use. Information regarding present and proposed land and resource uses and zoning for the site and potentially affected areas and information characterizing human and ecological populations that are reasonably likely to be exposed or potentially exposed to the release based on such use.	2.8
(F) Natural resources and ecological receptors.	2.10
(I) Information to determine the impact or potential impact of the hazardous substance from the facility on natural resources and ecological receptors, including any information needed to conduct a terrestrial ecological evaluation, under WAC 173-340-7492 or 173-340-7493, or to establish exclusion under WAC 173-340-7491.	2.10 and 6.7
(II) Where appropriate, a terrestrial ecological evaluation may be conducted so as to avoid duplicative studies of soil contamination that will be remediated to address other concerns, such as protection of human health. This may be accomplished by evaluating residual threats to the environment after cleanup action alternatives for human health protection have been developed. If this approach is used, the remedial investigation may be phased. Examples of sites where this approach may not be appropriate include: A site contaminated with a hazardous substance that is primarily an ecological concern and will not obviously be addressed by the cleanup action for the protection of human health, such as zinc; or a site where the development of a human health based remedy is expected to be a lengthy process, and postponing the terrestrial ecological evaluation would cause further harm to the environment.	2.10 and 6.7
(III) If it is determined that a simplified or site-specific terrestrial ecological evaluation is not required under WAC 173-340-7491, the basis for this determination shall be included in the remedial investigation report.	2.10 and 6.7
(G) Hazardous substance sources. A description of and sufficient sampling to define the location, quantity, areal and vertical extent, concentration within and sources of releases. Where relevant, information on the physical and chemical characteristics, and the biological effects of hazardous substances shall be provided.	6.7
(H) Regulatory classifications. Regulatory designations classifying affected air, surface water and ground water, if any.	N/A
(iv) Workplans. A safety and health plan and a sampling and analysis plan shall be prepared as part of the remedial investigation/feasibility study. These plans shall conform to the requirements specified in WAC 173-340-810 and 173-340-820.	VET-1405-PLN-01 Rev. 0, VET-1405-PLN-03 Rev. 0 and VET-1405-PLN-04 Rev. 0
(v) Other information. Other information may be required by the department.	N/A

1.2 Contact Information

The project coordinator for the USE Site RI/FS is Ms. Deborah Singleton of the Washington State Department of Ecology (Ecology). Ms. Singleton can be contacted at (509) 372-7988 or at 3100 Port of Benton, Richland, Washington 99354, in the Nuclear Waste Program, Richland Field Office.

2.0 General Facility Information

2.1 General Regulatory Overview

Commercial LLRW generated by hospitals, laboratories, universities, private industries, and nuclear power facilities have been transported to shallow-land disposal facilities across the United States since the early 1960s. Presently, Utah, South Carolina, and Washington accept wastes for disposal.

LLRW may generally consist of contaminated solids, liquids, animal carcasses, and small sealed sources. LLRW wastes in the form of liquids are normally stabilized (solidified) prior to disposal. This section of the RI Report provides information regarding specific LLRW materials that were reportedly accepted at the USE Site. The DOE, the Nuclear Regulatory Commission (NRC), and the U.S. Environmental Protection Agency (EPA) share responsibilities for managing LLRW. A certain measure of management also resides with the U.S. Department of Transportation (DOT) regarding transport of LLRW to approved facilities.

In Washington State, LLRW is covered under WAC 173-325 which is the statute that describes disposal of LLRW. A memorandum of understanding also exists between Ecology and the Washington State Department of Health (WDOH) where the WDOH is recognized as the primary state agency for the protection of human health and the environment from ionizing radiation. The WDOH regulates the cleanup of radioactive wastes and facilities under the *Revised Code of Washington* (RCW) Chapter 70.98.

Under the Hanford Federal Facility Agreement and Consent Order, Ecology is designated as the state agency overseeing cleanup at the Hanford Site, with WDOH reviewing and providing recommendations to Ecology regarding any aspects of radiological cleanup. The RI/FS process for the USE Site is being completed under the supervision of Ecology, and the specific project contact at Ecology is listed in Section 1.2 of this RI Report.

2.2 U.S. Ecology Site Overview

The Washington State and the Atomic Energy Commission (AEC) entered into a 100-year lease agreement for 1,000 acres of land on the Hanford Site¹ on 10 September 1964. In 1965, the state of Washington leased 100 acres of land to USE for the operation of the commercial LLRW site. The site was licensed to California Nuclear, Inc. (California Nuclear) and began accepting LLRW. In 1968, Nuclear Engineering Company acquired California Nuclear. At that time, Nuclear Engineering Company assumed the role of site operator for the LLRW Site. Nuclear Engineering Company changed its name to USE in 1981 and the site remains under their operation at the

¹ This lease is now between the state and DOE; the AEC was abolished, and the NRC and DOE were created.

present time. American Ecology, Inc. (headquartered in Boise, Idaho) owns USE as a subsidiary. Access is restricted to the USE Site and there are no permanent residences on or adjacent to the site. The nearest significant body of surface water is located approximately 9.7 km (6 mi) east at the Columbia River. Groundwater depth is over 91 meters (m) (300 feet [ft]) and the average precipitation is approximately 15 centimeters (cm) (6 inches [in]) per year. There are no domestic or municipal wells onsite or within several miles of the site. The USE Site is located in an area of Hanford known as the “Central Plateau.” The Central Plateau is an area of intensive waste management activities associated with U.S. government nuclear weapons production dating from the 1940s. On the Central Plateau, the “200 East” and “200 West” Areas were the center for chemical processing for the production of plutonium. These areas contain several large underground tank farms, storage facilities, and land disposal facilities. Figure 2 presents current site conditions.

The USE Site practices conventional shallow-land burial of packaged waste into unlined trenches (Figure 2 through Figure 4). Figure 5 illustrates early waste disposal practices at the site; wastes are no longer disposed of in this manner. Recent operations include placement of liners or secondary containment around waste packaging. The trenches range from 91.4 to 213.4 m (300 to 700 ft) long, 15.24 to 24.38 m (50 to 80 ft) wide and 9.1 to 15.2 m (30 to 50 ft) deep. There are currently 2 open operating trenches (Trench 18 unstable waste, and Trench 19 stable waste) and 20 filled trenches whose contents include 1 nuclear reactor vessel, 3 emptied underground tanks, large quantities of scintillation fluids, absorbed liquids, and large quantities of metal drums, fiber-board drums, and cardboard, wood, and metal boxes. Filled trenches are typically covered with at least 1.5 m (5 ft) of site soils. The next section provides further information regarding site disposal practices.



Figure 2 Site Map for the US Ecology Site



Figure 3 Waste Disposal Practices in 1972



**Figure 4 Metal Burial Box Covered in a Secondary Liner
Used in Waste Emplacement during Contemporary Operation**



Figure 5 Engineering Concrete Barriers Being Grouted in Place

The site is licensed to receive LLRW and naturally occurring and accelerator-produced radioactive material (NORM/NARM). Disposal access for LLRW is limited to 11 states by the Northwest Compact and the Rocky Mountain Compact. Approximately 80 percent of the LLRW disposed at the site is from generators in Washington and Oregon.

Several types of waste have been disposed at the USE Site since 1965. Waste types include low-level radioactive, NORM, NARM, non-radioactive hazardous and radioactive waste having a hazardous component. Since 1985, only LLRW, NORM, and NARM have been allowed for disposal. The LLRW includes waste such as trash, clothing, tools, hardware, and equipment contaminated by radioactive substances. The LLRW at the USE Site is typically generated by five sources. These sources are nuclear power plants, industrial users, government and military organizations, academic institutions, and the medical community.

NORM and NARM wastes include, but are not limited to, pipe scale from oil and gas pipelines, soils from cleanup of mineral processing sites, and measuring devices and gauges as stated in the DQO Report (EQM, 2003).

2.3 Conceptual Site Model and Remedial Investigation Decision Units

The DQO Summary Report communicated the preliminary conceptual site model guiding the development of the SOW and the SAP. Generally, this conceptual site model suggests that chemical contaminants in waste emplaced prior to 1985 may have leaked from packaging and contaminated the vadose zone and groundwater. Additionally, discharges or leaks from the resin tanks may also have contaminated the vadose zone and groundwater. To aid the planning and implementation of the investigation, the site was segregated into three decision units:

1. The Pre-1985 Trench Area
2. The Resin Tank Area
3. Groundwater flowing through and out of the site

These three units encompass the potential source areas of contamination and present a method for evaluating investigation data and forming a context for describing the nature and extent of contamination at the USE Site. Each of these decision units is described in the following subsections and presented in Figure 6.

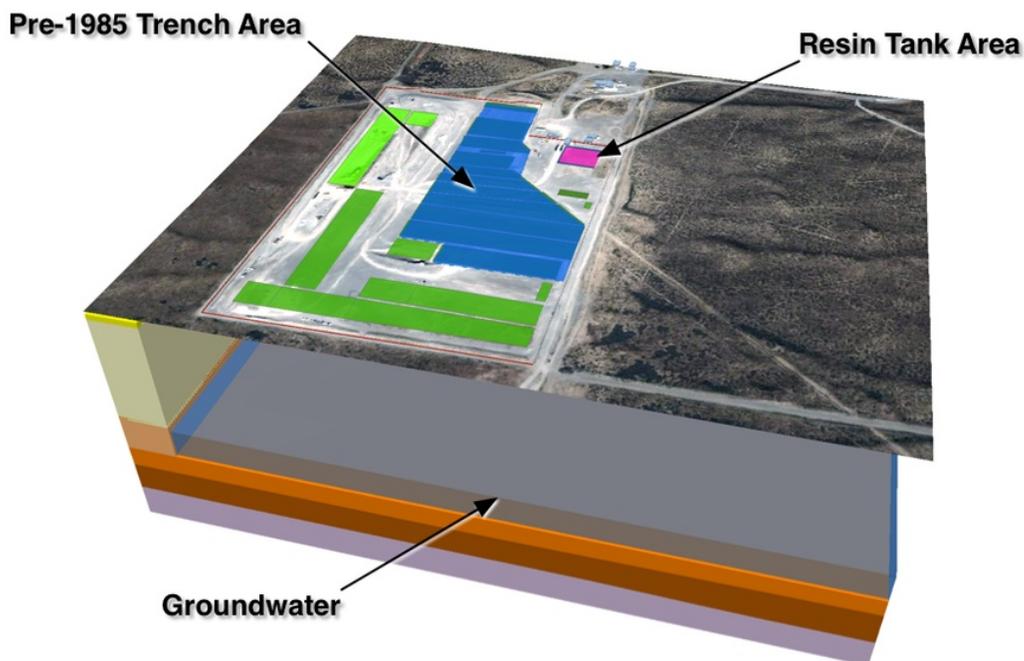


Figure 6 USE Site Remedial Investigation Decision Units

2.3.1 Pre-1985 Trench Area Decision Unit

The pre-1985 Trench Area consists of the trenches that may have received waste mixed with hazardous chemical constituents, and includes the Chemical Trench, which was closed in 1970 after receiving approximately 481.4 cubic meters (m^3) (17,000 cubic feet [ft^3]) of waste. Early disposal practices within the trenches included emplacement of waste in fiberboard, wood, and

cardboard, as well as metal containers. As described in the DQO Report (EQM, 2003), Table 2 describes USE Site disposal trenches, and indentifies those trenches as part of the Pre-1985 Trench Area.

Table 2 Trench Numbers and General Trench Information

Trench Area	Area	Trench Information
Pre-1985 Trench Area	Chemical	Closed. May contain absorbed liquids disposed in the trench, disposal of waste phenol, drums of chemical waste, phenolic resin, toluene, benzene, xylene, lead, and beryllium. Records of disposal from 1965-70 are incomplete. Trench used 1968-1972 for disposal of 17,000 ft ³ of non-radioactive material.
	Trench 1-4	Closed. Contain waste in metal drums, fiber-board drums, and cardboard boxes. Likely to contain scintillation fluids.
	Trench 4A & B	Closed. Trench 4A, which was open from 4/30/82-6/18/82, was designed for dewatered, feedwater heaters from J.A. Fitzpatrick power plant. Closed. Trench 4B, open from 7/9/84-8/23/85, has six IF-300s that contain activated hardware (very high radiation levels). There are four caissons (not wells); two were used for the disposal of "hot sources." The caissons are 30 foot vertical tubes, 6 feet apart, 24 inches in diameter with liners made of steel pipe that rest on eight-inch thick concrete pads. After a caisson was filled, a concrete cap was poured to seal the caisson.
	Trench 5	Closed. Known to have containerized/absorbed liquids disposed in the trench. Contains scintillation fluids. Contains mixed waste.
	Trench 6	Closed. Likely to contain scintillation fluids.
	Trench 7	Closed. Likely to contain scintillation fluids.
	Trench 7A	Closed. Need to confirm if hazardous substances are present or not.
	RXT	Closed. Head and Reactor Vessel Trench.
	Trench 8	Closed. Likely to contain scintillation fluids.
	Trench 9	Closed. Likely to contain scintillation fluids.
Post-1985 Trenches that are closed, no longer receiving waste	Trench 10	Closed. Likely to contain scintillation fluids.
	Trench 11A	Closed. Low-level radioactive waste, some waste stabilized with Aquaset/Petraset may also contain hazardous substance, likely to contain scintillation fluids. Drums from close out of Resin Tank Area.
	Trench 11B	Closed. Confirmed no hazardous substances present.
	Trench 12	Closed. Confirmed no hazardous substances present.
	Trenches 13	Closed. Confirmed no hazardous substances are present.
	Trench 14	Closed. Confirmed no hazardous substances are present.
Post-1985 Trenches that are active	Trench 16	Closed. Confirmed no hazardous substances present.
	Trench 18	Active. No hazardous substances present. Trench has unstable waste.
	Trenches 19	Active. No hazardous substances present. Trench has stable waste.

2.3.2 Resin Tank Area Decision Unit

In addition to the trenches, five underground storage tanks were installed for treatment of liquid LLRW. Two of these tanks were removed and the remaining three tanks were emptied in 1986. The three large tanks held up to 87,064 Liters (L) (23,000 gallons [gal]) of LLRW liquid, and the two smaller tanks had a capacity of 3,785 L (1,000 gal) each. The tanks provided storage for LLRW to be treated by solar evaporation. Processes involving solar evaporation normally include the controlled exposure of liquids to solar energy, which results in the transformation of liquids into the vapor state (evaporation). The LLRW was from laundering activities most likely associated with cleaning protective clothing and ion exchange resins from U.S. Navy nuclear power plants. During 1985, a rapid snowmelt generated large quantities of runoff, and pooled water entered one of the tanks, filling it to the riser. Changing liquid levels in the tanks indicated liquid release from the tanks, estimated at 378.5 to 454 L (100 to 120 gal).

In 1985-86, liquids from the tanks were removed, stabilized, and disposed of in Trench 11-A. The stabilization process likely involved the solidification of liquids using Aquaset/Petraset. The remaining tank bottom liquids were sampled and characterized as an extremely hazardous waste by Ecology (EQM, 2003). The two smaller tanks were removed and the remaining three tanks were closed in place after being filled with concrete. The tank area was covered with soil on August 12, 1988. Figure 7 portrays the tank locations verified using as-built drawings during performance of the RI.

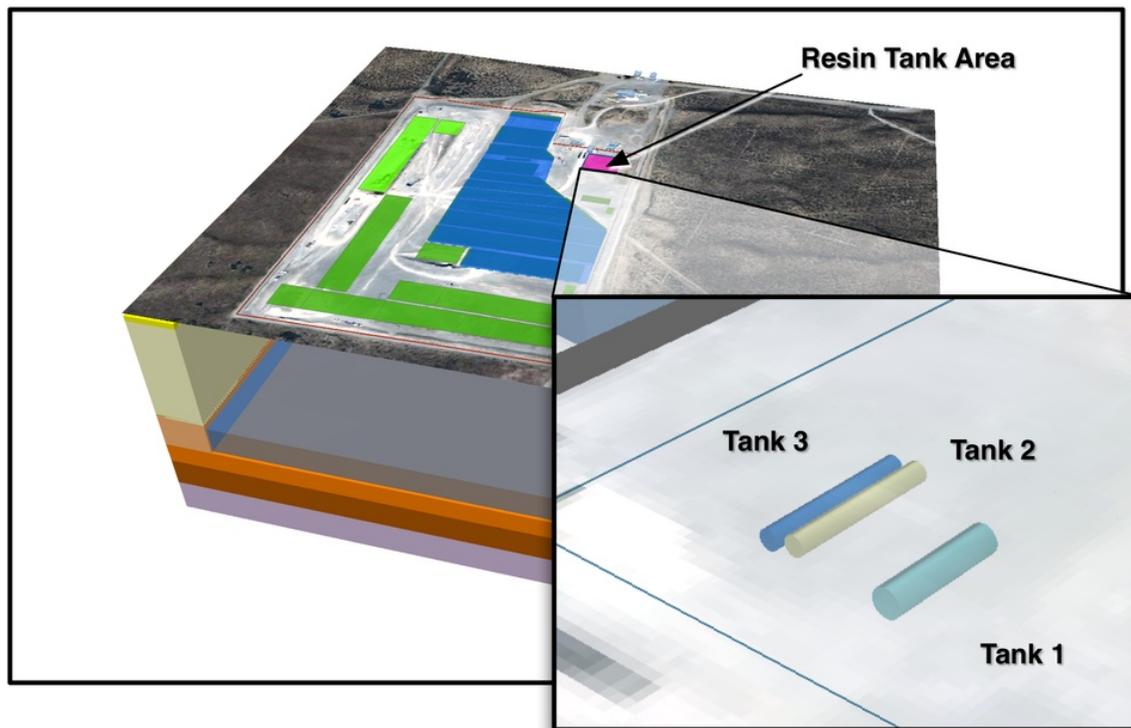


Figure 7 The Resin Tank Area and Configuration of the Remaining Tanks

2.3.3 Groundwater Decision Unit

The water table is positioned in the upper part of the Middle Ringold Formation (typically Unit E of the Wood Island Member), making the saturated thickness of the unconfined aquifer between 27.4 to 30.5 m (90 to 100 ft). The bottom of the unconfined aquifer is the low-permeability silty-sand in the Lower Mud Member of the Ringold Formation. Because of the potential for releases related to the site pre-1985 waste disposal, groundwater was investigated during fieldwork as part of a long-term monitoring program.

In 1986, four down-gradient wells (MW3, MW5, MW8, and MW10) and one up-gradient well (MW13) were constructed. Quarterly sampling and monitoring was conducted for specific conductivity, total organic carbon, total organic halides (TOX), pH, nitrates, and volatile organics analysis (VOA) (EQM, 2003). Figure 8 illustrates the location of groundwater monitoring wells on the USE Site.

In 1996, two additional up-gradient monitoring wells (Wells 9 and 9A) were constructed at the LLRW Site. The objective was to determine the saturated thickness of the unconfined aquifer and determine the grain size characteristics of the saturated zone. These data were used to validate transmissivity values used to model scenarios in the closure plan (EQM, 2003).

The interpretation of historical water table evaluations and groundwater flow directions have been problematic. A portion of this RI will establish a more accurate groundwater flow direction beneath the site. This will be an important step towards characterizing the fate and transport of site possible site contaminants.

2.4 Relevant Federal and State Laws

The following regulations and laws are applicable to the conduct of this investigation:

- **Atomic Energy Act (AEA) 42 U.S.C.** This Act establishes the regulatory and licensing basis for commercial and military use of atomic energy. The AEA gives the NRC responsibility for regulating the use of source, byproduct, and special nuclear materials. The AEA permits the NRC to enter into agreements with states to authorize regulation of radioactive materials covered by the agreement. These states are called "Agreement States."
- **Washington Nuclear Energy and Radiation Control Act, Chapter 70.98 RCW.** This Act establishes a state program for regulation of ionizing radiation for the protection of the occupational and public health and safety.
- **Radioactive Waste Act, Chapter 43.200 RCW.** Establishes a closure account and perpetual care and maintenance account to be used exclusively for final closure and decommissioning of the commercial LLRW site and gives authority to the Department of Ecology to implement the 1985 LLRW Policy Amendments Act.

- **Hazardous Waste Management Act, Chapter 70.105 RCW.** Regulates closure and corrective actions for releases of non-radioactive hazardous waste and mixed waste through the State Dangerous Waste Rules, Chapter 173-303 WAC.
- **Model Toxics Control Act, Chapter 173-340 WAC.** This Act (MTCA) establishes cleanup standards and requirements for the cleanup of hazardous waste sites.
- **Northwest Interstate Compact on Low-Level Radioactive Waste Management, Chapter 43.145 RCW.** Enacts the Northwest Interstate Compact into state law and establishes the Compact's regulatory provisions, eligible parties, and other operating requirements.



Figure 8 US Ecology Groundwater Monitoring Wells

2.5 Geology

The USE Site is located in the Pasco Basin, one of several structural and topographic basins of the Columbia Plateau. The Pasco Basin is a structural depression that has accumulated a thick sequence of fluvial lathstring and glacio-fluvial sediments (*Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415). The unconsolidated sediments, known as the Hanford and Ringold Formations, vary in thickness and texture, and overlie thick basaltic lava flows of the Columbia River Basalt Group. Together the Hanford and Ringold Formations hold an unconfined aquifer system. From the oldest to youngest, the major geologic units of interest are the Elephant Mountain Member of the Saddle Mountain Basalt (of the Columbia River Basalt Group), the Ringold Formation, the Cold Creek unit (CCU), the Hanford formation, and surficial Holocene deposits (Figure 9 and Figure 10).

2.5.1 Elephant Mountain Member

The Elephant Mountain Member of the Saddle Mountains Basalt Group is the uppermost basalt unit in the Central Plateau area (Appendix G of *200 Areas Remedial Investigation/Feasibility Study Implementation Plan- Environmental Restoration Program*, DOE/RL-98-28). The folding that produced the Yakima Fold Belt deformed the basalt, as well as the overlying Ringold Formation and CCU. Broad synclinal areas and tight anticlinal ridges, such as Rattlesnake Mountain and Gable Mountain, are evidence of this. Except for a small area north of the 200 East Area boundary where it has been eroded away, the Elephant Mountain Member is laterally continuous throughout the Central Plateau Area. The field investigations for this RI Report did not penetrate to the basalt.

2.5.2 Ringold Formation

The Ringold Formation is an interstratified sequence of unconsolidated clay, silt, sand, and gravel-to-cobble gravel deposited by the ancestral Columbia River. The Ringold Formation forms the lower part of the vadose zone throughout the 200 West Area and south of the 200 East Area. The Ringold Formation generally occurs completely in the saturated zone north of the 200 East Area, although relatively small isolated pockets of Ringold occur within the 200 East Area vadose zone. In the 200 Areas, these clastic sediments, from youngest to oldest, consist of four major facies: overbank-dominated deposits of the Upper Ringold; fluvial gravels of Unit E; paleosol and lacustrine muds of the lower mud sequence; and fluvial gravels of Unit A. Ringold Units B, C, and D are not present in the 200 Areas with the exception of localized occurrences of fluvial gravel of Unit C in the 200 East Area.

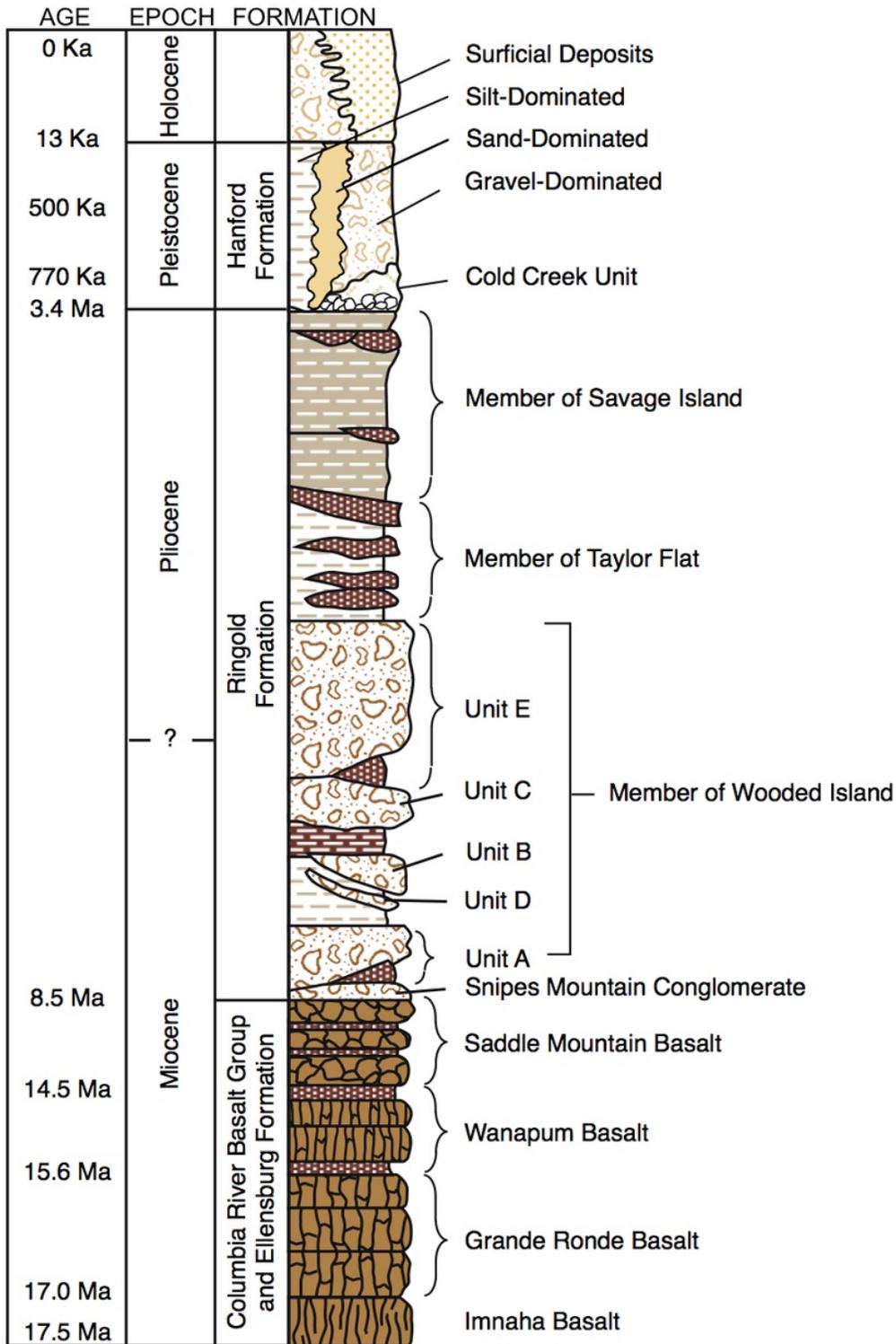


Figure 9 Major Geologic Units of Interest in the Central Plateau

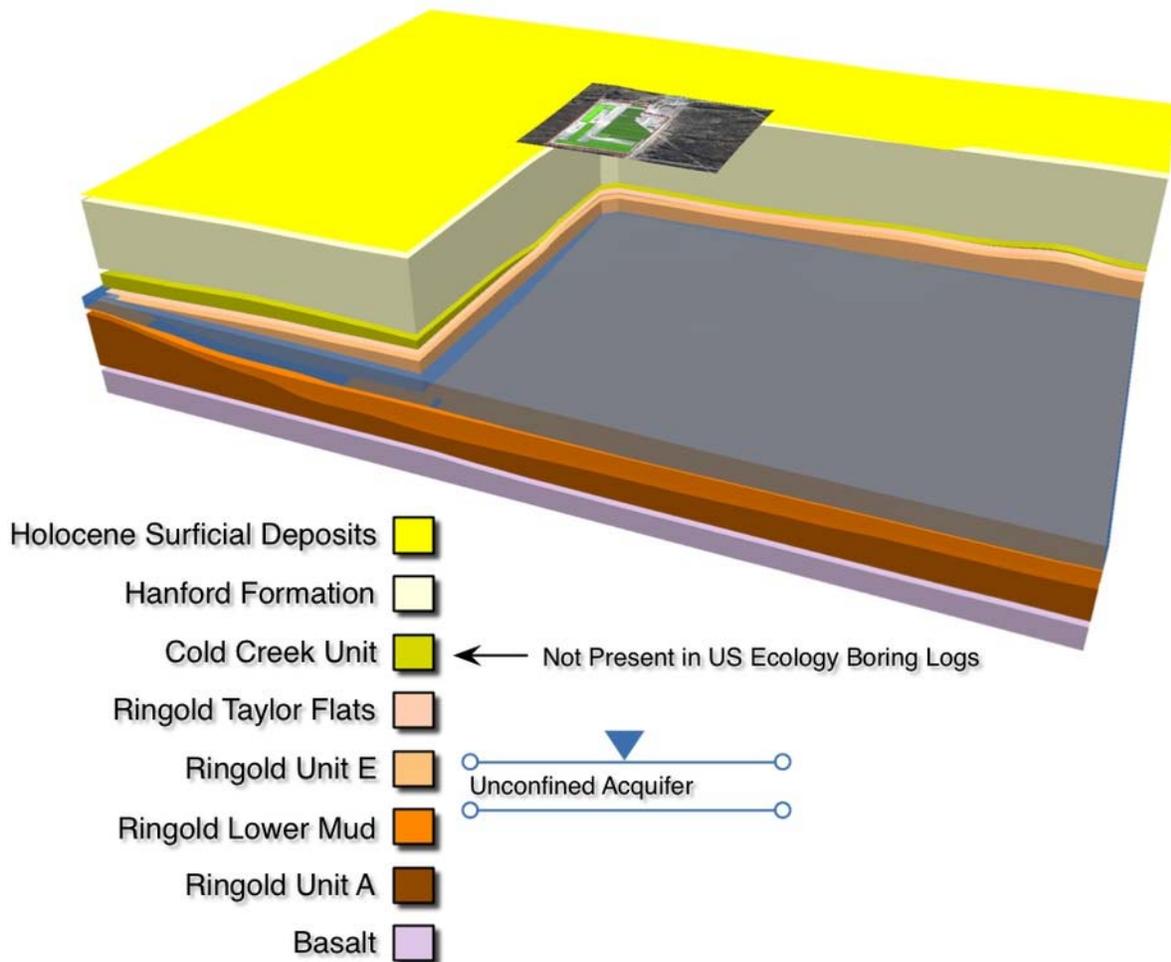


Figure 10 Stratigraphy of the Area Underlying the US Ecology Site

2.5.2.1 Unit A of the Ringold Formation

In the 200 East Area, the fluvial gravels and sands of Unit A generally thicken and dip to the south. This unit rises above the water table in small isolated pockets near the western and eastern boundaries of the 200 East Area and south of Gable Mountain. Unit A is below the unconfined aquifer and therefore is not part of the vadose zone in the 200 West Area.

2.5.2.2 Lower Mud Sequence of the Ringold Formation

The overbank and lacustrine deposits of the lower mud sequence occur beneath the gravels of Unit E. The lower mud sequence generally thickens and dips to the west and to the southeast away from the 200 East Area. The unit appears in the vadose zone as small isolated pockets in the center of the 200 East Area, underneath B Pond and between B Pond and Gable Mountain.

2.5.2.3 Unit E of the Ringold Formation

Unit E is the uppermost unit of the Ringold Formation in the 200 East and 200 North Areas. It is dominantly composed of fluvial gravel, but strata typical of the fluvial sand and overbank facies may be encountered locally. The unit is recognized by 1) coarse texture, 2) high proportion of quartzite and granitic clasts, 3) relatively low calcium carbonate content, 4) partial consolidation, and 5) relatively low natural gamma response. Gravels of Unit E occur in the southwest corner of the 200 North Area, at a thickness up to 5 m (16 ft), and in the southwest corner of the 200 East Area, at a thickness up to 35 m (115 ft). From the 200 North and East Areas, Unit E thickens to the south-southwest. Unit E is the only part of the Ringold Formation identified within the 200 North Area.

2.5.2.4 Upper Ringold Unit

The upper Ringold unit is missing in the 200 East and 200 North Areas and is discontinuous across the 200 West Area because of post Ringold erosion. The upper unit in the 200 West Area consists of silty overbank deposits and fluvial sands. This unit is recognized by 1) abundance of well-sorted sand, 2) light color, and 3) variable natural gamma response. It is found only in the west, north, and central portions of the 200 West Area. It dips to the south-southwest.

2.5.3 Cold Creek Unit

The CCU includes the standardized name for several post-Ringold formation and pre-Hanford formation units present beneath a portion of the Central Plateau area. The CCU includes the sediments formerly identified as the Plio-Pleistocene unit, caliche, early Palouse soil, pre-Missoula gravels, and side-stream alluvial facies in previous site reports. The CCU has been divided into five lithofacies: fine-grained, laminated to massive (fluvial-overbank and/or eolian deposits, formerly the early Palouse soil); fine- to coarse-grained, calcium-carbonate cemented (calcic paleosol, formerly the caliche); coarse-grained, multi-lithic (mainstream alluvium, formerly the pre-Missoula gravels); coarse-grained, angular, basaltic (colluvium); and coarse-grained, rounded, basaltic (side-stream alluvium, formerly side-stream alluvial facies). The CCU varies in thickness because it has been locally eroded, and facies are not present everywhere. There is a slight dip in CCU sediments to the south and/or southwest, and the dip is suspected of imposing some control on downward flow. While present regionally, an evaluation of local borehole reports suggests that the CCU is not present underneath the USE Site.

2.5.4 Hanford Formation

The Hanford formation is the informal stratigraphic name used to describe the Pleistocene cataclysmic flood deposits in the Pasco Basin. The Hanford formation consists predominantly of unconsolidated sediments ranging from boulder-size gravel to sand, silty sand, and silt. The sorting ranges from poorly sorted to well sorted. The Hanford formation is divided into three main facies associations: interbedded sand- to silt-dominated (formerly called the Touchet beds or slackwater facies); sand-dominated (formerly called the sand-dominated flood facies); and gravel-

dominated (formerly called the Pasco gravels), which have been further subdivided into 11 textural structural lithofacies. The USE Site contains the three main facies. The gravel-dominated facies are cross-stratified, coarse-grained sands and granule-to-boulder gravel. The gravel is uncemented and matrix-poor. The sand-dominated facies are well-stratified, fine- to coarse-grained sand, and granule gravel. Silt in these facies is variable and may be interbedded with the sand. Where the sand and silt content is low in the gravel-dominated facies, an open-framework texture is common. In general, from shallowest to deepest, the Hanford formation units encountered beneath the USE Site included an upper fine-grained unit (HFUF), the upper gravel-dominated unit (H1), a sand-dominated unit (H2), and a lower gravel-dominated unit (H3). These units are not laterally continuous beneath the site.

The cataclysmic floodwaters depositing sediments of the Hanford formation locally reshaped the topography of the Pasco Basin. The floodwaters deposited a thick sand and gravel bar (Cold Creek bar) constituting the higher southern portion of the 200 Areas, informally known as the 200 Areas Plateau. At the waning stages of the Ice Age floods, these floodwaters also eroded a channel north of the 200 Areas in the area currently occupied by West Lake and former Gable Mountain Pond. Both pre-Hanford formation erosion and the floodwaters removed the Ringold Formation from this area and deposited Hanford formation sediments directly over the basalt.

2.5.4.1 Clastic Dikes

Clastic dikes are common structures that occur in many of the geologic units in the Pasco Basin and vicinity. One subset, clastic injection dikes (Figure 11 and Figure 12, *obtained at <http://iceagefloods.blogspot.com>*), are fissures filled with sand, silt, clay, and minor coarser debris. Many dikes occur as near-vertical tabular bodies filled with multiple layers of unconsolidated sediments. Thin clay/silt linings separate the margins of most dikes and internal layers within dikes (*Clastic Injection Dikes of the Pasco Basin and Vicinity*, Fecht et al. 1999).

Classic dikes are commonly associated with the cataclysmic flood deposits, and can be seen in the trench walls at the USE Site. They appear as vertical to subvertical sediment-filled structures, especially within sand- and silt-dominated units. These dikes may provide preferential pathways for rapid lateral and vertical migration of contaminants through the vadose zone. On the Central Plateau, clastic dikes vary in width from less than 1 millimeter (mm) (0.04 in) to greater than 2 m (6.6 ft). Vertical lengths can range from less than 1 m (3.3 ft) to greater than 50 m (164 ft), with a large number greater than 20 m (66 ft) in size (*Final Environmental Impact Statement Commercial Low-Level Radioactive Waste Disposal Site Richland, Washington*, WDOH/320-031, 2004). Material filling the dikes is locally derived and ranges in size from mud to gravel. Clastic dikes occur in the Hanford formation on the Central Plateau. They are most common in the finer grained sand sequence and are rare in the open-framework gravel.



Figure 11 Close-up of a Nearby Clastic Dike

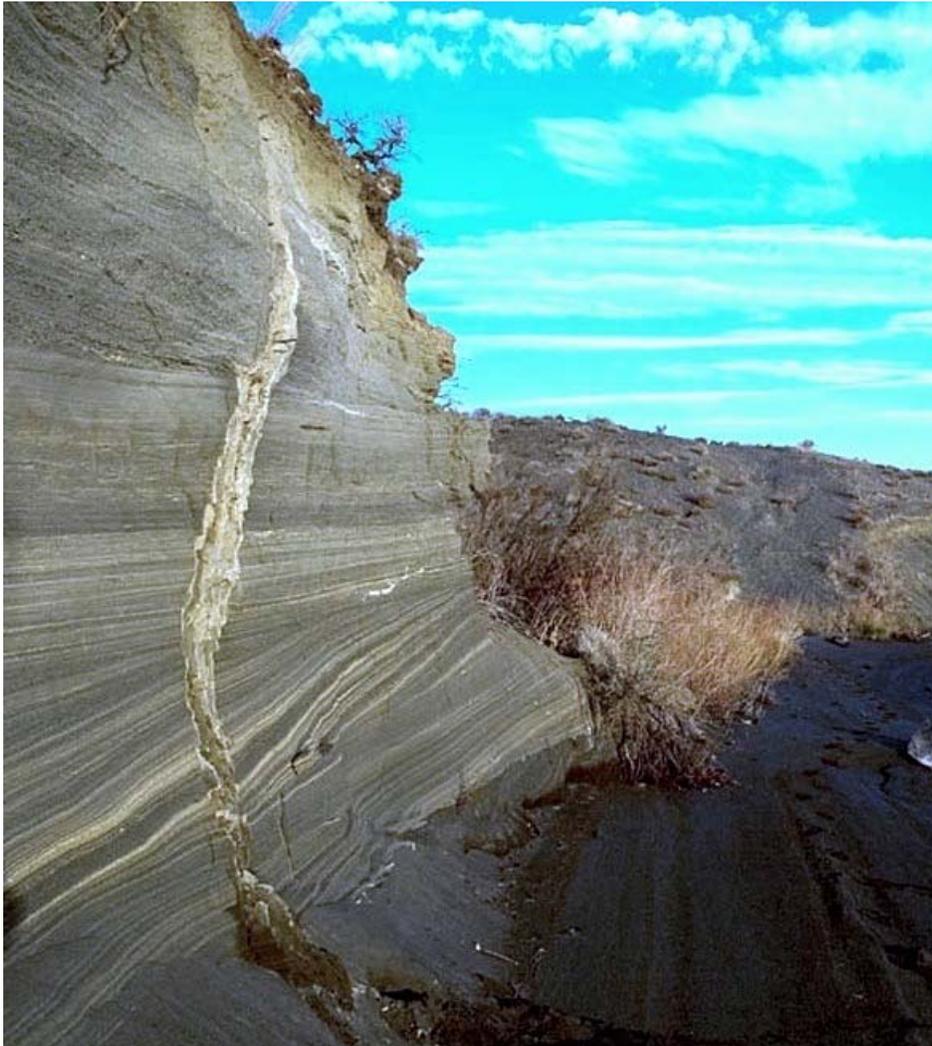


Figure 12 A Clastic Dike Along the Columbia River

2.5.5 Holocene Surficial Deposits

Surficial deposits include Holocene eolian sheets of sand forming a thin veneer over the Hanford formation across the USE Site, except in localized areas where the deposits are absent. Surficial deposits consist of very fine- to medium-grained sand to occasionally silty sand. The *Soil Survey: Hanford Project in Benton County, Washington* (Hajek, 1966) describes the predominant surface soil types on the Central Plateau as Quincy sand (40%), Burbank loamy sand (39%), and Ephrata sandy loam (14%). These site soils have characteristically lower water holding capacities. This is due to the low organic matter and a low percentage of clay on the USE Site. There has been fill material placed in and over some waste sites during construction and for contamination control. The fill consists of reworked Hanford Formation sediments and/or surficial sand and silt.

2.6 Hydrostratigraphy

Groundwater occurrence is typically described in terms of water saturation and the geologic materials above, within, and below this zone of saturation (the area where all pores and fractures are saturated with water). The amount of water saturation may not always be constant, and changes occur in response to variation in water recharge and discharge (often seasonally).

The term aquifer is typically applied to zones of saturation that contain a substantial volume of water that may be removed from the subsurface using wells installed into the zone of saturation. The aquifer associated with the Central Plateau (described in Section 2.4.2) is a type of aquifer defined as existing in an unconfined state. This implies that the geologic units above the zone of saturation do not preclude the downward movement of water into the saturated zone.

The upper limit of the zone of saturation is referred to as the water table. This water table represents the area where the pressure of water (within fractures of pore space) in the saturated zone is equal to atmospheric pressure. This concept may be visually understood by considering the level of standing water within a well that has been installed within an unconfined aquifer. The water level within the well casing will rise to a point of equilibrium that is approximately equivalent to the elevation of the water table for the unconfined aquifer.

The description of groundwater units often relies on an understanding of local and regional geology. The evaluation of groundwater conditions at the USE Site will begin with providing descriptions of site hydrostratigraphy that will relate groundwater occurrence and the nature of local stratigraphy (layered arrangement of geologic units).

The hydrostratigraphic units of the USE Site were determined by review of the drilling logs from the seven wells on the USE Site and 33 surrounding DOE wells on the Central Plateau. The hydrostratigraphic units present at the USE Site include Units 9, 8, 5, and 4 (Ringold Formation); Unit 1 (Hanford formation); and surficial deposits. The base of the unconfined aquifer typically is the top of the Ringold Unit 8 (Lower Mud) below the USE Site.

2.6.1 Vadose Zone

The vadose zone is the area between the ground surface and the water table. In contrast to the zone of saturation, this area is referred to as the unsaturated zone. Water may occur within fractures and pore space, but the total void space is unsaturated with respect to water. At the USE Site, the vadose zone thickness ranges from 98.1 to 103.3 m (322 to 339 ft). Sediments in the vadose zone are the Ringold Formation, the CCU, and the Hanford formation. Erosion during cataclysmic flooding removed some of the CCU and the Ringold Formation.

2.6.2 Unconfined Aquifer

The top of the unconfined aquifer (i.e. the water table) in the Central Plateau area occurs within the Ringold Formation, the CCU, or the Hanford formation, depending on the location. The base of

the unconfined aquifer is the top of the Ringold Unit 8 (Lower Mud), below the USE Site. Groundwater in the unconfined aquifer flows from recharge areas where the water table is higher (west of the Hanford Site) to areas where it is lower, near the Columbia River (*Hanford Site Groundwater Monitoring for Fiscal Year 2006*, PNNL-16346).

Groundwater beneath the USE Site occurs primarily in the Hanford formation. Depth to water varies from about 98.1 m (322 ft) to about 103.3 m (339 ft). Groundwater flow is towards the Columbia River in the easterly direction of the site (Figure 13). Estimates of recharge from precipitation are about 5 mm/yr (0.02 in/yr) and are largely dependent on soil texture and the type and density of vegetation (*Ground Water Levels at the Commercial LLRW Disposal Site*, Riley 2002).

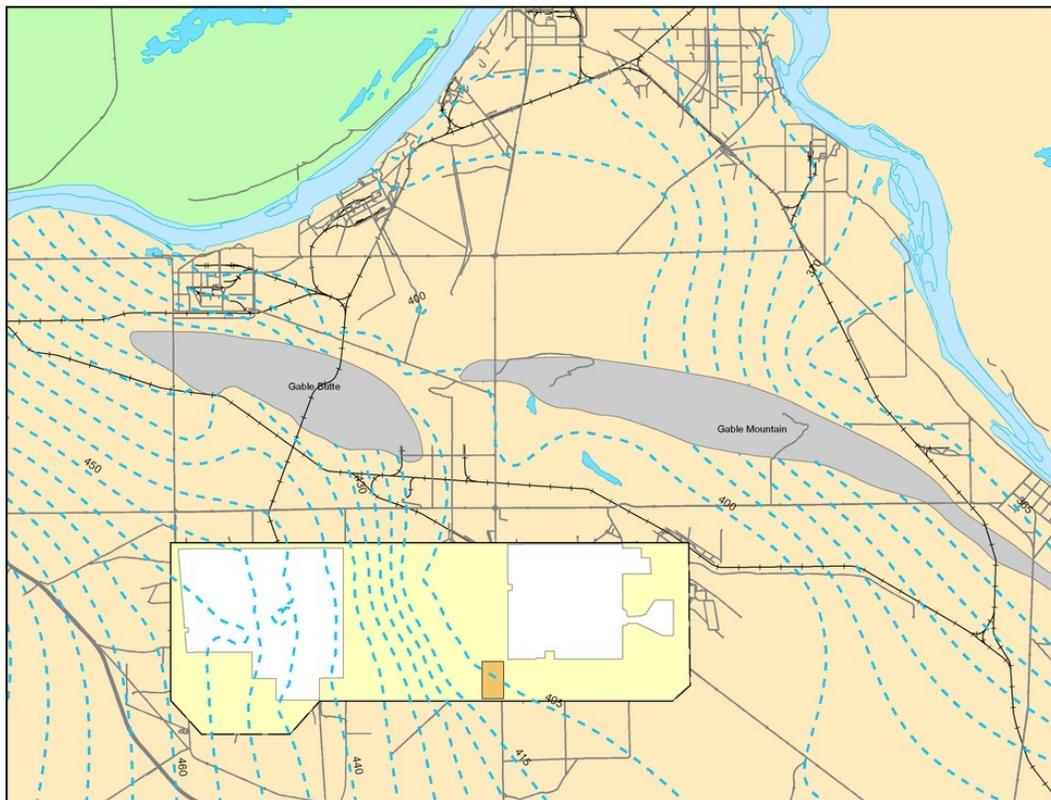


Figure 13 Hanford Site Mapped Hydraulic Heads, 2005

2.7 Local and Regional Climatological Characteristics

2.7.1 Seasonal Patterns of Precipitation

The average annual precipitation at the Hanford Meteorological Station (HMS) is 17 cm (6.8 in). Most precipitation occurs during the late autumn and winter, with more than half of annual precipitation occurring during the months from November through February.

Average monthly snowfall ranges from 0.25 cm (0.1 in) during October to a maximum of 13.2 cm (5.2 in) during December and decreases to 1.3 cm (0.5 in) during March. Snowfall accounts for about 38 percent of precipitation from December through February (PNL-6415).

2.7.2 Magnitude and Frequency of Significant Storm Events

Concerns about severe weather usually focus on hurricanes, tornadoes, and thunderstorms. Fortunately, Washington does not experience hurricanes; tornadoes are infrequent and generally small in the northwestern portion of the United States. For the 10 counties closest to the Hanford Site (Benton, Franklin, Grant, Adams, Yakima, Klickitat, Kittitas, and Walla Walla, counties in Washington, and Umatilla and Morrow counties in Oregon), there have been only 28 tornadoes recorded from 1950 through December 2006. Of these, 21 tornadoes had maximum wind speeds estimated to be in the range of 18 to 32 meters/second (m/s) (40 to 72 miles/hour [mph]), 4 had maximum wind speeds in the range of 33 to 50 m/s (73 to 112 mph), and 3 had maximum wind speeds in the range of 51 to 71 m/s (113 to 157 mph). There were no deaths or substantial property damage (in excess of \$50,000) associated with any of these tornadoes.

Hanford Site NEPA Characterization, PNL-6415, reports for the 5° block centered at 117.5° west longitude and 47.5° north latitude (where the Hanford Site is located), the expected path length of a tornado is 7.6 kilometers (km) (5 mi), the expected width is 95 m (312 ft), and the expected area is about 1.5 km² (1 mi²). The estimated probability of a tornado striking a point on the Hanford Site is 9.6×10^{-6} /yr. The probabilities of extreme winds associated with tornadoes striking a point can be estimated using the distribution of tornado intensities for the region.

The average occurrence of thunderstorms in the vicinity of the HMS is 10 per year. They are most frequent during the summer; however, they have occurred in every month. Thunderstorms can generate high-speed winds and hail. Using the National Weather Service criteria for classifying a thunderstorm as “severe” (i.e., hail with a diameter greater than or equal to 19 mm [3/4 in] or wind gusts greater than or equal to 25.9 m/s [58 mph]), only 1.9 percent of thunderstorm events surveyed at the HMS have been “severe” storms, and are based the wind gust criteria. High-speed winds at the Hanford Site are more commonly associated with strong, cold frontal passages. In rare cases, intense low-pressure systems can generate winds of near hurricane force (PNL-6415).

2.7.3 Temperature Extremes

Based on data collected from 1946 through 2004, the average monthly temperatures at the HMS range from a low of -0.7°C (31°F) in January to a high of 24.7°C (76°F) in July. Daily maximum temperatures at the HMS vary from an average of 2°C (35°F) in late December and early January to 36°C (96°F) in late July (PNL-6415).

2.7.4 Prevailing wind direction

The prevailing surface winds on Hanford’s Central Plateau are from the northwest and occur most frequently during the winter and summer. Winds from the southwest also have a high frequency of

occurrence on the Central Plateau. During the spring and fall, there is an increase in the frequency of winds from the southwest and a corresponding decrease in winds from the northwest (PNL-6415).

2.7.5 Variations in Barometric Pressure

A report from the Hanford Weather Station from 1988 to 1991 on barometric pressure found variations from year to year were minimal and were representative of a 10 or 20 year database (Table 3). The total yearly breathing for the Hanford Site is 125.5 cm of mercury (0.01432306 cm of mercury per hour) or 1.69 atmospheres. The average diurnal change from low to high is 0.10 cm (0.04 in) of mercury (*Barometric Pressure Variations* [WHC-EP-0651]).

Table 3 Barometric Pressure Annual Data

Value	Year				
	1950-1980	1988	1989	1990	1991
Average (inches of mercury)	29.21	29.25	29.26	29.22	29.23
Standard deviation (inches of mercury)	-	0.211	0.197	0.193	0.210
Number	-	8779	8756	8760	8758
Maximum (inches of mercury)	30.23	29.94	29.96	30.02	29.83
Minimum (inches of mercury)	28.10	28.52	28.79	28.50	28.33
Total increases (inches of mercury)	-	49.98	46.04	51.46	49.97
Total decrease (inches of mercury)	-	50.50	46.20	51.28	49.78

2.7.6 Wind Velocity

From 1945 to 2006, the average wind speed was 3.4 m/s (7.6 mph), the highest average speed was 3.9 m/s (8.8 mph), the lowest average wind speed was 2.8 m/s (6.2 mph) and the peak gust speed was 35.8 m/s (80 mph) (PNL-6415).

2.8 Land Use

The following section is from the *Final Environmental Impact Statement – Commercial Low-Level Radioactive Waste Disposal Site* (Final EIS, WDOH/320-031, 2004).

As the landowner, DOE is responsible for determining future land use for the Central Plateau and elsewhere at the Hanford Site. The current land use on the Hanford Central Plateau is waste management and disposal. DOE has published two documents on their intentions for future use of the Hanford Site, entitled *The Future for Hanford: Uses and Cleanup, the Final Report of the Hanford Future Site Uses Working Group* (DOE, 1992), and *Final Hanford Comprehensive Land-Use Plan Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement, DOE/DEIS-0222-F* (DOE, 1999).

The 1992 report proposed, "In general, the overall cleanup criteria for the Central Plateau should enable general usage of the land and groundwater for other than waste management activities in the horizon of 100 years from the decommissioning of waste management facilities and closure of waste disposal areas" (DOE, 1992).

At a subsequent date on 2 November 1999, DOE adopted a record of decision for the Hanford Comprehensive Land Use Plan (CLUP), designating the Central Plateau, including the commercial LLRW site, as a waste management zone. The CLUP states, "Lands within the Central Plateau geographic area would continue to be used for the management of radioactive and hazardous waste materials. These management activities would include the collection and disposal of radioactive and/or hazardous waste materials remaining onsite, contaminated groundwater management, current offsite commitments, and other related and compatible uses." The CLUP considers land use at the Hanford Site for at least the next 50 years (DOE, 1999), and land use is not expected to change for 50 years beyond the closure of the Hanford Site (Final EIS, WDOH/320-021, 2004).

On 9 June 2000, the Hanford Reach National Monument was established for its natural beauty and to protect the wildlife, rare plants, and shrub steppe habitat. The 200,000-acre monument surrounds the Hanford Site and includes the last free-flowing stretch of the Columbia River in the United States. The commercial LLRW site is located a minimum of 8 km [5 mi] from the monument. A Federal Planning Advisory Committee was established to make recommendations to the U.S. Fish and Wildlife Service on a plan for the monument. It is not known at this time how the monument may impact future land use at the commercial LLRW site.

2.9 Groundwater Use

For the purposes of this investigation, groundwater is planned for unrestricted use.

2.10 Natural Resources and Ecological Receptors

2.10.1 Vegetation

As mentioned in Section 2.8, the USE Site is an industrial facility. The facility controls vegetation growth as part of its operations. The information below describes the vegetation present in areas outside of the facility footprint.

The vegetation of the 200 Areas Plateau is characterized by native shrub-steppe, interspersed with large areas of disturbed ground dominated by annual grasses and forbs. In the native shrub-steppe, the dominant shrub is big sagebrush (*Artemisia tridentata*) and the understory is dominated by the native perennial, Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual, cheatgrass (*Bromus tectorum*). Other shrubs typically present include rabbitbrush (*Chrysothamnus* spp.), spiny hopsage (*Grayia spinosa*), and antelope bitterbrush (*Purshia tridentata*). Other native bunchgrasses that are also present include Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*). Common herbaceous species include turpentine

cymopterus (*Cymopterus terebinthinus*), globemallow (*Sphaeralcea munroana*), balsamroot (*Balsamorhiza careyana*), milkvetch (*Astragalus* spp.), yarrow (*Achillea millifolium*), and daisy (*Erigeron* spp.).

Disturbed habitat communities are primarily the result of either range fires or mechanical disturbance (e.g., from road clearing or facility construction). Mechanical disturbance typically entails a loss of soil structure and disruption of nutrient cycling, which have a significant effect on the plant species that will re-colonize a site. The principal colonizers of disturbed sites are annual weeds, such as Russian thistle (*Salsola kali*), Jim Hill mustard (*Sisymbrium altissimum*), bur-ragweed (*Ambrosia acanthicarpa*), and cheatgrass. Once disturbed, native stands of vegetation may take decades (or centuries if the soil has been removed) in the mid-Columbia climate to return to a state near to the original condition. Disturbed areas with sandy soils that lack vegetation typically have higher recharge rates than sites with a plant cover (DOE/RL-98-28).

The vegetation that was present in and around the former waste ponds and ditches on the central plateau includes cottonwood (*Populus trichocarpa*), willows (*Salix* spp.), sedges (*Carex* spp.), and cattails (*Typha latifolia*). However, most of this vegetation has died with the cessation of liquid effluents flowing to the ponds and ditches. The only pond that remains in the central plateau area is the naturally occurring West Lake. It exists because of a naturally shallow water table, and is vegetated with riparian species such as bulrush (*Scirpus* spp.).

2.10.2 Wildlife

As mentioned in Section 2.8, the USE Site is an industrial facility. The facility controls the presence of wildlife, since it may impact the integrity of site operations. *The Hanford Site Biological Resources Management Plan* (DOE, 2001) provides specific details regarding site practices for the DOE and its contractors. This plan outlines a consistent approach to monitor, assess, and mitigate impact and conserve fish, wildlife, and plant populations and their habitats. The information provided in this RI describes the wildlife present in areas outside of the facility footprint.

The mammal that most frequents the central plateau is the mule deer (*Odocoileus hemionus*). While mule deer are much more common along the Columbia River, the few that forage throughout the central plateau make up a distinct group called the Central Population (DOE/RL-98-28). A large elk herd (*Cervus canadensis*) currently resides on the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE). Occasionally a few animals have been seen just south of the 200 Areas, and their presence may increase as the herd on ALE continues to grow. Other mammals common to the central plateau are badgers (*Taxidea taxus*), coyotes (*Canis latrans*), Great Basin pocket mice (*Perognathus parvus*), northern pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging ability and have been suspected of excavating contaminated soil at 200 Area radioactive waste sites (*Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, U.S.A.E.C. Hanford Reservation*, O'Farrell et al. 1973). The majority of badger diggings are a result of searches for food, especially

other burrowing mammals such as pocket gophers and mice. Pocket gophers and mice (especially Great Basin pocket mice and deer mice) are abundant in the 200 Areas, consume predominantly vegetation, and can excavate large amounts of soil as they construct their burrows (Hakonson et al. 1982). Mammals associated with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and various bat species.

Common bird species in the 200 Areas include starlings (*Sturnus vulgaris*), horned larks (*Eremophila alpestris*), meadowlarks (*Sturnella neglecta*), western kingbirds (*Tyrannus verticalis*), rock doves (*Columba livia*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Burrowing owls (*Athene cunicularia*) commonly nest in the central plateau in abandoned badger or coyote holes. Loggerhead shrikes (*Lanius ludovicianus*) and sage sparrows (*Amphispiza belli*) are common nesting species in habitats dominated by sagebrush. Long-billed curlews (*Numenius americanus*) have been observed nesting on inactive 200 Areas waste sites.

Common reptiles at the 200 Areas include gopher snakes (*Pituophis melanoleucus*) and sideblotched lizards (*Uta stansburiana*). Three of the most common groups of insects include darkling beetles, grasshoppers, and ants.

2.10.3 Terrestrial Ecological Receptors

Since the USE facility controls the presence of wildlife and vegetation as part of its operations, only minimal ecological receptors are expected. These receptors may include those animals capable of moving through fences (i.e. small mammals, birds, etc.). However, in areas around the USE site, wildlife and vegetation are exposed to contaminants. PNNL (1997) reported that no plant or animal species protected under the Endangered Species Act (or species listed by the state of Washington) were observed in the vicinity of the LLRW site during the 9 October 1997 biological review (*Cultural Resources Review of the US Ecology 100 Acre Sublease*, PNNL-98-600-001, 1997).

A terrestrial ecological screening is likely not required for the LLRW site since all contaminated soil and hazardous substances are (or will be) covered by buildings, paved roads, pavement, or other physical barriers to limit exposure of plants and/or wildlife. This is described in the Final EIS (WDOH/320-031, 2004).

Should hazardous materials or radionuclides enter the food web, the potential degree of bioaccumulation is based upon the specific contaminant, plant or animal species, and the portion of the biota it enters. This may vary depending on accumulation in tissue and bone for animals, and seeds or vascular material for plants.

Outside of the USE Site, wildlife and plants on the Central Plateau have a history of taking up contaminants from waste sites through burrowing and root penetration (e.g., *Mammal Occurrence and Exclusion at the Hanford Site*, WHC-SA-1252-S; *Historical Records of Radioactive Contamination in Biota at the 200 Areas of the Hanford Site*, WHC-MR-0418). Plant roots can

take up radionuclides to varying extents, depending on the radionuclide, plant species, depth of contamination, and soil chemistry. Plants such as Russian thistle that have both deep roots and grow preferentially on disturbed, poor soils are especially known for taking up certain radionuclides and then releasing them to the environment as the plant dies back in the fall or as animals eat the contaminated parts of the plant. Animals that burrow, such as harvester ants, mice, pocket gophers, and badgers, have all been found to distribute contaminants from buried waste sites at Hanford. For example, O'Farrell et al. (1973) documented the spread of radionuclides by black-tailed jackrabbits (*Lepus californicus*) licking contaminated salts in the BC Cribs and leaving contaminated fecal pellets and urine over an area of several square miles. Animals digging into waste sites can distribute contaminants or be affected by contaminants by many pathways, including 1) wind dispersal of excavated soil, causing spread of contamination; 2) animal consumption of the soil (e.g., if it contains a salt and is consumed on purpose, or is lodged on the pelt of a prey species consumed by a predator); 3) a dose to burrowing animals from radionuclides in the soil; and 4) excavated contaminated materials exposing other animals to an external dose.

3.0 Field Investigation

The field investigation collected and analyzed samples characterizing the distribution of hazardous substances present at the site, and threats to human health and the environment. Vista Engineering provided field management and technical support, while EnergySolutions LLC, in Richland, Washington (ES), provided work execution and safety support. Sampling activities were conducted at three decision units: the Resin Tank Area, Pre-1985 Trench Area, and groundwater, at locations and depths required by the Statement of Work (USE, 2006). The sampling program involved three primary activities:

- Completing a civil survey, borehole survey, and gyroscopic survey of groundwater monitoring wells installed at the USE Site. Results from these surveys will be used to assure the quality, construction, and trueness of site wells.
- Collection of shallow soil samples with the Hydraulic Hammer Rig (HHR) to characterize the lateral extent of impact from the 1985-flood event in the resin tank area, and collection of subsurface soil samples with the HHR in the Resin tank Area and pre-1985 Trench Area to characterize the vertical and lateral extent of contamination in the vadose zone.
- Installation of soil gas monitoring wells with the HHR in the pre-1985 Trench Area.

The final field locations for soil borings, vadose zone wells and groundwater wells, were reported by X, Y, and Z in Washington State Plane Coordinates, south zone (North American Datum of 1983 and North American Vertical Datum of 1988), for the RI and are attached in Appendix A: Final Field Locations.

3.1 Well Surveys

A borehole camera was used to inspect and document the integrity of the internal surfaces for each of the well casings. This was conducted January 23, 2008 through January 29, 2008. The borehole camera videos are on file for review at Ecology. The results of this survey are as follows:

- **MW-3** — there were no conditions to report on the inspection, total depth recorded at 106.4 m (349 ft) below ground surface (bgs) and top of screen recorded at 94.5 m (310 ft) bgs.
- **MW-5** —there were no conditions to report on the inspection, total depth was recorded at 106 m (348 ft) bgs and the top of the screen was recorded at 94 m (309 ft) bgs.
- **MW-8** — there was a significant bulge noticed in the screen approximately 96 m (315 ft) to 96.3 m (316 ft) bgs. The total depth was recorded at 104.9 m (344 ft) bgs and the top of the screen was recorded at 92 m (302 ft) bgs.
- **MW-9** — the 6” polyvinyl chloride (PVC) casing was reduced to 4” PVC at approximately 12.2 m (40 ft) bgs to total depth which is not noted in the well completion report. The top of the first screen was recorded at 320 ft bgs, and bottom of first screen was recorded at 330 ft bgs. There was a 4-inch PVC blank from 101 m (330 ft) to 102 m (335 ft) bgs. The top of the second screen was recorded 102 m (335 ft) to 104 m (340 ft) bgs. There was an

obstruction in the borehole at 106.2 m (349 ft) bgs that appeared to be a piece of galvanized piping with a pitless adaptor connected. The camera survey was unable to continue at well MW-9 because of the risk of wrapping the camera around this obstruction.

- **MW-9A** — the initial camera survey was stopped due to approximately 10 cm (4 in) of standing oil at the standing water level, 98.5 m (323 ft) bgs. USE removed the standing oil using absorbent socks, and the second camera survey did not observe standing oil in the well. The oil was first noted in 1996 during drilling activities. The 1997 data log also reported the presence of oil. Ecology requested WDOH to clarify the origin of the oil. WDOH reported that the oil resulted from riser pipe residual and was not associated with the casing or sealers used during well installation. Oil was again observed in the same wells (9 and 9A) during the MTCA investigation groundwater sampling. Ecology will continue to monitor this situation with USE personnel. Top of screen was observed at 98.8 m (324 ft) bgs. There was pump wiring in the bottom of the monitoring well at total depth, 114 m (375 ft) bgs.
- **MW-10** — the total depth was recorded at 109.4 m (359 ft) bgs and the top of screen was recorded at 97.5 m (320 ft) bgs. In the bottom there was what appeared to be a pitless adaptor connection.
- **MW-13** — there were no conditions to report on the inspection, the total depth was 106.4 m (349 ft) bgs and the screen was observed at 94 m (309 ft) bgs.

Historically, groundwater elevation data has been inconclusive in illustrating groundwater gradient and flow direction across the USE Site. A gyroscopic well deviation survey was concurrently performed with the borehole camera survey to note deviations from the vertical direction, as documented in Table 4. The gyroscopic survey found the USE wells deviate from vertical 0.009 to 0.083 m (0.030 to 0.272 ft). While not readily apparent, when taken in context to the relatively flat gradient in this location, these deviations can significantly impact recorded water level measurements. An example illustration of the severe deviation in MW-8 is found in Figure 14. Often these deviations can be seen when wells are installed in formations such as those located on the Central Plateau. These deviations are often caused when the driller is trying to achieve production rates too high for the formations. As the drill string rotates and encounters cobbles or other obstructions, it “spins” off the obstruction and begins to deviate from true vertical.

The final element of the well surveys included a new civil survey for horizontal and vertical geolocation. This survey was performed by a registered surveyor and referenced to permanent monuments in order to eliminate survey information as a potential source of error when interpreting groundwater elevation data (Refer to Section 4.2 for a discussion of how true water levels were determined during long-term monitoring activities).

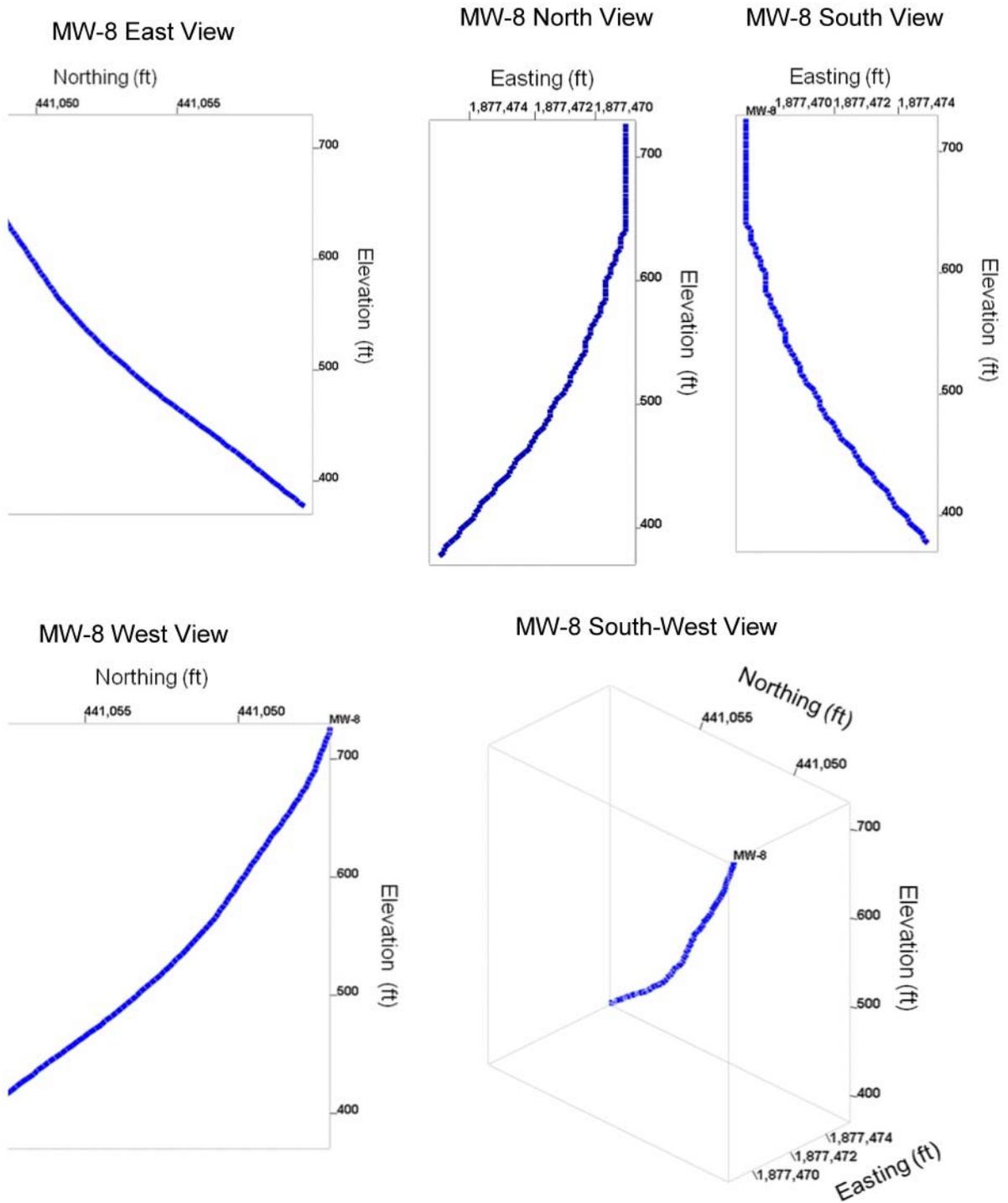


Figure 14 MW-8 Gyroscopic Well Deviation Survey Results

Table 4 Summary of Well Deviation Survey Results

Well	Max Deviation & Depth (degrees, meters)	Depth Measured	Depth Vertical	Difference Measured – Vertical
MW-3	2.1 degrees at 93.5 m	306.678 ft	306.606 ft	0.072 ft
MW-5	3.7 degrees at 94.1 m	308.781 ft	308.725 ft	0.056 ft
MW-8	3.4 degrees at 97.1 m	318.617 ft	318.345 ft	0.272 ft
MW-9	1.3 degrees at 97.5 m	319.985 ft	319.893 ft	0.092 ft
MW-9A	0.8 degrees at 97.5 m	319.952 ft	319.923 ft	0.030 ft
MW-10	1.9 degrees at 98.3 m	322.659 ft	322.600 ft	0.059 ft
MW-13	3.4 degrees at 94.0 m	308.391 ft	308.286 ft	0.105 ft

3.2 Soil Sampling

Soil sampling activities consisted of taking soil samples from boreholes and test pits and analyzing the samples for a variety of chemical and physical properties. Appendix B: Field Activity Reports provides a field activity report for each borehole advanced during the RI field investigation. The field activity reports include relevant sample collection depths, vadose zone well details and other notable borehole details as applicable. Soil samples were collected from the Resin Tank Area decision unit and around the pre-1985 Trench decision unit. These soil-sampling activities were used to characterize the areal and vertical distribution and concentrations of hazardous substances in the soil that may have resulted from historical releases. The sample analysis will provide properties of surface and subsurface soils that are likely to influence the type and rate of hazardous substance migration or which are likely to affect the ability to implement alternative cleanup actions.

Subsurface soil samples were collected using an ES HHR with a Mavik Environmental dual-wall sampler. The HHR (Figure 15) is comprised of a EuroDrill®, HD5012 percussion drilling system with a hydraulically powered mast and hammer mounted on a rubber tire backhoe.



Figure 15 Hydraulic Hammer Rig Advancing a Slant Boring in the Resin Tank Area

The EuroDrill[®] HD5012 was designed for driving anchors and pilings in civil construction projects², but was adapted by ES, for subsurface soil sampling in Hanford Site soils. The HHR pushes a string of inner and outer steel rods into the vadose zone, requiring 450 ft-lbs of energy to advance the rotating head (Figure 16). The outer push tubing is attached to a fluted drive head that rotates with the rods (Figure 17). As is evidenced by the figure, the inner drill rod is connected to a retractable tip that can be retrieved for sampling.

² Personal communication with Mr. Joe Patterson, TEI Rock Drills, January 2, 2007.



**Figure 16 Energy Solutions Operators Adding Additional Drill Rod
Note the Dual Inner and Outer Rods**



***Figure 17 Demonstration Drive Point
Note the Reusable “Dummy” Tip on the Inner Rod***

The inner rod travels within the outer tube and is used to retrieve a sampler holding 594 grams (g) (21 ounces [oz]) of soil. The drill rods are made up of 1.2 m (3.94 ft) long sections attached together to meet the required sample depth. During the sampling activities at the waste site, the HHR rotating head operated at a rate of less than 10 revolutions per minute, although it is capable of rotating up to 68 revolutions per minute (rpm). The rotating rate was optimized to allow for maximum depth of penetration by moving the soil away from the rods using a fluted cone tip. The slower rotational rate minimizes heat and soil disturbance while the cone tip is being advanced, allowing representative soil samples to be collected for volatile organic analysis³. However, the

³ Personal communication with Mr. John Auten, Senior Drilling Engineer, Mavrik Environmental, January 28, 2007.

HHR can only be used in unconsolidated sediments and the maximum depth of penetration is limited by the presence of highly-consolidated or cemented geologic units.

The dual wall system with a “dummy” tip was advanced to a pre-determined sample depth specified in the SAP (VET-1405-PLN-03). The tubing was then back-pulled slightly to relieve pressure from the drive shoe and tip. When a sampling depth was achieved, and the rods were back-pulled for sampling, the removable tip was removed by extracting the inner rods. Upon removal of the inner string of tubing, the sampler was attached to the inner string and returned to the bottom of the outer casing (push tubing), and positioned against the inner receiver face of the drive shoe. The inner and outer tubing strings were then “locked” together by use of a proprietary method, and the entire assembly was advanced through the targeted sample interval. The sampler body holds three stainless-steel liners 3.17 cm (1.25 in) outside diameter (OD) x 2.7 cm (1.08 in) inside diameter (ID). Figure 18 shows a Mavik Environmental fluted drive tip and inner sampler tube assembly.

The HHR, as with most direct push technology approaches, does not bring soil cuttings to the surface. This is important at mixed-waste and radiologically contaminated sites where waste minimization is a high priority. The only soil brought to the surface using the HHR are depth-discrete soil samples obtained specifically for analytical purposes. In addition to obtaining depth-discrete soil samples, the HHR was used to install 30 GeoInsight® soil vapor monitoring wells with a screen depth ranging from 1.5 m to 27.4 m (5 ft to 90 ft) bgs.

Once the full sampler was at the surface, it was field surveyed for radiological contamination prior to extracting the liners. The liners were removed from the sampler body and field surveyed for radiological contamination a second time. Trained, sample-handling technicians documented the sample recovery, condition, and percent of volume recovered. A picture of the sample was taken with the sample number, date, and depth (Figure 19). The technicians packaged the sample for shipment to the selected laboratory for analysis.

After a designated sample was collected, the “dummy” tip was reattached to the inner string, returned to the bottom, and placed inside the casing shoe. The entire assembly was then advanced to the next designated sample depth, and the process was repeated until the sample depths were achieved or the tubing met push refusal. Upon completion of the final sample extraction or upon reaching refusal, the dummy tip or sampler was removed and the borehole was decommissioned per requirements of Chapter 173-160 WAC, “Minimum standards for construction and maintenance of wells,” which consisted of placing bentonite clay crumbles down the outer rods from the ground surface as the rods were withdrawn.



Figure 18 Demonstration of the Mavik Environmental Sampler

Soil sampling was conducted 30 January 2008 through 20 May 2008. Soil samples were collected, packaged and shipped in accordance with *Standing Operating Procedure for Soil Sampling on the US Ecology Site RI/FS* (VET-1405-PRO-01) to ensure sample collection, handling, and analysis would result in data of sufficient quality to plan and evaluate remedial actions at the site. Ecology personnel also collected split samples that were submitted to accredited laboratories of analyses. WDOH collected supplemental soil samples for radiological constituent analysis concurrently with the MTCA RI for chemical constituent analysis. However, radiological constituent results are not provided in this RI Report.



Figure 19 Documentation of Sample Collection

3.2.1 Pre-1985 Trench Decision Unit Activities

There were 18 boreholes advanced within the pre-1985 Trench Area to collect soil samples (see Figure 20). These borings were intended to measure the concentrations of potential contaminants that may have migrated from the waste packaging inside the trenches.

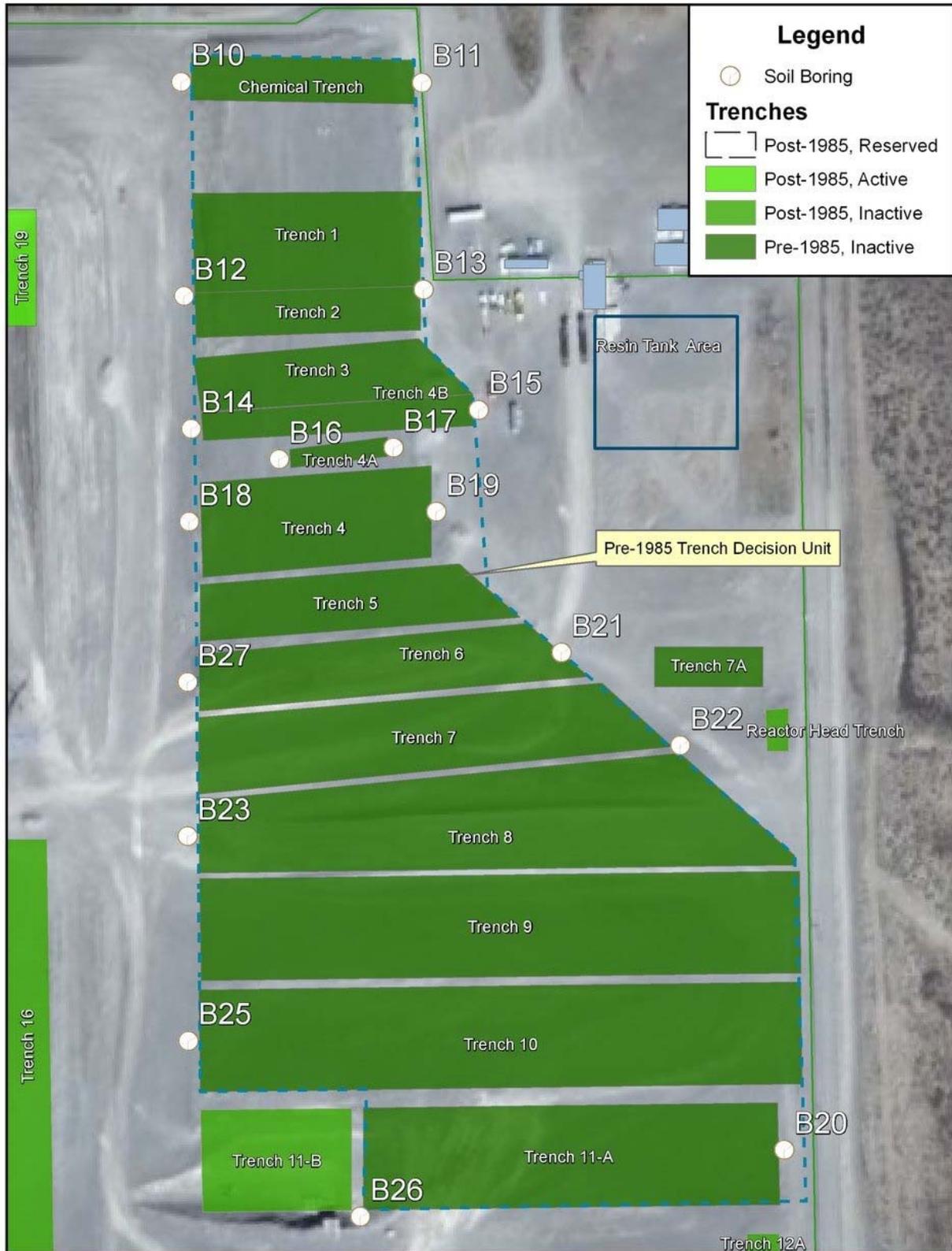


Figure 20 Soil Boring Locations in the Pre-1985 Trench Decision Unit

In many locations throughout this decision unit, a “resistive” zone was encountered during drilling between 19.8 to 27.4 m (65 to 90 ft) bgs. The depth was variable depending upon the overburden depth and location. A sample of this material was retrieved and examined; the soil was a silty-sand, with a light tan/gray, gray white appearance. It had moderate to poor sorting with less than 5 percent coarse-grained, 10 percent medium-grained, 70 to 75 percent very fine-grained, and 5 to 15 percent silt material. The soil was moderate to well compacted with calcium carbonate (CaCO_3) and intergranular CaCO_3 cementing. It was approximately 60 to 70 percent quartz, 15 to 25 percent basalt grains, approximately 5 percent mica (both biotite and muscovite), pyrite, trace pyrite, and some interstitial iron staining. The resistive zone had moderate to strong hydrochloric acid reaction. There were calcium carbonate blebs/mottling, with a white to light gray color and interstitial silt/clay sized white material. This soil is interpreted as a moderately well developed Paleosol with very fine-grained and variably cemented (some zones or areas are well cemented while others are moderate to poorly cemented). The fine grain size and interstitial materials (silt and CaCO_3) made displacement with the HHR difficult. The variability of the cementation/compaction would account for the changing success rate when attempting to push through the vadose zone and shallow refusal in one case resulting in a sample planned but not collected.

3.2.2 Resin Tank Area Decision Unit Soil Sampling

A Ground Penetrating Radar (GPR) Survey was performed by hydroGEOPHYSICS, Inc. at the Resin Tank Area to confirm the locations of the three remaining 1960s buried tanks prior to drilling in this area. The survey was performed on May 8, 2008.

HydroGEOPHYSICS, Inc. established a survey grid covering the area of the estimated tank locations with a 200 MHz GPR antenna. A plan view map of the site with centerlines and endpoints of each tank was the anticipated deliverable. However, the GPR data collected during the survey was unsuccessful in locating the resin tanks for a number of technical issues noted in Appendix C: Groundwater Penetrating Radar Report. Because the GPR survey was inconclusive, existing as-built drawings and conservative approach distances were utilized to provide a sufficient safety factor for advancing the two slant borings.

Six vertical boreholes were drilled in the Resin Tank Area to collect soil samples. Two slant boreholes were installed to sample soils directly below the resin tanks. Borehole B-1, north of Tank 3 was drilled 35° from horizontal/55° from vertical, advancing towards the south. Borehole B-2, south of Tank 1 was drilled 64° from horizontal/26° from vertical, advancing toward the north. Ten shallow test pits were dug with the HHR bucket in order to sample the soils at the interface between the fill material and native soils. These samples were designed to investigate the impacts of the flood event that occurred in the Resin Tank Area. Figure 21 shows the locations of the shallow test pits, and slant, and vertical boreholes around the Resin Tank Area.

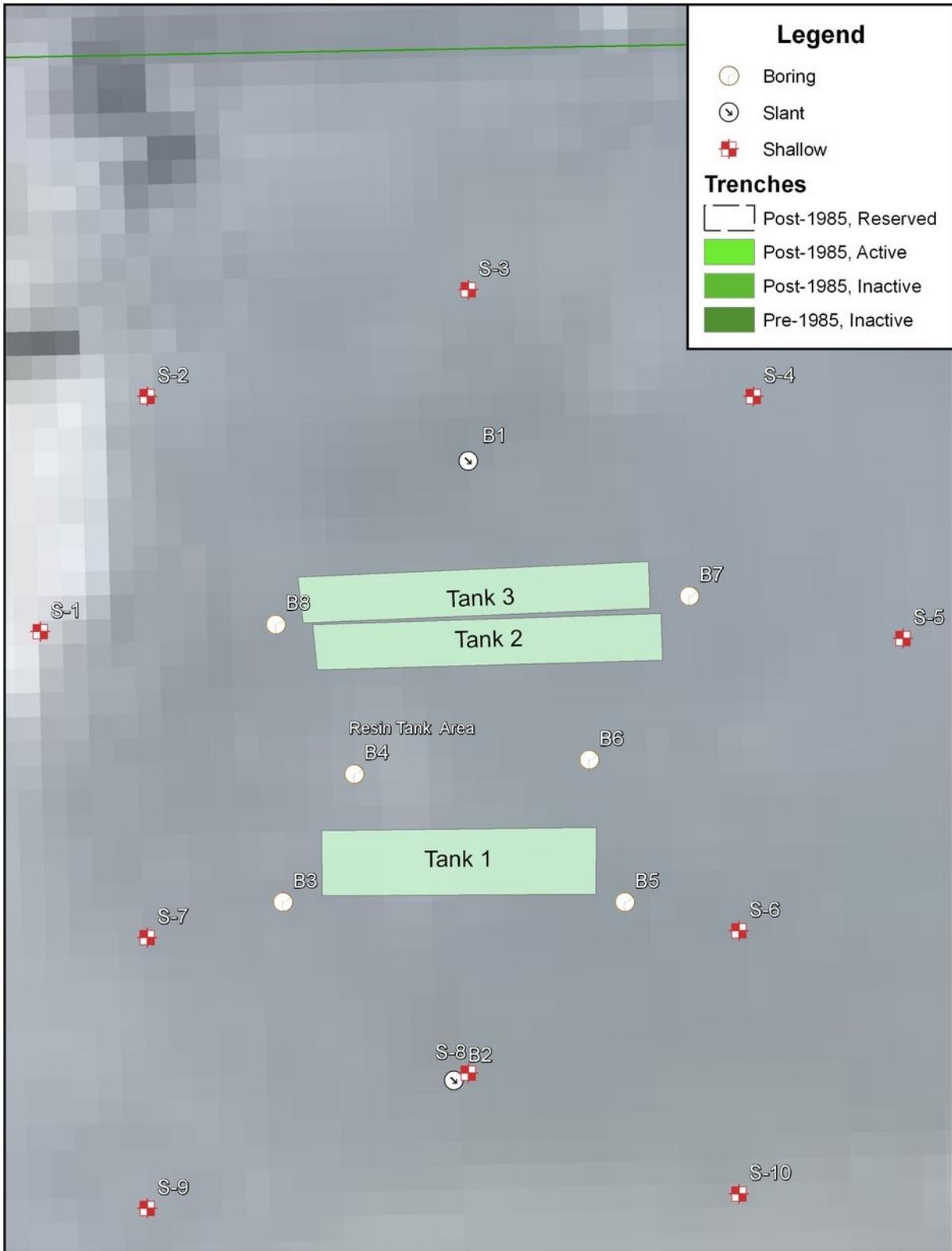


Figure 21 Locations of Resin Tank Soil Samples

3.2.3 Soil Sample results

There were 133 of the 134 soil samples specified in the SOW (USE, 2006) that were successfully collected for the following analyses: volatile organic compounds (VOCs), anions, metals, semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phenols, and cyanide as specified in the SAP (VET-1405-PLN-03). Table 5 provides a summary of the laboratory analyses performed by Lionville Laboratory, Inc. (LVL), in Lionville, Pennsylvania. Because a methods-based target analytical approach was required for this investigation, 226 individual analytes were reported. A total of 27,358 soil sample chemical analytical results were generated from the soil sampling campaign. Of these results, only 969 results were flagged as detects. Of the 969 detects:

- 203 were flagged as estimated non-detects during data validation;
- an additional two results were rejected during validation; and
- 54 results were flagged as estimated detects below the quantitation limit.

Analytical results for soil samples are presented in Appendix D: Soil Sample Results. Data validation and data quality assessment are described in Section 5.0. The process used to screen analytes to identify potential contaminants of concern is described in detail within Section 6.0. Quality control samples were also collected as outlined in the SAP (VET-1405-PLN-03). These included: matrix spike (MS), matrix spike duplicate (MSD), field duplicate (FD), trip blanks (TB), and equipment rinsate (ER). A summary by sample type is presented in Table 6.

In addition to the chemical analyses, fourteen samples were analyzed for physical properties including: total soil porosity, bulk density, dry soil bulk density, grain size analysis, plastic limits, pore size distribution, moisture content, pH, cation-exchange capacity, fine (percent <200 mesh), and fraction soil organic carbon. Shaw Environmental analyzed physical properties samples; the results are available in Appendix E: Physical Soil Sample Results.

Table 5 Summary of Analytical Methods

Analyte	Method	Preservation
Anions	9056	Cool to 4°C
Anions, Sulfide	9030B	Cool to 4°C
Cyanide	9010A	Cool to 4°C
Metals, ICP	6010B	Cool to 4°C
Metals, Mercury	7470A/7471A	Cool to 4°C
Metals, Hexavalent Chromium	7195 or 7196A or 7197 or 7198	Cool to 4°C
Metals, Uranium	ASTM D5174 or 6010B	Cool to 4°C

Table 5 Summary of Analytical Methods

Analyte	Method	Preservation
Volatile Organic Compounds	8260B	SW-846, Method 5035A, cool to 4°C
Semi-Volatile Organic Compounds	8270C	Cool to 4°C
Polynuclear Aromatic Hydrocarbons	8270C	Cool to 4°C
Polychlorinated Biphenyls	8082	Cool to 4°C
Phenols	9065	Cool to 4°C

Table 6 Soil Sample Breakdown

Sample Type	Number of Samples
Borehole "Real" Samples	123
Shallow Soil Samples	10
Field Duplicates	7
Equipment Rinsates	8
Matrix Spike/Matrix Spike Duplicates	7/7
Trip Blanks	37
Physical Properties Samples	14
Total Number of Soil Samples	213

During past soil borings in the Resin Tank Area, there was a correlation made between radiation levels and discolored soils beneath the underground tanks. During current soil sampling activities only one soil sample collected for the RI field investigation in the Resin Tank Area had field-detectable radiological contamination. Sample B148 was collected from Borehole B-2A, the slant borehole south of Tank 1 from a depth of 25 to 27 ft bgs (31 to 33 ft bgs on slant). As a result, a subset of this sample additionally had total alpha, total beta, and gamma analysis performed by Test America, Richland, Washington. Cobalt-60 was detected at 30.9 pCi/g and Potassium-40 was detected at 12.8 pCi/g. Only trace amounts (<1 pCi/gm) of other gamma emitting radionuclides were detected. Alpha was undetected. Gross Beta was detected at 19.3 pCi/g. The remaining sample was shipped for chemical analysis.

3.3 Vadose Zone Soil Gas Monitoring Well Installation

Thirty vadose zone soil-gas monitoring wells were installed as part of the RI field investigation in accordance with the SAP (VET-1405-PLN-03) and the SOW (USE, 2006). Except for one

location, vadose zone wells were installed upon completion of soil sample collection at each location. No soil was collected at location VW-3, and only vadose zone wells were installed. The HHR pulled back and constructed a soil vapor monitoring well using GeoInsight® well components as previously discussed in Section 3.2. Figure 22 through Figure 25 depict the installation of vadose zone well VW-1-46, which is typical for other wells installed during this project. Figure 26 depicts the locations where soil-gas monitoring wells were installed. At each location, three vadose zone wells were installed approximately 0.6 m (2 ft) apart. Each well was completed at variable depths. Vadose zone wells were installed at the depth specified in the SOW (USE, 2006), except at VW-4 where the completion depth was adjusted to account for current overburden conditions. Table 7 provides the depths of each vadose zone well installed as part of this RI. The results and techniques used during vadose zone soil gas sampling are described in Section 4.0.

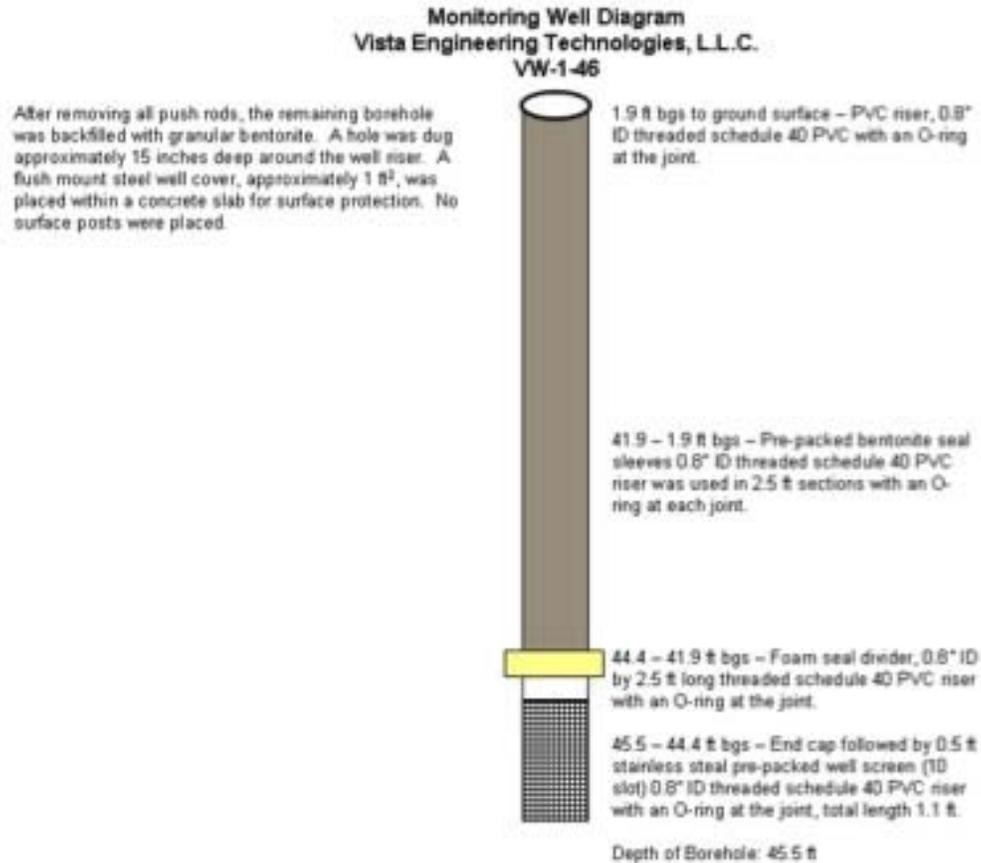


Figure 22 Vadose Zone Well VW-1-45 Diagram.



Figure 23 Geolnsight Vadose Zone Screen Readied for Installation



Figure 24 Well Screen and Casing Being Lower for Installation



Figure 25 Well-Installed and Readied for Surface Completion

Table 7 Remedial Investigation Installed Vadose Zone Wells

HHR Push	Well ID	Well Depth (ft)	Well Depth (m)
B11B	VW-6-5	5	2
B11C	VW-6-20	21	6
B11D	VW-6-65	65	20
B12A	VW-7-76	77	23
B12B	VW-7-36	32	10
B12C	VW-7-6	7	2
B13A	VW-5-75	75	23
B13B	VW-5-30	31	9
B13C	VW-5-5	6	2
B17A	VW-4-76	77	23

Table 7 Remedial Investigation Installed Vadose Zone Wells

HHR Push	Well ID	Well Depth (ft)	Well Depth (m)
B17B	VW-4-31	32	10
B17C	VW-4-16	17	5
B20A	VW-8-75	76	23
B20B	VW-8-30	31	9
B20C	VW-8-5	6	2
B21A	VW-2-75	75	23
B21B	VW-2-30	30	9
B21C	VW-2-5	5	2
B24A	VW-1-90	91	28
B24B	VW-1-45	46	14
B24C	VW-1-5	6	2
B25B	VW-9-90	91	28
B25C	VW-9-45	46	14
B25D	VW-9-5	6	2
B26A	VW-10-90	91	28
B26B	VW-10-45	46	14
B26C	VW-10-5	6	2
NA	VW-3-85	86	26
NA	VW-3-40	41	12
NA	VW-3-5	6	2

HHR = Hydraulic Hammer Rig



Figure 26 Vadose Zone Monitoring Locations

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4.0 Long-Term Monitoring

Long-term monitoring activities included periodic sampling of USE Site groundwater, as well as existing and newly installed vadose zone soil gas monitoring wells. The purpose of this sampling program is to evaluate potential changes that may occur in the concentration and distribution of contaminants within the vadose zone soil gases, or in the groundwater over a 2-year period.

Long-term monitoring includes quarterly sampling of both vadose zone wells and groundwater monitoring wells for eight consecutive quarters. All sampling is complete and the following sections discuss the long-term monitoring data collection process. These results are combined with the field investigation results reported in the previous section to build the analytical results data set that will be used in the following sections for screening of potential contaminants of concern and establishing the nature and extent of those constituents.

4.1 Vadose Zone Soil Gas Sampling

Thirty vadose zone wells were installed as part of the RI field investigation (Section 3.3). Eleven vadose zone wells in place prior to the RI were also sampled as part of the long-term monitoring program. Of the eleven existing wells, four wells are around the Chemical Trench and five wells are located around Trench 5. One well was installed near Trench 10 and the final existing well is located out of the fenced area on the USE Site. Soil gas samples were collected from around the pre-1985 Trench Areas. The RI sought to adequately characterize the areal and vertical distribution and concentrations of volatile organic compounds in the vadose zone due to historic release.

Soil gas sampling commenced in June 2008. Each of the 41 vadose zone wells was monitored for 8 consecutive quarters to categorize seasonal variations and identify long-term trends. Subsurface air samples were collected into specially prepared summa canisters and analyzed for VOCs by Gas Chromatography/Mass Spectrometry in accordance with Method TO-15. Soil gas samples were collected, packaged, and shipped in accordance with the *Standing Operating Procedure on TO-15 Sampling for the US Ecology Site RI/FS* (VET-1405-PRO-03) to ensure sample collection, handling, and analysis would result in data of sufficient quality. Figure 27 and Figure 28 show soil gas samples being collected. Figure 29 is a picture of two vadose zone wells in place prior to the RI and Figure 30 is a picture of a vadose zone well installed as part of the RI.



Figure 27 A Vista Engineering Personnel Collecting a Soil Gas Sampling from a New Vadose Zone Well



Figure 28 Sample Train Installed on an Existing USE Vadose Zone Well



Figure 29 Vadose Zone Wells T-51 and T-52



Figure 30 Vadose Zone Well VW-8

4.1.1 Soil Gas Sample Results

Over the course of the long-term monitoring period, soil vapor samples were collected and analyzed in accordance with Method TO-15 by Southwest Research Institute in Texas. Because of the methods-based target analytical approach used on this project, approximately 53 constituents were reported for each sample, depending on the number of tentatively identified compounds reported for a given sample. A total of 25,428 results have been reported for the eight quarters of soil gas sampling. Of the 25,428 results, 0 (0%) were estimated, 65 (≈0.3%) results were rejected during validation and no (0%) reported detects were qualified as nondetects. Analytical results for soil gas samples are presented in Appendix F: Soil Gas Sample Results. Data validation and data quality assessment is described in Section 5.0. The process used to screen analytes to identify potential contaminants of concern is described in detail within Section 6.0. Two Field duplicate (FD) QC samples were also collected per quarter as outlined in the SAP (VET-1405-PLN-03). A summary breakdown of sample types is presented in Table 8.

Table 8 Soil Gas Sample Breakdown

Sample Type	Number of Samples
Normal "Real" Samples	350
Field Duplicates	16
Matrix Spike/Matrix Spike Duplicates	0
Trip Blanks	0
Total Number of Soil Gas Samples	366

4.2 Groundwater Samples

The RI groundwater monitoring activities consisted of sampling seven existing wells for chemical analysis. Groundwater samples were collected throughout the USE Site. Long-term monitoring activities are intended to characterize the areal and vertical distribution and concentrations of hazardous substances in the groundwater due to historic release. The groundwater sampling commenced in February 2008. USE monitoring wells were monitored for eight consecutive quarters.

Figure 31 illustrates the location of sampled monitoring wells. At the conclusion of collecting samples at each well, the pH, temperature of water, and specific conductivity were recorded (Table 9). Groundwater samples were collected, packaged, and shipped in accordance with the Standing Operating Procedure for Groundwater Sampling on the USE Site RI/FS (VET-1405-PRO-04) to ensure sample collection, handling, and analysis would result in data of sufficient quality to plan and evaluate remedial actions at the site. See Figure 32 and Figure 33 for an example of groundwater sample collection. Samples were shipped daily to the accredited laboratory for analyses. Matrix spike (MS), MSD, and FD QC samples were also collected as outlined in the

SAP (VET-1405-PLN-03). Quarterly groundwater data collected are included in Appendix H: Groundwater Sample Results.

Table 9 Quarterly Groundwater pH, Temperature and Specific Conductivity

Well Number	Date/Time of Sample	pH	Temperature (°C)	Specific Conductivity (micromhos)
MW-3	28 Feb 08/ 1201	7.67	20.4	390
MW-3	7 May 08/ 1239	7.76	21	370
MW-5	27 Feb 08/ 0920	7.65	19.7	430
MW-5	6 May 08/ 1335	7.62	21.5	390
MW-5	6 May 08/ 1335	7.62	21.5	390
MW-8	27 Feb 08/ 1158	7.77	19.6	410
MW-8	7 May 08/ 0756	7.63	20.7	400
MW-9	26 Feb 08/ 1121	7.48	20.1	430
MW-9	6 May 08/ 1003	7.6	22.4	370
MW-9A	26 Feb 08/ 1338	7.57	20.8	400
MW-9A	6 May 08/ 1210	7.69	22.7	380
MW-10	28 Feb 08/ 0922	7.52	19.7	400
MW-10	28 Feb 08/ 0922	7.52	19.7	400
MW-10	7 May 08/ 1034	7.57	21.2	390
MW-13	26 Feb 08/ 0933	7.51	20	390
MW-13	6 May 08/ 0814	7.53	21.9	370



Figure 31 Locations of Groundwater Monitoring Wells



Figure 32 Water Level Measurement and Groundwater Sampling



Figure 33 Groundwater Sample Collection

4.2.1 Ground Water Results

Groundwater samples have been analyzed for the following constituents: VOCs, SVOCs, PAHs, PCBs, anions, chromium VI, sulfide, metals, mercury, uranium, phenols, and cyanide in accordance with the SAP (VET-1405-PLN-03). Table 10 provides a summary of the laboratory analyses performed by LVL. Because a methods-based target analytical approach was required for this investigation, 195 individual analytes were reported. A total of 17,881 analytical results have been generated from the groundwater sampling campaign. Of these results, only 1850 results (≈10%) were flagged as estimated values. 60 results (≈0.3%) were rejected and 12 results (≈0.07%) were reported as detect and qualified as non-detects. Analytical results for soil samples are presented in Appendix H: Groundwater Sample Results. Data validation and data quality assessment is described in Section 5.0. The process used to screen analytes to identify potential contaminants of concern is described in detail within Section 6.0. MS, MSD, FD, and TB QC samples were also collected as outlined in the SAP (VET-1405-PLN-03). A summary breakdown of sample types is presented in Table 11.

Table 10 Summary of Analytical Methods

Analyte	Method	Preservation
Anions	9056	Cool to 4°C
Anions, Sulfide	9030B	ZnAc/NaOH
Cyanide	9010A	NaOH
Metals, ICP	6010B	HNO ₃
Metals, Mercury	7470A/7471A	HNO ₃
Metals, Hexavalent Chromium	7195 or 7196A or 7197 or 7198	HNO ₃
Metals, Uranium	ASTM D5174 or 6010B	HNO ₃
Volatile Organic Compounds	8260B	HCl
Semi-Volatile Organic Compounds	8270C	Cool to 4°C
Polynuclear Aromatic Hydrocarbons	8270C	Cool to 4°C
Polychlorinated Biphenyls	8082	Cool to 4°C
Phenols	9065	H ₂ SO ₄

Table 11 Groundwater Sample Breakdown

Sample Type	Number of Samples
Normal "Real" Samples	64
Field Duplicates	8
Matrix Spike/Matrix Spike Duplicates	8/8
Trip Blanks	10
Total Number of Groundwater Samples	98

4.2.2 Analysis of Groundwater Flow Direction

4.2.2.1 Regional Water Levels

The average water-level elevations measured in 19 wells within the 200 East Area suggest water levels in this area have declined by an average of 0.07 m (0.23 ft) from March 2005 through April 2006. These data were corrected for borehole deviation from vertical (PNNL-16346).

The slight decline in the 200 East Area is in comparison to no change in the average water level at the USE Site from the first quarter 2005 to first quarter 2006. The 200 East decline over this time period is less than the previous annual decline (0.13 m [0.4 ft] from March 2004 to March 2005), and is below the average rate of decline observed from June 1997 to March 2002 (0.17 m/yr [0.56 ft/yr]) (PNNL-16346). Beginning in the fall of 2002, the rate of water-table elevation decline in the 200 East Area and vicinity slowed significantly, with water levels actually increasing in some wells.

The discussions in PNNL-16346 regarding 200 East area water levels provide a basis for understanding the observations at USE. Groundwater flow in the central portion of the Hanford Site, encompassing the 200 East Area, is significantly affected by the presence of a buried flood channel, which lies in a northwest to southeast orientation. The water table in this area is very flat (i.e., the hydraulic gradient is estimated to be $\sim 10^{-5}$) due to the high permeability of the Hanford formation. The flat nature of the water table (i.e., very low hydraulic gradient) in the vicinity of the 200 East Area makes determination of the flow direction difficult. This is because the uncertainty in the water-level elevation measurements is greater than the actual relief present on the water table.

4.2.2.2 US Ecology Site Water Levels

A review of groundwater levels 1993 through 2008 collected by USE technicians show an average decrease in slope of water levels of 0.1 m/yr (0.32 ft/yr). The two southernmost wells, MW-9 and MW-9A were installed and data collection started the second quarter 1997. MW-13 data from 1998 and 1999 was omitted from comparison due to a bad sounding tape. This problem was limited to MW-13 as each well uses its own sounding device. An updated water-level map was

developed by using the water level monitoring data from USE wells that had been corrected for the deviations reported in Section 3.1. These corrected water levels correlate nicely with those water levels recorded at nearby off-site wells (Figure 34). Figure 35 through Figure 41 graphically show the decrease in water level of each of the seven wells present on the USE Site from 1993 through 2008 (these graphs have not been corrected for deviations).

The hydraulic gradient was determined for USE water levels in May 2008. The water level elevations were 123.8 m (406.10 ft) at MW-13 and 122.0 m (400.22 ft) at MW-8. From MW-13 to MW-8, the hydraulic gradient was 0.00405 ft/ft. Using values for hydraulic conductivity and effective porosity for the Unit E Member of the Ringold Formation, a groundwater flow velocity can be calculated using Equation 1.

$$\text{Equation 1} \quad V = \frac{K}{n_e} \left(\frac{dh}{dl} \right)$$

Vista Engineering maintains a large suite of hydrogeologic parameters used for groundwater modeling on the Central Plateau, all of which have been tested and validated (for which good agreement has been shown between modeled and actual results) in Appendix D of *Feasibility Study for 200-ZP-1 Groundwater Operable Unit* (DOE/RL-2007-28). Using the mean values in Table 12, and completing the calculation above, a local groundwater velocity of 0.6075 m/day (2 ft/day) was calculated.

Table 12 Hydrogeologic Parameters Used for Calculating Groundwater Velocity

Parameter	Units	No. of Measurements	Minimum	Maximum	Mean	Standard Deviation
Effective porosity	cm ³ /cm ³	64	0.02	0.46	0.14	0.10
Hydraulic conductivity	m/day	244	8.E-05	1280	21	96

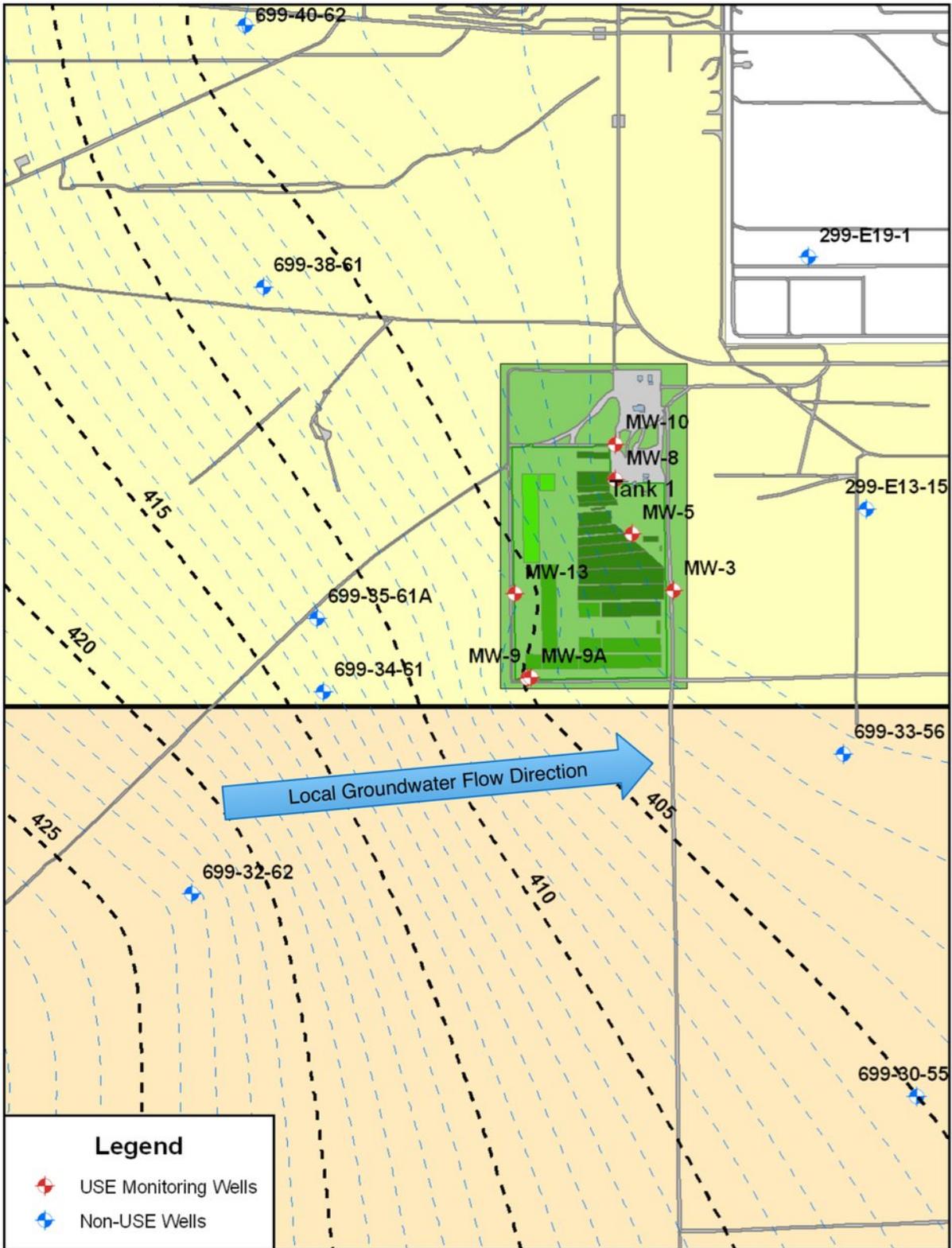


Figure 34 Corrected Site Water Levels from both USE and Non-USE Wells

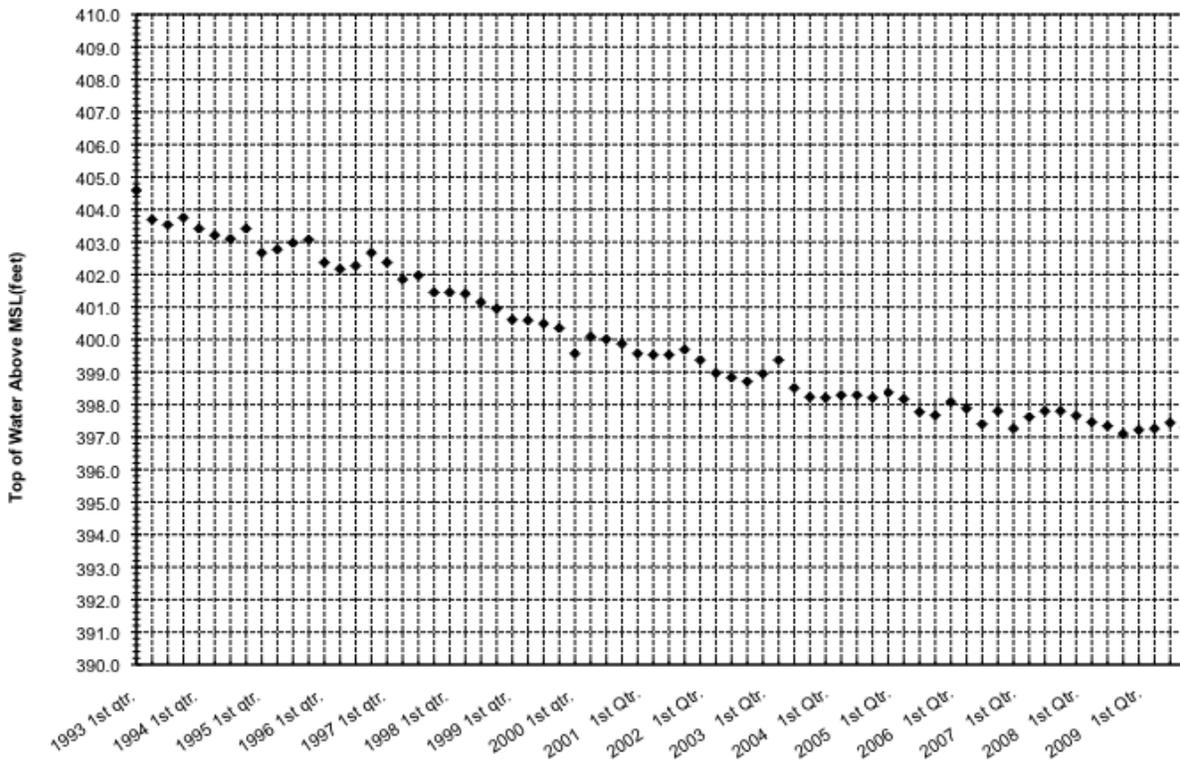


Figure 35 MW-3 Water Levels 1993-2009

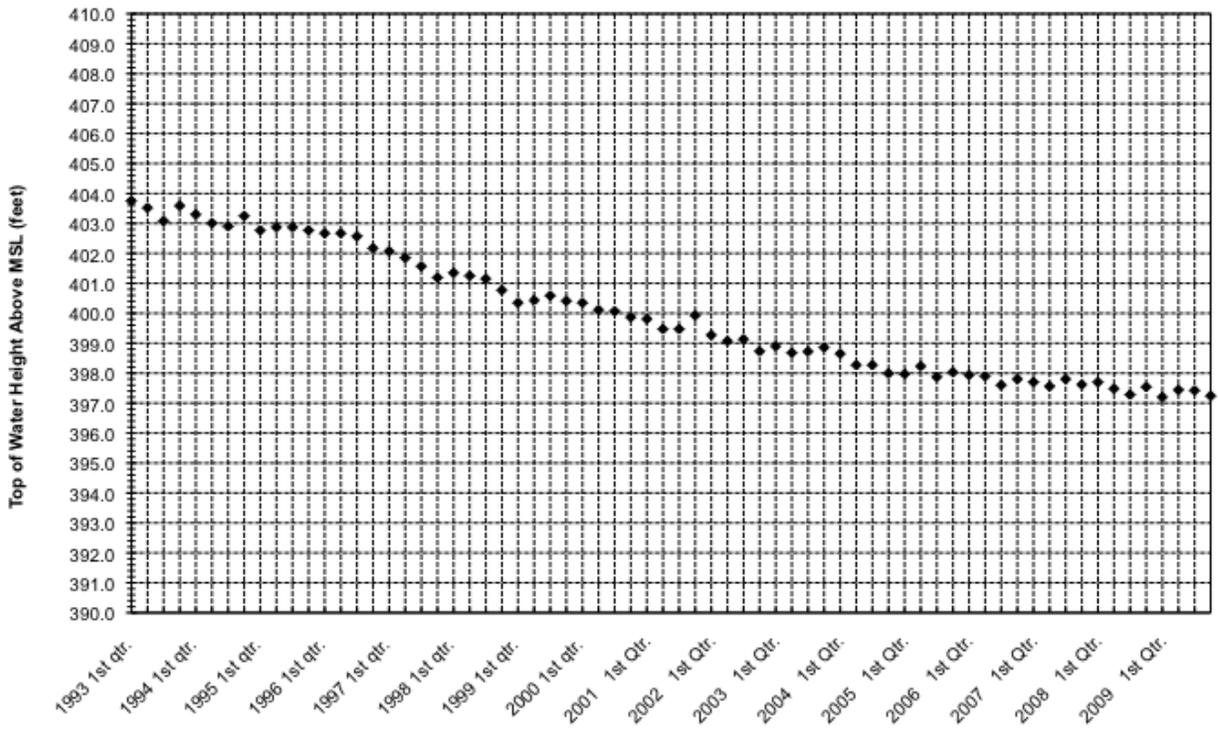


Figure 36 MW-5 Water Levels 1993-2009

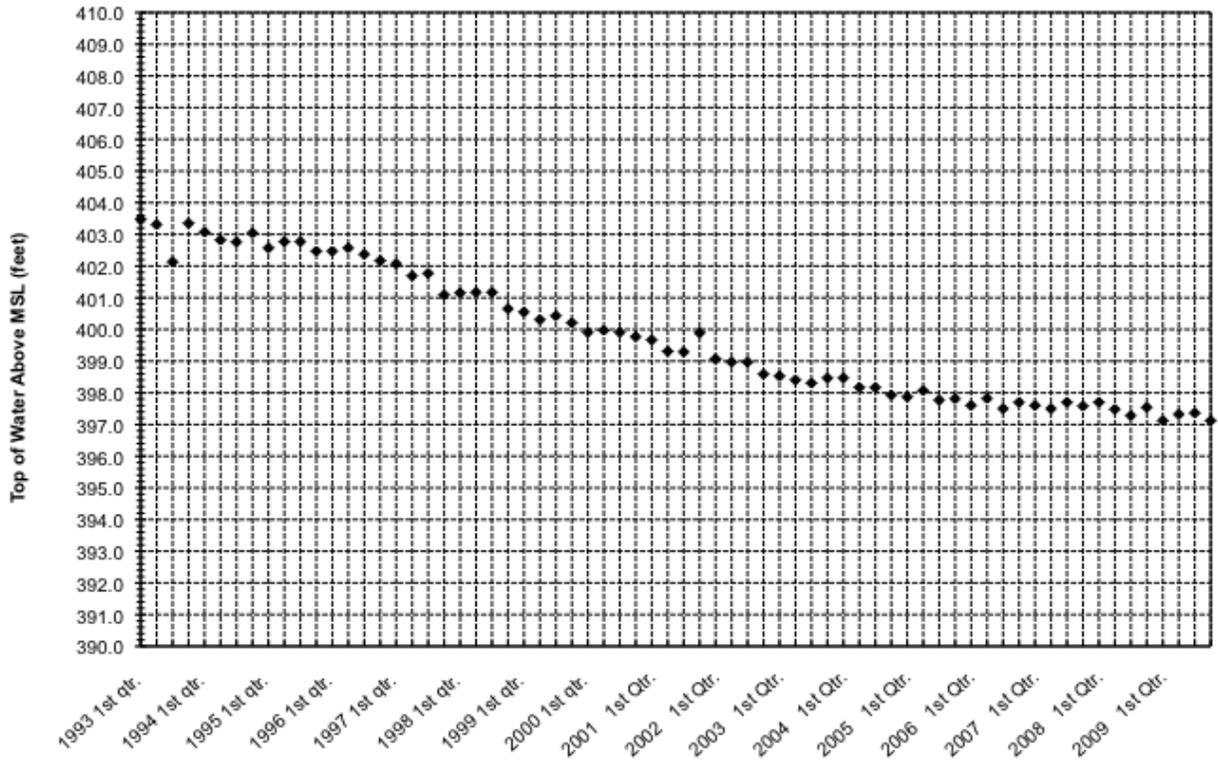


Figure 37 MW-8 Water Levels 1993-2009

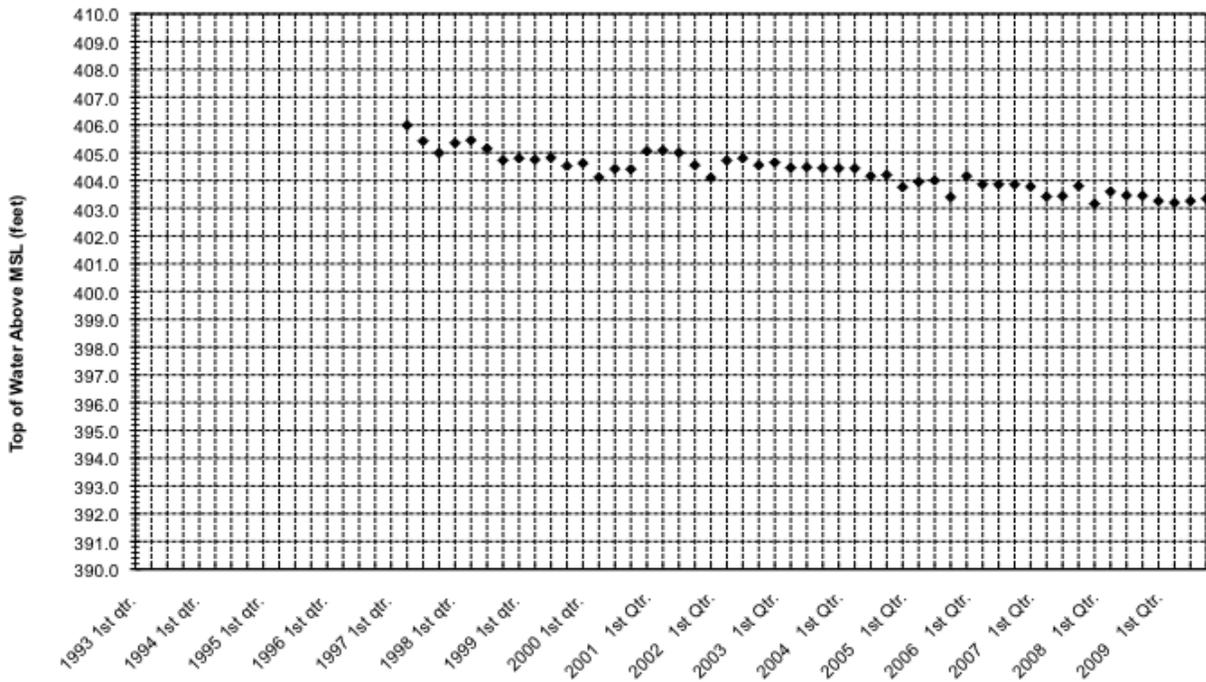


Figure 38 MW-9 Water Levels 1997-2009

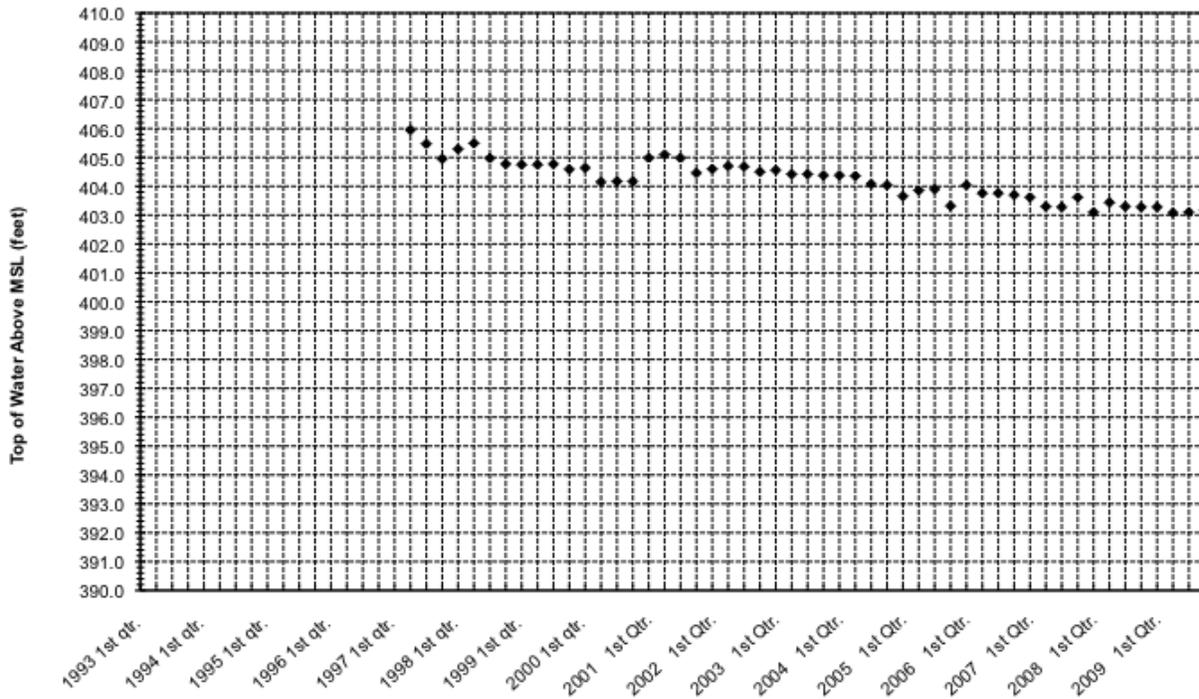


Figure 39 MW-9A Water Levels 1997-2009

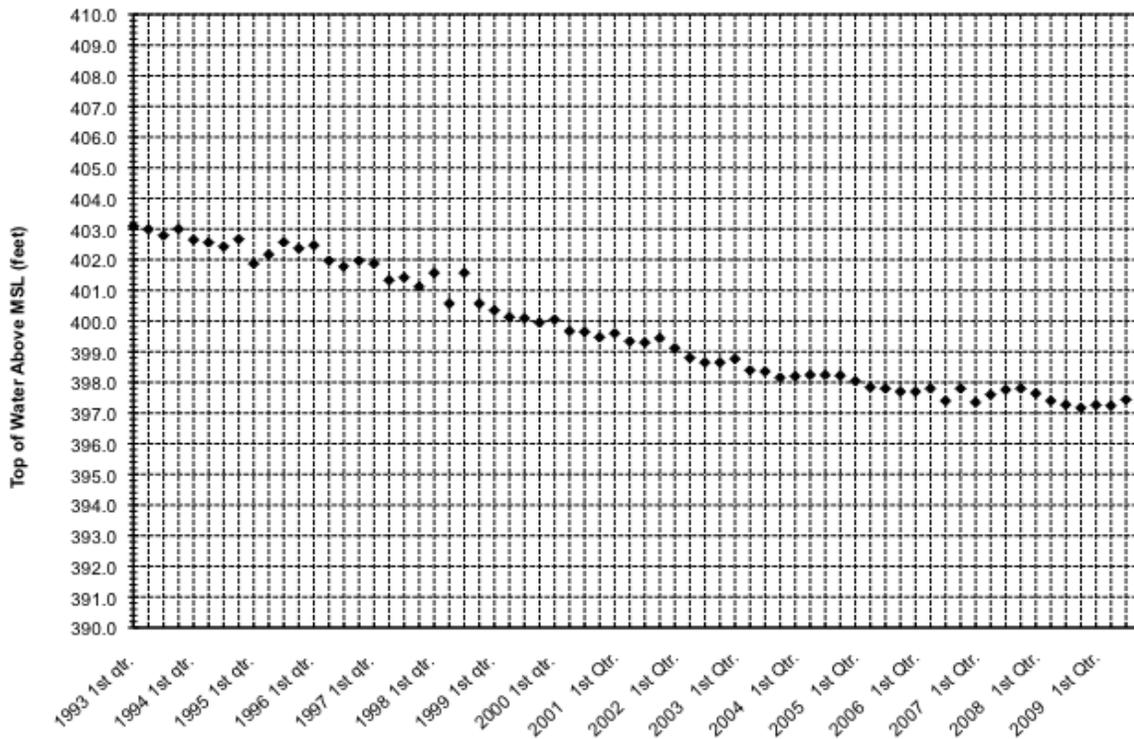


Figure 40 MW-10 Water Levels 1993-2009

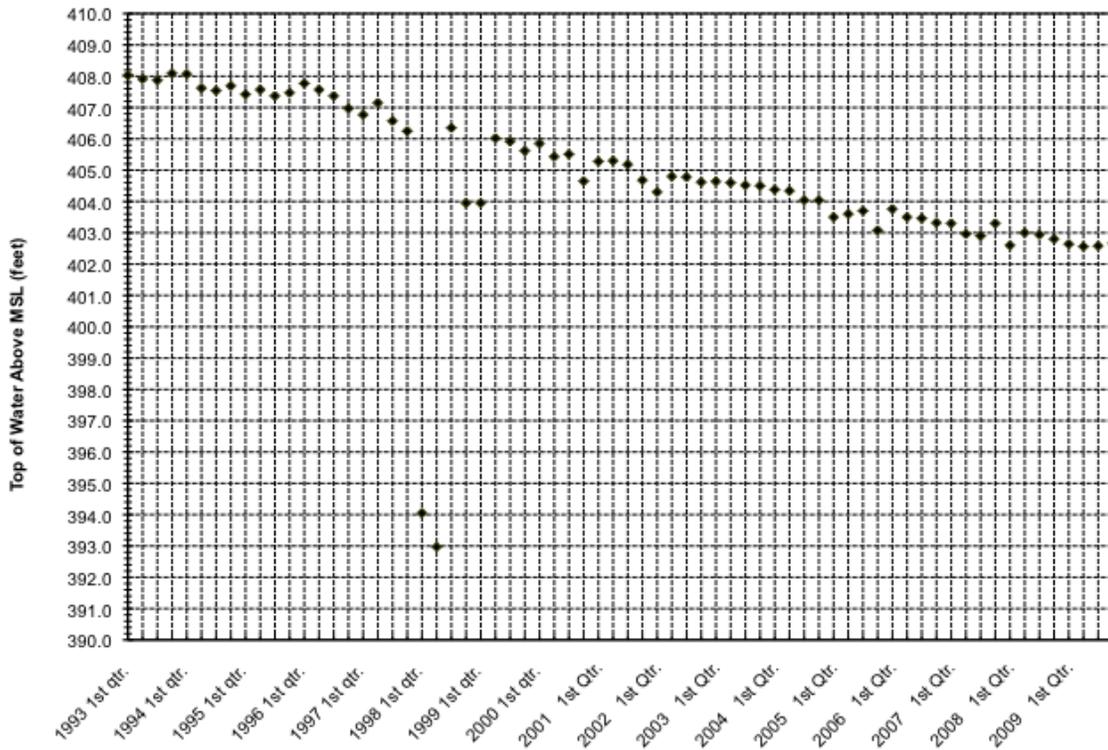


Figure 41 MW-13 Water Levels 1993-2009

4.3 Waste Management

Personnel contamination prevention efforts included the appropriate engineering and administrative controls. In place was a *Health and Safety Plan for the US Ecology Site RI/FS* (HASP; VET-1405-PLN-04), if an event had occurred where personnel were to become contaminated.

Decontamination and radiological release of equipment followed the USE procedures for equipment release from the site, ROP-44, *Richland Operating Procedure – Decontamination of Operational Equipment* and ROP-45, *Richland Operating Procedure – Transport Vehicle Decontamination*.

Whenever practicable, new, disposable sampling equipment was used to collect each sample to eliminate the need for cleaning and prevent the cross-contamination of samples. Where it was not practical to use disposable sampling equipment, pre-operational cleaning of sampling equipment followed *Standing Operating Procedure for Pre-Operational Cleaning of Sampling Equipment on the US Ecology Site RI/FS* (VET-1405-PRO-06).

4.4 Records

Project records generated as part of the field investigation are managed in accordance with the QAPjP (VET-1405-PLN-02) and *Standing Operating Procedure for Record Keeping on the US Ecology Site RI/FS* (VET-1405-PRO-05) for recording keeping and kept on file at the Vista Engineering Technologies, LLC (Vista Engineering), office in Richland, WA. Project records include chain of custody (COC) forms, monitoring logs, analytical packages, correspondence, inspection/audit records, field logbooks, nonconformance reporting and sample photos.

5.0 Data Validation

5.1 Methodology

Environmental Quality Management, Inc. (EQM) and Dade Moeller & Associates (Dade Moeller) performed data validation and assessment according to the specifications required by MTCA and as described in the QAPjP (VET-1405-PLN-02). The validation protocol was based on the EPA Functional Guidelines for Organic and Inorganic Methods using the current version of the validation requirements used at the Hanford Site. The DQO Report (EQM, 2003) specified the use of Level C in *Data Validation Procedure for Chemical Analysis* (BHI-01435) which is based on the EPA Functional Validation Guidelines. Per the DQO Report, 10 percent of the data was validated per Level C, unless more extensive validation was required or requested. Since publication of the DQO Report, BHI-01435 has been updated and released as HNF-20433, which is used at Hanford on a site-wide basis. Level C provides an evaluation of the data review performed by the laboratory and a summary of QC as listed in the bulleted items below. The validation included:

- Verification of the required deliverables, requested versus reported analyses, evaluation of requested versus achieved detection limits, and evaluation and qualification of results based on analytical holding times.
- Verification of transcription errors, and evaluation and qualification of results based on method blank result criteria.
- Validation, evaluation, and qualification of sample results based on matrix spike, laboratory control sample, and laboratory duplicates or matrix-spikes/matrix-spike duplicates (as appropriate to the method).
- Field blanks and field duplicates. Per the DQO Report (EQM, 2003), should significant problems such as method blanks with contamination well above allowable limits occur, more extensive validation (such as Level D) may be required.
- Electronic data deliverables were used for data validation, minimizing data entry.

5.2 Data Validation Results

Data validation was performed for chemical soil, soil gas and groundwater samples collected as part of the RI field investigation and long-term monitoring efforts. The results of the data validation reports are summarized below and can be found in full in Appendix I: Data Validation Reports. The results of each data validation package are described in the following subsections.

Samples were collected from the USE Site according to the SAP (VET-1405-PLN-03). Samples were analyzed for metals (including mercury), chromium (VI), cyanide, sulfide, inorganic anions, total phenols, PCBs, VOCs, and SVOCs.

Analyses were conducted by LVL following the *Specification for Analytical Laboratory Services: Soil and Water Analysis* (VET-1405-SPEC-03) and the SAP. Soil gas analyses were conducted by Southwest Research Inst. (SwRI) in accordance with *Specification for Analytical Laboratory Services: Select Soil Gas Volatiles by Method TO-15* (VET-1405-SPEC-01) and the SAP (VET-1405-PLN-03). In addition to the printed data package, electronic data deliverables, consisting of a number of Microsoft Excel® files containing tables of results and associated QC were also provided.

5.2.1 EQM-DVAL-USE-001

This report describes the data validation of samples collected under the chains of custody (COC) documents listed in Table 13. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 14 summarizes the validation results for each type of analysis.

Table 13 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-001

VET-1405-COC-001	VET-1405-COC-010	VET-1405-COC-015
VET-1405-COC-002	VET-1405-COC-011	VET-1405-COC-016
VET-1405-COC-003	VET-1405-COC-012	VET-1405-COC-018
VET-1405-COC-004	VET-1405-COC-013	
VET-1405-COC-005	VET-1405-COC-014	

Except for nitrite and phosphate results from groundwater samples G004 and G005, results were acceptable for project decision-making. Samples G004 and G005 were collected on February 27, 2008. These samples were unacceptable because the holding times for the two samples were more than two times the 48-hour holding time limit, and the results were non-detects in each of the four cases. The validation rules require non-detect results be rejected for decision-making if obtained after holding times of more than twice the holding time limit. Therefore, the results were qualified as rejected and flagged “UR.”

Table 14 Summary Validation Results by Analysis in EQM-DVAL-USE-001

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	957	86	The majority of the qualifiers are due to unacceptable matrix spike recoveries. There were a few qualifiers placed due to poor LCS recoveries.
Mercury	31	0	None of the data was qualified during validation.
Chromium (VI)	33	2	Two sample results were qualified due to high matrix spike recovery.
Cyanide	33	0	None of the data was qualified during validation.
Sulfide	33	1	One result was qualified due to an unmet hold time.

Table 14 Summary Validation Results by Analysis in EQM-DVAL-USE-001

Analysis	Number of Results	Number of Qualified Results	Summary
Anions	231	46	Most qualifications were due to unacceptable MS and MSD recoveries. Four results were rejected due to unmet hold times.
Total phenols	33	0	None of the data was qualified during validation.
PCBs	231	0	None of the data was qualified during validation.
VOCs	3513	579	Results were qualified mainly for blank contamination, LCS and MS/MSD out of range.
SVOCs	2278	528	The majority of qualifiers were due to unacceptable LCS, MS and/or MSD recoveries. In a few cases, MS/MSD RPDs required qualification, as did method blank contamination.

LCS - laboratory control sample
 MS - matrix spike
 MSD - matrix spike duplicate
 PCB - polychlorinated biphenyl

RPD - relative percent difference
 SVOC - semi-volatile organic compound
 VOC - volatile organic compound

5.2.2 EQM-DVAL-USE-002

This report describes the data validation of samples collected under the COC documents listed in Table 15. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 16 summarizes the validation results by analysis.

Table 15 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-002

VET-1405-COC-007	VET-1405-COC-029	VET-1405-COC-043
VET-1405-COC-008	VET-1405-COC-032	VET-1405-COC-044
VET-1405-COC-009	VET-1405-COC-033	VET-1405-COC-045
VET-1405-COC-020	VET-1405-COC-035	VET-1405-COC-046
VET-1405-COC-022	VET-1405-COC-039	VET-1405-COC-054
VET-1405-COC-027	VET-1405-COC-040	VET-1405-COC-056

Asterisks (*) that were used as qualifiers in the volatile organic compounds and semi-volatile organic compounds sections were removed. As stated in an email from Orlette Johnson of LVL (July 30, 2008), these qualifiers were hold-over's from other LVL projects that request a flag for each time a spike sample recovery is outside limits.

As a result of this validation process, less than 10 percent of the data were qualified, and less than 0.5 percent of the data were rejected. Rejected data included SVOCs and metals.

- SVOCs: Nine polychlorinated phenols and chlorinated ethers in each of samples B049 and B085 were rejected. These results were rejected due to recoveries of less than 10 percent for the surrogate compound 2,4,6-tribromophenol. All rejected results were nondetects.
- Metals: Results for silicon in forty-seven samples in batches 08L0093, 08L0125, 08L0146, 08L0163, 08L0166, 08L0178, and 08L0200 were rejected due to extremely low laboratory control sample (LCS) recoveries, less than 50 percent. All rejected results were detects.

Table 16 Summary Validation Results by Analysis in EQM-DVAL-USE-002

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	1769	85	The majority of the qualifiers apply to silicon in soils due to low LCS. Forty-seven silicon results were rejected due to extremely low LCS recoveries. A majority of the zinc data are estimated. Other qualification was due to out-of-specification MS/MSD recoveries for antimony, calcium, and iron, and contamination of blanks with sodium and zinc.
Mercury	61	0	Mercury was not detected in most samples.
Chromium (VI)	61	8	All water sample results were qualified due to low MS recoveries. No data were rejected.
Cyanide	61	0	Cyanide was not detected in the samples.
Sulfide	61	1	One result was qualified as estimated due to holding time. Sulfide was not detected in the samples.
Anions	427	47	The qualification of anion results was primarily due to low MS recoveries for chloride and sulfate. No data were rejected.
Total phenols	61	0	Phenols were detected in only three samples.
PCBs	426	63	All qualification of data was due to RPDs not meeting the 20% limit. No data were rejected.
VOCs	6240	184	Results were qualified due to high LCS recoveries and contamination of blanks with laboratory contaminants. No data were rejected.
SVOCs	4209	545	Surrogate recoveries of less than 10% caused 18 nondetect results for polychlorinated compounds to be rejected. Other results were qualified as estimates due to high RPDs and low LCS, MS, and MSD recoveries.

LCS - laboratory control sample
 MS - matrix spike
 MSD - matrix spike duplicate
 PCB - polychlorinated biphenyl

RPD - relative percent difference
 SVOC - semi-volatile organic compound
 VOC - volatile organic compound

5.2.3 EQM-DVAL-USE-003

This report describes the data validation of samples collected under the COC documents listed in Table 17. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 18 summarizes the validation results by analysis.

Table 17 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-003

VET-1405-COC-019	VET-1405-COC-042	VET-1405-COC-055
VET-1405-COC-023	VET-1405-COC-047	VET-1405-COC-057
VET-1405-COC-025	VET-1405-COC-048	VET-1405-COC-059
VET-1405-COC-026	VET-1405-COC-049	VET-1405-COC-061
VET-1405-COC-031	VET-1405-COC-050	VET-1405-COC-062
VET-1405-COC-037	VET-1405-COC-051	VET-1405-COC-063

Please note that the groundwater data for this quarter was split between two validation reports. The data validation for Vista COCs VET-1405-COC-043 and VET-1405-COC-045 were included in EQM-DVAL-USE-002 (See Appendix I: Data Validation Reports).

Asterisks (*) used as qualifiers in the semi-volatile organic compounds section were removed. As stated in an email from Orlette Johnson of LVL (July 30, 2008), these qualifiers were holdovers from other LVL projects that request a flag for each time a spike sample recovery is outside limits.

As a result of this validation process, results for silicon in forty-five samples in batches 08L0125, 08L0146, 08L0163, 08L0178, 08L0200, 08L0210 and 08L0220 were rejected due to extremely low laboratory control sample recoveries, less than 50 percent. All rejected results were detects.

Table 18 Summary Validation Results by Analysis in EQM-DVAL-USE-003

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	1798	238	The majority of the qualifiers apply to silicon in soils due to low LCS. Forty-five silicon results were rejected due to extremely low LCS recoveries. All of the antimony data for soil samples were qualified as estimated due to low matrix spike recoveries. Other qualification was due to out-of-specification MS/MSD recoveries for barium, calcium, chromium, iron, and silver and contamination of blanks with sodium. Some data were also qualified due to high RPDs.
Mercury	62	0	Mercury was not detected in most samples. No results were qualified.
Chromium (VI)	62	4	All water sample results were qualified as estimated due to low MS recoveries. One soil sample result was qualified as estimated for a high LCS recovery. No data were rejected.
Cyanide	62	0	Cyanide was not detected in the samples. No data were qualified.

Table 18 Summary Validation Results by Analysis in EQM-DVAL-USE-003

Analysis	Number of Results	Number of Qualified Results	Summary
Sulfide	62	3	Three results were qualified as estimated due to holding time. Sulfide was detected in only four samples. No data were rejected.
Anions	434	3	Three sulfate results were qualified as estimated due to a low MS recovery. No data were rejected.
Total phenols	62	0	Phenols were detected in ten soil samples. No data were qualified.
PCBs	434	65	The qualifications were due to exceeding holding time requirements and RPDs exceeding the 20% precision limit. No data were rejected.
VOCs	6321	185	Results were qualified due to high LCS recoveries and low levels of contamination in blanks with common laboratory contaminants, low matrix spike recoveries and high RPDs. No requested data were rejected.
SVOCs	4325	1584	Most qualification was due to MS and LCS recoveries and RPDs. Many results were qualified for multiple reasons. No data were rejected.

-
- | | |
|---------------------------------|---------------------------------------|
| LCS - laboratory control sample | RPD - relative percent difference |
| MS - matrix spike | SVOC - semi-volatile organic compound |
| MSD - matrix spike duplicate | VOC - volatile organic compound |
| PCB - polychlorinated biphenyl | |

5.2.4 EQM-DVAL-USE-004

This report describes the data validation of samples collected under the COC documents listed in Table 19. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 20 summarizes the validation results by analysis.

Table 19 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-004

VET-1405-COC-064	VET-1405-COC-065	VET-1405-COC-066
VET-1405-COC-067	VET-1405-COC-068	VET-1405-COC-069
VET-1405-COC-070	VET-1405-COC-071	

No data were rejected as a result of this validation process.

Table 20 Summary Validation Results by Analysis in EQM-DVAL-USE-004

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	4890	0	No data were qualified.

5.2.5 EQM-DVAL-USE-005

This report describes the data validation of samples collected under the COC documents listed in Table 21. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 22 summarizes the validation results by analysis.

Table 21 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-005

VET-1405-COC-072	VET-1405-COC-073	VET-1405-COC-074
VET-1405-COC-075	VET-1405-COC-076	VET-1405-COC-077

No data were rejected as a result of this validation process.

Table 22 Summary Validation Results by Analysis in EQM-DVAL-USE-005

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	8	All qualifications applied to silver results were due to a high MS/MSD RPD. No data were rejected.
Mercury	8	0	Mercury was not detected in any samples. No results were qualified.
Chromium (VI)	8	0	No results were qualified.
Cyanide	8	0	Cyanide was not detected in the samples. No data were qualified.
Sulfide	8	0	Sulfide was not detected in any samples. No results were qualified.
Anions	56	1	One nitrate result was qualified as estimated due to a missed hold time. No data were rejected.
Total phenols	8	0	Phenols were not detected in any samples. No data were qualified.
PCBs	56	0	PCBs were not detected in any samples. No data were qualified.
VOCs	859	12	Results were qualified due to low levels of contamination in blanks with common laboratory contaminants. One tentatively identified compound, butylated hydroxytoluene, was present in blanks and one sample. This detection was qualified "UJ". No data were rejected.

Table 22 Summary Validation Results by Analysis in EQM-DVAL-USE-005

Analysis	Number of Results	Number of Qualified Results	Summary
SVOCs	562	142	The majority (126 results) of qualification was due to MS and LCS recoveries and RPDs. The rest of qualification was due to blank contamination and surrogate recoveries. Approximately 20 results were qualified for multiple reasons. No data were rejected.
LCS - laboratory control sample		RPD - relative percent difference	
MS - matrix spike		SVOC - semi-volatile organic compound	
MSD - matrix spike duplicate		VOC - volatile organic compound	
PCB - polychlorinated biphenyl			

5.2.6 EQM-DVAL-USE-006

This report describes the data validation of samples collected under the COC documents listed in Table 23. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 24 summarizes the validation results by analysis.

Table 23 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-006

VET-1405-COC-072	VET-1405-COC-073	VET-1405-COC-074
VET-1405-COC-075	VET-1405-COC-076	VET-1405-COC-077
VET-1405-COC-078	VET-1405-COC-079	

Please note that duplicate failures (relative percent difference [RPD] >25%) do not lead to qualification of data per the validation rules. However, RPDs that are greater than 25 percent indicate significant sampling heterogeneity. Table 2-2 of EQM-DVAL-USE-006 (See Appendix I: Data Validation Reports) lists numerous results with RPDs >25 percent.

No data were rejected as a result of this validation process.

Table 24 Summary Validation Results by Analysis in EQM-DVAL-USE-006

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	4855	0	No data were qualified.

5.2.7 EQM-DVAL-USE-007

This report describes the data validation of samples collected under the COC documents listed in Table 25. Validation was performed using an electronic data checker to evaluate whether batch

QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 26 summarizes the validation results by analysis.

Table 25 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-007

VET-1405-COC-080	VET-1405-COC-081	VET-1405-COC-082
VET-1405-COC-083	VET-1405-COC-084	VET-1405-COC-085

No data were rejected as a result of this validation process.

Table 26 Summary Validation Results by Analysis in EQM-DVAL-USE-007

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	0	No results were qualified.
Mercury	8	0	Mercury was not detected in any samples. No results were qualified.
Chromium (VI)	8	3	Three results were qualified as estimated due to missed hold times.
Cyanide	8	0	Cyanide was not detected in the samples. No data were qualified.
Sulfide	8	0	Sulfide was not detected in any samples. No results were qualified.
Anions	56	3	Three phosphate results were qualified as estimated due to missed hold times. No data were rejected.
Total phenols	8	0	Phenols were not detected in any samples. No data were qualified.
PCBs	56	0	PCBs were not detected in any samples. No data were qualified.
VOCs	858	0	No data were qualified.
SVOCs	579	0	No data were qualified.

PCB - polychlorinated biphenyl

SVOC - semi-volatile organic compound

VOC - volatile organic compound

5.2.8 EQM-DVAL-USE-008

This report describes the data validation of samples collected under the COC documents listed in Table 27. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 28 summarizes the validation results by analysis.

Table 27 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-008

VET-1405-COC-086	VET-1405-COC-087	VET-1405-COC-088
VET-1405-COC-089	VET-1405-COC-090	VET-1405-COC-091
VET-1405-COC-092	VET-1405-COC-093	VET-1405-COC-094
VET-1405-COC-095	VET-1405-COC-096	

One TIC was rejected as column bleed.

Table 28 Summary Validation Results by Analysis in EQM-DVAL-USE-008

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2526	1	One silane result was rejected as column bleed.

5.2.9 EQM-DVAL-USE-009

This report describes the data validation of samples collected under the COC documents listed in Table 29. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies any QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds the qualifiers. Table 30 summarizes the validation results by analysis.

Table 29 Chains Of Custody Applicable To The Data Validated In EQM-DVAL-USE-009

VET-1405-COC-103	VET-1405-COC-104	VET-1405-COC-105
VET-1405-COC-106	VET-1405-COC-107	VET-1405-COC-108
VET-1405-COC-109	VET-1405-COC-110	VET-1405-COC-111
VET-1405-COC-112	VET-1405-COC-113	

One TIC was rejected as column bleed.

Table 30 Summary Validation Results by Analysis in EQM-DVAL-USE-009

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2777	1	One silane result was rejected as column bleed.

5.2.10 EQM-DVAL-USE-010

This report describes the data validation of samples collected under the COC documents listed in Table 31. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 32 summarizes the validation results by analysis.

Table 31 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-010

VET-1405-COC-097	VET-1405-COC-098	VET-1405-COC-099
VET-1405-COC-100	VET-1405-COC-101	VET-1405-COC-102

Table 32 Summary Validation Results by Analysis in EQM-DVAL-USE-010

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	0	No results were qualified
Mercury	8	5	Mercury was not detected in the samples. Results were qualified as estimated due to missed hold times.
Chromium (VI)	8	3	Three results were qualified as estimated due to missed hold times.
Cyanide	8	0	Cyanide was not detected in samples. No data were qualified.
Sulfide	8	0	Sulfide was not detected in samples. No data were qualified.
Anions	56	9	Three nitrate and one phosphate results were qualified as estimated due to missed hold times. Three nitrate and two phosphate nondetect results were rejected due to missed hold times by greater than twice the limit.
Total Phenols	8	0	Phenols were not detected in any samples. No data were qualified.
PCBs	58	7	PCBs were not detected in any samples. Seven results (from one sample) were rejected due to missing hold times.
VOCs	858	0	No results were qualified.
SVOCs	625	0	No data were qualified.

5.2.11 EQM-DVAL-USE-011

This report describes the data validation of samples collected under the COC documents listed in Table 33. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 34 summarizes the validation results by analysis.

Table 33 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-011

VET-1405-COC-114	VET-1405-COC-115	VET-1405-COC-116
VET-1405-COC-117	VET-1405-COC-118	VET-1405-COC-119
VET-1405-COC-120	VET-1405-COC-121	VET-1405-COC-122
VET-1405-COC-123	VET-1405-COC-124	

Table 34 Summary Validation Results by Analysis in EQM-DVAL-USE-011

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2549	4	Four TICs rejected due to column bleed.

5.2.12 EQM-DVAL-USE-012

This report describes the data validation of samples collected under the COC documents listed in Table 35. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 36 summarizes the validation results by analysis.

Table 35 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-012

VET-1405-COC-125	VET-1405-COC-126	VET-1405-COC-127
VET-1405-COC-128	VET-1405-COC-129	

Table 36 Summary Validation Results by Analysis in EQM-DVAL-USE-012

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	0	No results were qualified.
Mercury	8	0	No results were qualified.
Chromium (VI)	8	4	Four results were qualified as estimated due to missed hold times.
Cyanide	8	0	Cyanide was not detected in the samples. No data were qualified.
Sulfide	8	0	Sulfide was not detected in any samples. No results were qualified.
Anions	56	14	Two nitrate, four nitrite and four phosphate results were qualified as estimated due to missed hold times. Two nitrite and two phosphate nondetect results were rejected due to missed hold times by greater than twice the limit.
Total Phenols	8	0	Phenols were not detected in any samples. No data were qualified.
PCBs	58	0	PCBs were not detected in any samples. No data were qualified.
VOCs	780	10	Results for dichlorodifluoromethane were qualified due to low LCS, MS, and MSD recoveries.
SVOCs	601	198	Results were qualified due to low LCS, MS, and MSD results as well as for high MS/MSD/ RPDs. Aldol condensation products were rejected as instrument artifacts.

5.2.13 EQM-DVAL-USE-013

This report describes the data validation of samples collected under the COC documents listed in Table 37. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 38 summarizes the validation results by analysis.

Table 37 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-013

VET-1405-COC-130	VET-1405-COC-131	VET-1405-COC-132
VET-1405-COC-133	VET-1405-COC-134	VET-1405-COC-135

Table 38 Summary Validation Results by Analysis in EQM-DVAL-USE-013

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	0	No results were qualified.
Mercury	8	0	No results were qualified.
Chromium (VI)	8	8	All results were qualified as estimated due to missed hold times.
Cyanide	8	0	Cyanide was not detected in the samples. No data were qualified.
Sulfide	8	0	Sulfide was not detected in any samples. No results were qualified.
Anions	56	0	No results were qualified.
Total Phenols	8	0	Phenols were not detected in any samples. No data were qualified.
PCBs	56	0	PCBs were not detected in any samples. No data were qualified.
VOCs	858	0	No results were qualified.
SVOCs	595	165	Results were qualified due to low LCS. Aldol condensation products were rejected as instrument artifacts.

5.2.14 EQM-DVAL-USE-014

This report describes the data validation of samples collected under the COC documents listed in Table 39. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 40 summarizes the validation results by analysis.

Table 39 Chains of Custody Applicable to the Data Validated in EQM-DVAL-USE-014

VET-1405-COC-136	VET-1405-COC-137	VET-1405-COC-138
VET-1405-COC-139	VET-1405-COC-140	VET-1405-COC-141
VET-1405-COC-142	VET-1405-COC-143	VET-1405-COC-144
VET-1405-COC-145	VET-1405-COC-146	VET-1405-COC-147

Table 40 Summary Validation Results by Analysis in EQM-DVAL-USE-014

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2660	59	Column bleed, a laboratory instrument artifact, was qualified as rejected (R).

5.2.15 DM-DVAL-USE-015

This report describes the data validation of samples collected under the COC documents listed in Table 41. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 42 summarizes the validation results by analysis.

Table 41 Chains of Custody Applicable to the Data Validated in DM-DVAL-USE-015

VET-1405-COC-148	VET-1405-COC-149	VET-1405-COC-150
VET-1405-COC-151	VET-1405-COC-152	

Table 42 Summary Validation Results by Analysis in DM-DVAL-USE-015

Analysis	Number of Results	Number of Qualified Results	Summary
Metals	232	0	No data were qualified.
Mercury	8	0	Mercury was not detected in any samples. No results were qualified.
Chromium (VI)	8	6	Data were qualified for missed hold times.
Cyanide	8	0	No data were qualified.
Sulfide	8	0	Sulfide was not detected in any samples. No results were qualified.
Anions	56	12	Nitrate, nitrite, and orthophosphate data were qualified as estimated due to missed hold times. No data were rejected.
Total Phenols	7	0	No data were qualified.
PCBs	56	0	PCBs were not detected in any samples. No data were qualified.

Table 42 Summary Validation Results by Analysis in DM-DVAL-USE-015

Analysis	Number of Results	Number of Qualified Results	Summary
VOCs	858	22	Data were qualified due to low MS recovery and high MS/MSD RPD. No data were rejected.
SVOCs	584	234	Qualification was due to LCS recoveries, MS/MSD recoveries and MS/MSD RPDs. Two TICs were rejected as column bleed.

5.2.16 DM-DVAL-USE-016

This report describes the data validation of samples collected under the COC documents listed in Table 43. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 44 summarizes the validation results by analysis.

Table 43 Chains of Custody Applicable to the Data Validated in DM-DVAL-USE-016

VET-1405-COC-153	VET-1405-COC-154	VET-1405-COC-155
VET-1405-COC-156	VET-1405-COC-157	VET-1405-COC-158
VET-1405-COC-159	VET-1405-COC-160	VET-1405-COC-161
VET-1405-COC-162	VET-1405-COC-163	VET-1405-COC-164
VET-1405-COC-165		

Table 44 Summary Validation Results by Analysis in DM-DVAL-USE-016

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2587	2	Two sample results were qualified due to the raw result exceeding the highest calibration standard concentration.

5.2.17 DM-DVAL-USE-017

This report describes the data validation of samples collected under the COC documents listed in Table 45. Validation was performed using an electronic data checker to evaluate whether batch QC met criteria. The electronic data checker identifies QC samples outside of validation criteria and the chemist evaluates the impact of the anomaly and adds qualifiers. Table 46 summarizes the validation results by analysis.

Table 45 Chains of Custody Applicable to the Data Validated in DM-DVAL-USE-017

VET-1405-COC-166	VET-1405-COC-167	VET-1405-COC-168
VET-1405-COC-169	VET-1405-COC-170	VET-1405-COC-171
VET-1405-COC-172	VET-1405-COC-173	VET-1405-COC-174
VET-1405-COC-175	VET-1405-COC-176	

Table 46 Summary Validation Results by Analysis in DM-DVAL-USE-017

Analysis	Number of Results	Number of Qualified Results	Summary
TO-15	2581	1	One sample result was qualified due to the raw result exceeding the highest calibration standard concentration.

5.3 Summary of Data Usability

Over the course of the project, more than 70,677 results have been reported for field investigation and long-term monitoring activities. Of these results, 5,415 (~7.7%) have been qualified as estimated measurements, and less than 0.3% of the project results (237) have been rejected. Of the results reported by the laboratories as quantifiable measurements, 18 (~0.03%) were qualified during data validation as non-detects due to QC issues. The two-tiered data validation approach effectively implemented the Level A and C data validation required by the QAPjP. The data are well formed and appropriate; meeting project data quality objectives. The dataset is usable and sufficient for project decision-making purposes.

5.3.1 Detection Limit Evaluation

All of the detection limits were deemed acceptable for supporting project decision-making purposes. In most cases, detection limits were appropriate, and met SAP requirements. In those cases where a contract-required detection limit was not specified in the SAP (typically due to method implementation or site conditions), standard laboratory reporting limits were used. The analytes in this category included:

- Chromium (VI)
- Cyanide
- Sulfide
- Anions in Soil
- Phenol

5.3.2 Rejected Data

While it was not necessary to reject many data results on this project, there were cases when it occurred. In the cases of nitrate and phosphate analyses, results were rejected due to missed holding times. For silicon analysis, there were very low Laboratory Control Spike recoveries that necessitated the rejection of silicon results in nine batches. Tentatively identified compounds documented as common laboratory contaminants or “Common Instrument Artifacts” were also rejected. These typically included alcohols and ketones used to make surrogates and standards.

6.0 Identification of Hazardous Substances Requiring Further Evaluation

The MTCA RI collected over 70,000 results during the initial field assessment and the long-term monitoring program, which lasted two years. The DQO Report (EQM, 2003) and SOW (USE, 2006) developed the method-based target analyte approach for this MTCA investigation. The SOW required evaluation of 226 individual analytes.

Vista Engineering and Neptune & Company, Inc. collaborated with the Washington State Department of Ecology to develop a screening process to identify hazardous substances during the MTCA investigation that will require further evaluation. Neptune & Company, Inc. completed this screening process under the requirements of the DQO, the SOW, and recommendations from the Washington State Department of Ecology. The process of selecting hazardous substances included two specific components:

- The initial goal was to establish screening levels for evaluating risk in order to define levels of protectiveness for contact pathways including soil contact, soil vapor, and protectiveness of groundwater using MTCA (WAC-173-340) together with recommendations from the Washington State Department of Ecology.
- The second priority was to obtain a list of constituents that warrant further evaluation during the MTCA remedial investigation as discussed in Section 7.0.

Human health screening assessments were completed for soil, groundwater, and air. An ecological screening assessment was completed for wildlife exposure to soil and soil vapor. Animals and plants within the Central Plateau are not expected to be at risk for exposure to groundwater given that groundwater depths tend to range from 98.1 m (322 ft) to 103.3 m (339 ft).

The first step of the assessment was to compare soil concentrations from the USE Site to background concentrations. Analytes found to have concentrations consistent with background levels were not carried forward in the screening assessment. The methods used to perform the background comparisons, along with the results, are provided in the Subsection 6.2.

The screening assessments proceeded by comparing an exposure point concentration (EPC) to the appropriate screening level. The exposure point concentrations were computed following the guidance given in WAC 173-340-740(7) and using decision logic provided in *Representative White Paper entitled Representative Concentration* (WCH, January 2008). The specific calculation method is described in the Section 6.3.

Soil data are provided in concentration units of mg/kg and µg/kg, while groundwater data are provided in concentration units of mg/L and µg/L. The tables present the data in the units they were received. However, soil-screening values are presented in concentration units of mg/kg and all groundwater-screening values are presented in concentration units of µg/L. The data and

screening value concentration units are shown in every table for clarity and to ensure comparison with consistent units.

6.1 Data Preparation

Neptune received the full database on March 29, 2010, which was transmitted as a Microsoft Access® Database file labeled 1405Data.mdb. The database query “EDD-DVAL Query” was extracted to a Microsoft Excel® file and imported into the programming language and statistical software environment R which is available under the GNU General Public License.

The database query is comprised of the merged and modified data Neptune created in March 2009 for preliminary risk assessment screening, along with the addition of new soil vapor and groundwater data collected during long-term monitoring that extended beyond the initial field assessment portion of the MTCA remedial investigation.

There were therefore no issues with duplicate records, consistent concentration units, or CAS identification numbers associated with data that had been previously included in the preliminary dataset submitted to Neptune during the initial risk assessment screening. The new soil vapor and groundwater data collected during the long-term monitoring did, however, contain duplicate records and these duplicate records were handled in the same manner as the previous risk assessment algorithms. These algorithms will be discussed in the sections that follow. In addition, the database query did not contain necessary fields “FinalQualifier”, “detect”, “SampleTop”, and “SampleBottom”. These fields were added for Neptune’s calculations. Two additional soil vapor flagging tables were added to the Excel data file on April 22, 2010. These two files were labeled: Group P Flagging Table 1-19-2010.xls, and Group Q Flagging Table 030110.xls.

The preliminary data from the MTCA investigation (all data with the exception of long-term soil vapor and groundwater monitoring) was transmitted to Neptune on March 5, 2009, in the form of the following Excel files:

- EQM-DVAL-USE-001_DV Summary Tables Group A 7-14-08.xls
- DV Summary tables, Group B 12-22-08 em.xls
- Group C DV Summary Table 1-15-09 em.xls
- Group E Flagging Table 12-08-08.xls
- USE G Flagging Table em 021309.xls

These files contained USE soil and groundwater data collected during the initial fieldwork performed during the MTCA RI. In addition to the files above, Neptune also received soil sample depth information on March 5, 2009, in the Microsoft Excel file labeled Borehole&SampleTypes&SampleNumber.xlsx in order to provide spatial orientation for the samples. Soil vapor data was provided to Neptune in the file entitled EQM-DVAL-USE-004_USE D Flagging Table.xls to complete the preliminary data package.

Neptune merged each of the aforementioned files into a single database and multiple records were found for many of the media-sample-analyte combinations. The multiple records for soil and groundwater included actual duplicate records where the same record was included in more than one of the original data files and multiple measurements of the same media-sample-analyte combination using different measurement methods.

Through conversations between the project technical staff and the data validator, the following decision logic was implemented to correct for the occurrence of multiple soil and groundwater records:

- Actual duplicates would be removed (i.e., duplicate results of the same value).
- For the cases of multiple measurements,
 - If there were no detects, then the record with the minimum estimated quantitation limit (EQL) would be kept.
 - If there was one or more detects, then in an effort to be conservative, the maximum detect would be kept.

For soil vapor, the multiple records were measurements at different dilutions. In these cases, the soil vapor measurement with the lowest dilution and without an E lab qualifier (indicating detection outside the calibration range) was retained.

The final data used in Neptune's assessment "EQM-DVAL-USE-modified.xls" was included as an electronic attachment transmitted by Neptune for their MTCA investigation risk assessment using complete data from the initial field assessment together with long-term monitoring of soil vapor and groundwater. The final data file used in this assessment, were analyzed, and data summary tables for soil, groundwater, and soil vapor are presented in Appendix J: Summary Tables Supporting the Screening of Target Analytes. These tables provide sample sizes, number of detects, and basic summary statistics.

6.2 Soil Background Comparisons

The first step of the assessment was the comparison of the site soil concentrations to background soil concentrations. Analytes found to be consistent with background were not carried forward in the screening assessment. The background comparisons were based upon a weight-of-evidence approach, and soil samples were compared to five comparison criteria to be evaluated. Samples failing more than two criteria are considered to be above background concentrations.

The background data set is from the Hanford area and is the result of the background characterization study reported in *Review of Hanford Site Soil Background Report*, DOE/RL-92-24 (nonradionuclides). The study included a data quality objectives process following EPA guidance and approved SAPs (DOE/RL-92-24, Vol. 1, Rev. 4). Note that sample depth information was not available for the background data. In the absence of an argument for any other decision, the entire set of site samples, regardless of depth, were compared as a whole to the background samples.

Background comparisons were performed using a weight-of-evidence approach combining summary statistics, side-by-side boxplots, and the results of several two-sample statistical hypothesis tests. These tests, collectively called the Gilbert Toolbox, are described below.

6.2.1 Gilbert Toolbox

The Gilbert Toolbox is a set of statistical hypothesis tests that each help to determine if site concentrations are similar to or greater than background concentrations. The comparison procedure involves simultaneously running four two-sample statistical hypothesis tests: the two-sample t -test; the Wilcoxon Rank Sum test; the Quantile test; and the Slippage test. The t -test and the Wilcoxon Rank Sum test compare the centers of the underlying distributions, while the Quantile test and the Slippage test compare the upper concentrations of the two distributions.

6.2.2 Two-sample t -test

The two-sample t -test is a parametric test for a difference between two population means. This test can be used when the two populations are independent, and the two underlying distributions are approximately statistically normal or the sample sizes are large enough. If the assumptions are not satisfied, then the non-parametric Wilcoxon Rank Sum (WRS) test is more appropriate. If the assumptions are reasonably satisfied, then the t -test has more power than the WRS test.

6.2.3 Wilcoxon Rank Sum Test

The WRS test is a non-parametric test for a difference between the centers (means or medians) of two populations. Precise knowledge of either distributional form is not required. However, the two underlying distributions are assumed to have approximately the same shape so that the only difference between them is a shift in location. This test is a non-parametric method that relies on the relative rankings of data values. The version of the WRS test used for this analysis accounts for non-detects by using the Gehan ranking system.

The WRS test may produce misleading results if there are many tied data values. When many ties are present, their relative ranks are the same, and this has the effect of diluting the statistical power of the WRS test. Consequently, WRS test results for metals with many non-detects with the same detection limit should be used cautiously.

6.2.4 Quantile Test

The Quantile test is a test for a shift to the right in the upper-tail of the site distribution versus the background distribution. This assesses whether the largest detected concentrations in the site data set are statistically larger than the largest values in the background data set. It is assumed that the distributions have approximately the same shape.

The tested location in the upper-tail is determined by the quantile value used for the test. Quantile values close to 0.5 result in a test similar to the two-sample t -test or the WRS test. Quantiles closer to 1.0, test for differences in the extreme upper-tails of the site and background distributions, and

provide results that are similar to those from the Slippage test. Quantile values of 0.75 and 0.90 were used for these background comparisons.

6.2.5 Slippage Test

The Slippage test compares site data to the maximum background concentration. The test determines if the number of site data points are greater than the maximum background concentration is statistically too large to be just due to chance or if the two distributions are truly similar. This test compares the extreme upper-tails of the site and background distributions.

6.2.6 Conclusions

Table 47 presents summary statistics and the results of the statistical tests comparing site and background data. Side-by-side boxplots are presented in Appendix J: Summary Tables Supporting the Screening of Target Analytes. A p -value in Table 47 greater than 0.05, indicates that site data concentrations are similar to background for the tested analyte. The information from the summary statistics, boxplots, and p -values are all synthesized into a weight-of-evidence approach for determining which analytes are elevated above background conditions. As previously stated, in order for the concentration of an analyte to be judged as greater than background, it must fail two or more criteria under this weight-of-evidence approach. Based on all of the evidence, only total chromium, nickel, and silicon will be carried forward in the screening assessment. Note that analytes found to be consistent with background will not be shown in the screening tables presented later in this document.

Table 47 Summary Statistics and Statistical Hypothesis Test p-values for the Soil Background Comparisons

Analyte	CAS ID	N Bkg	N Bkg Detects	N Site	N Site Detects	Two-Sample t-test	Gehan Test	Quantile Test (0.75)	Quantile Test (0.90)	Slippage Test
Aluminum, Total	7429-90-5	153	153	140	140	1	1	1	1	1
Antimony, Total	7440-36-0	78	8	140	36	1	1	0.01757	0.7478	1
Arsenic, Total	7440-38-2	150	133	140	140	0.9212	0.7182	0.9934	0.9979	1
Barium, Total	7440-39-3	153	153	140	140	1	1	1	1	1
Beryllium, Total	7440-41-7	150	137	140	136	1	1	1	1	1
Cadmium, Total	7440-43-9	150	5	140	84	1	1	1	1	1
Calcium, Total	7440-70-2	153	153	140	140	0.9999	0.991	1	1	1
Chloride	16887-00-6	152	152	140	97	0.9999	0.119	0.9319	1	1
Chromium, Total	7440-47-3	153	153	140	140	1.31E-30	0	4.08E-21	3.33E-08	2.06E-06
Cobalt, Total	7440-48-4	151	151	140	140	1	1	1	1	1
Copper, Total	7440-50-8	153	153	140	140	1	1	1	1	1
Fluoride	16984-48-8	152	150	140	6	0.8908	0	1	0.9998	1
Iron, Total	7439-89-6	153	153	140	140	1	1	1	1	1
Lead, Total	7439-92-1	153	153	140	140	1	1	1	1	1
Magnesium, Total	7439-95-4	153	153	140	140	1	0.9928	1	1	1
Manganese, Total	7439-96-5	153	153	140	140	1	1	1	1	1
Mercury, Total	7439-97-6	151	30	138	13	1	1	0.9936	1	1
Molybdenum, Total	7439-98-7	96	9	140	140	1	1	1.81E-06	0.6031	1
Nickel, Total	7440-02-0	153	152	140	140	1.07E-07	4.87E-10	0.0003059	0.4737	1
Phosphate	14265-44-2	153	45	140	2	0.926	0	1	0.9993	1
Potassium, Total	9/7/7440	150	150	140	140	1	0.9619	1	1	1
Selenium, Total	7782-49-2	125	8	140	16	1	1	1	1	1
Silicon, Total	7440-21-3	133	133	48	48	1.30E-07	0	5.68E-31	7.19E-09	8.10E-07

Table 47 Summary Statistics and Statistical Hypothesis Test p-values for the Soil Background Comparisons

Analyte	CAS ID	N Bkg	N Bkg Detects	N Site	N Site Detects	Two-Sample t-test	Gehan Test	Quantile Test (0.75)	Quantile Test (0.90)	Slippage Test
Silver, Total	7440-22-4	150	49	140	1	1	1	1	1	1
Sodium, Total	7440-23-5	150	149	140	140	1	1	1	1	1
Sulfate	14808-79-8	153	153	140	128	0.9977	0.002234	0.9946	1	1
Thallium, Total	7440-28-0	151	6	140	15	1	1	1	1	1
Titanium, Total	7440-32-6	115	115	140	140	1	1	0.999	0.9995	1
Uranium, Total	7440-61-1	47	47	140	1	1	0.9999	1	1	1
Vanadium, Total	7440-62-2	153	153	140	140	1	1	0.9996	0.9991	1
Zinc, Total	7440-66-6	153	153	140	140	1	1	1	1	1

6.3 Exposure Point Concentrations

The screening assessment involved comparing an EPC to the appropriate screening level. The decision logic for EPC estimation applies only to chemicals (nonradionuclides). The EPC calculation does not apply to radionuclides, which is consistent with the entire MTCA RI. The evaluation of small sample sizes from the investigation relied more on policy-based decisions than statistically based decisions.

Neptune developed ProUCL-based decision logic for computing EPCs as implemented for the Hanford River Corridor Baseline Risk Assessment (RCBRA) to assess ecological and human health risk (WCH, 2008). Note that the RCBRA decision logic is developed from the 2007 version of ProUCL. The current version issued in February 2009 offers minor changes that do not require an update to the RCBRA upper confidence limit (UCL) decision logic to accommodate the changes in ProUCL. It should also be noted that all data, detects and nondetects, are used to compute EPCs. If there are less than five detects, the EPC is set to the maximum detect. The remainder of this section describes the decision logic for computing EPCs used herein as well as for the RCBRA project.

1. If there are no detects, then no EPC is computed.
2. If the number of detects is 1 to 4, then the EPC is set to the maximum detected value.
3. If the number of detects is greater than or equal to 5, then the EPC is computed in the following manner:

EPC = median(Student's-*t* UCL, parametric UCL, nonparametric UCL), where the parametric UCL is chosen from Table 48 and the nonparametric UCL is chosen from Table 49. Table 48 and Table 49 are adapted from ProUCL guidance. The median is selected to temper the erratic nature of several of the UCL methods.

Table 48 Parametric Computation of a UCL of Mean of a Gamma Distribution with Shape Parameter, *k*, and Sample Size, *n*

Shape Parameter, <i>k</i>	Sample Size, <i>n</i>	Method
$k \geq 0.5$	For all <i>n</i>	Approximate gamma 95% UCL
$0.1 \leq k < 0.5$	For all <i>n</i>	Adjusted gamma 95% UCL
$k < 0.1$	<i>n</i> < 15	95% Hall's bootstrap UCL
	<i>n</i> ≥ 15	Adjusted gamma 95% UCL

Table 49 Nonparametric Computation of 95 percent UCL of the Mean with Kaplan-Meier Estimation of the Mean and Standard Deviation in Cases with Non-Detects

Std Dev of the log Data, σ	Sample Size, n	% Non-detects	Method
$\sigma \leq 0.5$	For all n	All	95% UCL based on Student's-t
	$n \leq 50$		95% Chebyshev
	$n > 50$	0-20 %	95% BCa Bootstrap
$0.5 < \sigma \leq 1.0$	All n	[20%, 40%)	95% BCa Bootstrap
	All n	$\geq 40\%$	95% UCL based on Student's-t
	$n < 40$		99% Chebyshev UCL
$1.0 < \sigma \leq 1.5$	$n \geq 40$	$< 50\%$	97.5% Chebyshev UCL
	All n	$> 50\%$	95% BCa Bootstrap
	$n < 40$		99% Chebyshev UCL
$1.5 < \sigma \leq 2.0$	$n \geq 40$	$< 50\%$	97.5% Chebyshev UCL
	$n < 40$		97.5% Chebyshev UCL
	$n \geq 40$	$\geq 50\%$	95% Chebyshev UCL
	$n < 40$		99% Chebyshev UCL
$\sigma > 2.0$	$n < 50$	All	97.5% Chebyshev UCL
	$n \geq 50$		99% Chebyshev UCL

Following ProUCL guidance, a gamma regression on order statistics (ROS) approach is used to impute concentrations for non-detects before computing the parametric UCL. The Kaplan-Meier (KM) mean and standard deviation estimates are used for computing the nonparametric UCL.

This decision logic follows many ProUCL recommendations. However, ProUCL suggests computing UCLs using two approaches and then taking the maximum value. Neptune finds this approach to be overly conservative, especially with the erratic nature of the several of the ProUCL methods, and hence recommends using the median of three methods.

Note that the gamma methods can produce erratic and overly conservative estimates if the shape parameter and sample size are small. This behavior is tempered by the fact that the EPC is chosen as the median of three methods. In addition, for certain datasets the shape parameter cannot be estimated (due to optimization issues). In these cases, the EPC is set to the average of the Student's-t UCL and the nonparametric UCL.

6.4 Human Health Screening-Level Assessment

Overview

The calculation of screening levels precede the establishment of cleanup levels. Consistent with the US EPA Region X Memorandum (dated April 17, 2007), screening should be performed at 1E-6

cancer risk with an associated hazard quotient of 0.1 for individual chemicals. Soil, groundwater, and air screening levels related to chemical cancer risk and hazard have been calculated using the Model Toxics Control Act (MTCA) for human health screening-level assessment under the guidance of the Washington State Department of Ecology.

Soil, groundwater, and air screening levels related to chemical cancer risk and hazard have been calculated using the screening models of the MTCA published by Ecology in the current WAC Part 173-340. The direct-contact soil screening levels were calculated based on the methods described in WAC 173-340-740 [MTCA Method B soil screening levels for unrestricted land use]. Soil screening levels related to groundwater protection via the leaching pathway were also calculated based on the three-phase partitioning model described in WAC 173-340-747. Air screening levels for unrestricted land use were calculated according to the methods described in WAC 173-340-750. Calculation of exposure point concentrations in soil, groundwater, and air is discussed in the preceding section. For detected analytes that were elevated over background or for which there was no background data, exposure point concentrations were compared to the applicable screening levels. The results of this analysis are discussed in more detail within the following sections.

6.4.1 Calculation of MTCA Method B Soil Screening Levels

Unrestricted land use soil screening levels were calculated according to Equations 740-1 (noncarcinogens) and 740-2 (carcinogens) in WAC 173-340-740. These equations are reproduced here:

$$\text{Noncarcinogen Soil Screening Level (mg/kg)} = (\text{RfD} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{HQ} \cdot \text{AT}) / (\text{SIR} \cdot \text{AB} \cdot \text{EF} \cdot \text{ED})$$

$$\text{Carcinogen Soil Screening Level (mg/kg)} = (\text{RISK} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{AT}) / (\text{CPF} \cdot \text{SIR} \cdot \text{AB} \cdot \text{EF} \cdot \text{ED})$$

where,

Parameter Name	Value	Units
Method B average body weight (ABW)	16	kg
Method B soil ingestion rate (SIR)	200	mg/day
Method B exposure duration (ED)	6	yr
Method B noncarcinogen averaging time (AT)	6	yr
Method B exposure frequency (EF)	1	unitless
Method B target cancer risk (RISK)	1E-06	unitless
carcinogenic averaging time (AT)	75	yr
gastrointestinal absorption fraction (AB)	1	unitless
unit conversion factor (UCF)	1E+06	mg/kg
target hazard quotient (HQ)	0.1	unitless
cancer potency factor (CPF)	(see Table C-1)	(mg/kg-day) ⁻¹
reference dose (RfD)	(see Table C-1)	(mg/kg-day)

The hierarchy of references for chemical toxicity criteria used to calculate screening levels is described in a 2003 memorandum from EPA's Office of Solid Waste and Emergency Response (OSWER) (EPA 2003). The use of current EPA toxicity criteria, and this hierarchy of references, is consistent with the human health risk assessment framework for establishing cleanup levels described in WAC 173-340-708.

Ecology provides chemical toxicity criteria and associated screening levels in an on-line database: (<https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx>); however, this database is not actively maintained and was therefore not cited for toxicity criteria or any values dependent on these criteria.

In accordance with the 2003 EPA OSWER memorandum (EPA 2003), the primary source of toxicity values used in these calculations is EPA's on-line database, Integrated Risk Information System (IRIS; cfpub.epa.gov/ncea/iris/index.cfm). The second tier of toxicity criteria are the provisional peer-reviewed toxicity values (PPRTV) published by the National Center for Environmental Assessment (NCEA) in EPA's Office of Research and Development.

These values are developed on a chemical specific basis when requested by EPA's Superfund program, but the documentation for them is generally not citable. PPRTV values were obtained from EPA's table of regional screening values ([www.epa.gov/reg3hwmd/risk/human/rb-concentration table/](http://www.epa.gov/reg3hwmd/risk/human/rb-concentration-table/)). The third tier of references include values published in EPA's Health Effects Assessment Summary Tables (HEAST), and other sources such as California EPA and the Agency for Toxic Substances and Disease Registry. The toxicity data used in the calculation of MTCA Method B screening levels are provided in Table J-4 of Appendix J: Summary Tables Supporting the Screening of Target Analytes.

Unrestricted land use (Method B) direct contact screening levels are shown in Table J-5 included in Appendix J: Summary Tables Supporting the Screening of Target Analytes. WAC 173-340-708(5) states that for multiple hazardous substances with "similar types of toxic response", the hazard index should not exceed 1.0. By request of Ecology, a value of 0.1 was used for the hazard quotient in order to account for potential effects of toxicological synergy that may change the risk posed by hazardous substances when acting as a mixture.

6.4.2 Calculation of MTCA Groundwater Screening Levels

The groundwater screening level for each analyte was established as the EPA or WAC 246-290-310 drinking water maximum contaminant level (MCL) [WAC 173-340-720(4)(b)(i)], unless an MCL was not available or the MCL was not sufficiently protective [WAC 173-340-720(4)(b)(iii)]. An MCL is considered sufficiently protective if it is associated with a cancer risk less than or equal to 1E-05 or a hazard index less than or equal to 1.0 [WAC 173-340-720(7)(b)]. Note that by request of the Ecology, the target hazard quotient was set to 0.1. If an MCL was found to be associated with a cancer risk greater than 1E-05, it was adjusted down until the cancer risk equaled 1E-05. Similarly, if an MCL was found to be associated with a hazard index greater than 1.0, it was adjusted down until the hazard index equaled 1.0. If an MCL was not available, a groundwater screening level was

calculated using WAC Equation 720-1 (noncarcinogens) or 720-2 (carcinogens) as applicable, depending on the toxicity data available. If both cancer and noncancer toxicity data were available, the lower of the two screening levels was selected.

Equations 720-1 (noncarcinogens) and 720-2 (carcinogens) from WAC 173-340-720 are reproduced here:

$$\text{Noncarcinogen GW CUL } (\mu\text{g/L}) = (\text{HQ} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{AT} \cdot \text{RfD}) / (\text{DWIR} \cdot \text{INH} \cdot \text{DWF} \cdot \text{ED})$$

$$\text{Carcinogen GW CUL } (\mu\text{g/L}) = (\text{RISK} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{AT}) / (\text{CPF} \cdot \text{DWIR} \cdot \text{INH} \cdot \text{DWF} \cdot \text{ED})$$

where,

Parameter Name	Value	Units
noncarcinogen body weight (ABW)	16	kg
noncarcinogen averaging time (AT)	6	yr
noncarcinogen drinking water rate (DWIR)	1	L/day
noncarcinogen exposure duration (ED)	6	yr
carcinogen body weight (ABW)	70	kg
carcinogen averaging time (AT)	75	yr
carcinogen drinking water rate (DWIR)	2	L/day
carcinogen exposure duration (ED)	30	yr
unit conversion factor (UCF)	1000	μg/mg
drinking water fraction (DWF)	1	unitless
inhalation correction factor (INH)	(see Table C-3)	unitless
target hazard quotient (HQ)	0.1	unitless
target cancer risk (RISK)	1E-06	unitless
cancer potency factor (CPF)	(see Table C-1)	(mg/kg-day) ⁻¹
reference dose (RfD)	(see Table C-1)	(mg/kg-day)

Drinking water MCLs, inhalation correction factors, noncarcinogen and carcinogen groundwater CULs, and final groundwater CULs are provided in Table J-6 included in Appendix J: Summary Tables Supporting the Screening of Target Analytes.

6.4.3 Calculation of MTCA Groundwater Protection Soil Screening Levels

Groundwater protection soil screening levels were calculated according to the three-phase partitioning model shown in Equation 747-1 in WAC 173-340-747. The three-phase partitioning model uses a dilution factor to calculate the vadose zone soil pore water concentration in equilibrium with the groundwater screening level concentration. The model then calculates the bulk soil concentration of a chemical in equilibrium with the concentration in pore water. That bulk soil concentration is the groundwater protection soil screening level. The three-phase partitioning model is based on the assumption of equilibrium conditions in the vadose zone and groundwater. If a

vertical profile of soil concentrations in a borehole indicates changing concentrations with depth, soil concentrations in contact with groundwater are most applicable for comparison to the calculated groundwater protection soil screening levels.

WAC 173-340-747 provides default parameter values for several soil properties. However, WAC 173-340-747(5) also provides procedures for deriving site-specific input parameter values for the three-phase partitioning model. Consistent with WAC 173-340-747(5), site-specific soil data were acquired for the following parameters: soil fraction of organic carbon (f_{oc}), dry bulk soil density (ρ_b), effective soil porosity, and degree of saturation. Data for the latter two parameters were used to calculate air-filled (θ_a) and water-filled (θ_w) porosities, which are inputs to the three-phase partitioning model. Default parameter values from WAC 173-340-747 were used for the dilution factor.

Environmental data for f_{oc} , ρ_b , effective soil porosity, and degree of saturation were acquired for fourteen site soil samples and published in Appendix E: Physical Soil Sample Results. For each of the parameters, the average value among all 14 soil samples was used to represent the parameter value in the equation for calculating groundwater protection soil screening levels.

Data for f_{oc} were published as “percent organic (volatile) residue” and converted to f_{oc} by dividing the reported values by 100. Data for effective porosity and degree of saturation were also reported as percent and converted to fractions by dividing by 100. Values of θ_w were calculated as the product of effective porosity and degree of saturation. Values of θ_a were calculated as effective porosity minus θ_w .

The screening levels are shown in Table J-7 included in Appendix J: Summary Tables Supporting the Screening of Target Analytes. Equation 747-1 from WAC 173-340-747 is reproduced here:

$$\text{Soil Screening Level} = \text{GW CUL} * \text{UCF} * \text{DF} * [\text{Kd} + (\theta_w + (\theta_a * \text{Hcc})) / \rho_b]$$

where,

Parameter Name	Value	Units
groundwater cleanup level (GW CUL)	(see Table C-3)	µg/L
unit conversion factor (UCF)	0.001	mg/ug or kg/g
dilution factor (DF)	20	unitless
soil-water partition coefficient (Kd)	(see Table C-4)	L/kg
water-filled porosity (θ_w)	0.0933	unitless
air-filled porosity (θ_a)	0.1824	unitless
Henry's constant (Hcc)	(see Table C-4)	unitless
dry bulk soil density (ρ_b)	1.972	kg/L

6.4.4 Calculation of MTCA Air Screening Levels

Unrestricted land use air screening levels were calculated according to Equations 750-1 (noncarcinogens) and 750-2 (carcinogens) in WAC 173-340-750(3). These equations are reproduced here:

$$\text{Noncarcinogen Air Screening Level } (\mu\text{g}/\text{m}^3) = (\text{RfD} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{HQ} \cdot \text{AT}) / (\text{BR} \cdot \text{ABS} \cdot \text{EF} \cdot \text{ED})$$

$$\text{Carcinogen Air Screening Level } (\mu\text{g}/\text{m}^3) = (\text{RISK} \cdot \text{ABW} \cdot \text{UCF} \cdot \text{AT}) / (\text{CPF} \cdot \text{BR} \cdot \text{ABS} \cdot \text{EF} \cdot \text{ED})$$

where,

Parameter Name	Value	Units
Method B average body weight (ABW)	16	kg
Method B (noncarcinogenic) breathing rate (BR)	10	m ³ /day
Method B (carcinogenic) breathing rate (BR)	20	m ³ /day
Method B (carcinogenic) exposure duration (ED)	30	yr
Method B target cancer risk (RISK)	1E-06	unitless
noncarcinogenic exposure duration (ED)	6	yr
noncarcinogen averaging time (ATnc)	6	yr
carcinogen averaging time (ATcarc)	75	yr
exposure frequency (EF)	1	unitless
inhalation absorption fraction (ABS)	1	unitless
unit conversion factor (UCF)	1E+03	μg/g
target hazard quotient (HQ)	0.1	unitless
cancer potency factor (CPF)	(see Table C-5)	(mg/kg-day) ⁻¹
reference dose (RfD)	(see Table C-5)	(mg/kg-day)

Published toxicity reference concentrations (mg/m³) and unit risk values (μg/m³)⁻¹ were converted to the corresponding reference dose (RfD) and carcinogenic potency factor (CPF) values assuming an inhalation rate of 20 m³/day and an adult body weight of 70 kg (154 lbs), as described in WAC 173-340-708(7). Unrestricted land use (Method B) air screening levels are shown in Table J-9 included in Appendix J: Summary Tables Supporting the Screening of Target Analytes. WAC 173-340-708(5) states that for multiple hazardous substances with "similar types of toxic response", the hazard index should not exceed 1.0.

6.4.5 Estimation of Building Concentrations from Soil Gas Concentrations

The initial screening assessment compared the EPCs directly to MTCA ambient air thresholds for Method B (unrestricted) land use. This was an extremely protective comparison. The MTCA thresholds pertain to indoor and outdoor air, whereas the EPCs are calculated from concentrations of chemicals in subsurface soil gas. For those chemicals to be inhaled by human receptors, the soil gasses must move up through the soil column and enter the atmosphere or a building. At the point that the soil gasses do that, they are immediately diluted by mixing with above-ground air.

Comparing soil gas EPCs directly to MTCA thresholds was done as a first screen to determine if the concentrations of chemicals in soil gas are so low as to not be a concern even if they were inhaled directly, as described in WAC 173-340-740(3)(c)(iv)(B)(I). Subsequent evaluation of a second-tier screening of potential risks posed by soil gas, using modeling methods to estimate breathing air concentrations [WAC 173-340-740(3)(c)(iv)(B)(III)] was also conducted.

EPA's Johnson and Ettinger model, SG-Screen, version 3.1, February 2004 (http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm) was used to estimate building concentrations from the soil gas source. The model assumes that a 100 m² (1076 ft²) building is constructed on the site. For this project, the building was assumed to be on a slab-on-grade since a basement is unlikely on this site. The model also assumes that soil physical properties are homogeneous with depth, and that contaminants diffuse upwards through the soil until reaching the building slab, where they are drawn by a pressure gradient into the building through the foundation and through cracks along the belowground wall seams and foundation base seams.

The Johnson and Ettinger model, used in this manner, provides a more realistic screening assessment for chemicals in soil gas. The Johnson and Ettinger model includes many conservative assumptions to ensure that it is still protective of possible indoor air concentrations. This second level screening assessment is conducted to attempt to focus attention during the MTCA FS on those chemicals in soil gas that may potentially cause significant risks to human health.

The input values used in the model are given in the table below. Environmental data for soil porosity, dry bulk density, and moisture content (% wet wt) were acquired for 14 site soil samples and published in Appendix E: Physical Soil Sample Results. For each of the parameters, the average value among all 14 soil samples was used to represent the parameter value in the model as shown in Table 50.

Table 50 Johnson & Ettinger Model Parameters

Parameter	Units	Spreadsheet Cell	Value	Description/Notes
Soil gas conc C _g	ppmv	H12	EPC	The EPC was taken from Table 4a in "US Ecology Screening Level Risk Assessment 090320.doc".
Depth below grade to bottom of enclosed space floor, L _F	cm	E24	15	Assumes the building is on a slab foundation.
Soil gas sampling depth below grade, L _s	cm	F24	762	The typical trench depth is 45'. The best single number to use is about midway through the depth of the trench, which is roughly 25'. A few analytes were run at 10 and 50' for uncertainty analysis.
Average soil temp, T _s	deg C	G24	52 deg F = 11 deg C	From Figure 8 in the Model Users' Guide.
Vadose zone SCS soil type		H24 or J24	Loamy sand	Based on average data from the lab report (ave %Sand: 78.3; ave %Silt/clay: 21.5).

Table 50 Johnson & Ettinger Model Parameters

Parameter	Units	Spreadsheet Cell	Value	Description/Notes
Soil vapor permeability, kv	cm ²	J24	1.56e-8 from model calculation	The user can either define the soil type and estimate permeability or else just enter a value for permeability. Because we used site data for bulk density, porosity, and water content, we had to enter in a value here. So the model was run first with LS soil-type default parameters, giving a soil vapor permeability of 1.56e-8 cm ² .
Average vapor flow rate into bldg	L/m	J36	(model calculates)	This can be calculated by the model or entered in as a value.
Vadose zone soil dry bulk density, pbA	g/cm ³	F36	1.97	Based on average data from the lab report (ave: 123.2 lb/ft ³)
Vadose zone soil total porosity, nV	Unitless	G36	0.276	Based on average data from the lab report (ave: 27.6%)
Vadose zone soil water-filled porosity, thetawV	cm ³ /cm ³	H36	0.048	Based on average data from the lab report (ave: 4.8%)

6.5 Comparison of Measured Soil, Groundwater, and Air Concentrations to Screening Levels

Exposure point concentrations calculated from values reported in the USE soil, groundwater, and soil gas data sets were compared to the MTCA screening levels to identify possible risk drivers. Exposure point concentrations calculated using soil data from within a 0 to 4.6 m (0 to 15 ft) depth interval were compared to direct-contact (Method B) MTCA screening levels, as directed in WAC 173-340-740(6). For groundwater protection, exposure point concentrations calculated using soil and data from throughout the unsaturated zone were compared to the MTCA screening levels.

For vapor inhalation, indoor air concentrations modeled from exposure point concentrations calculated using soil gas data from throughout the unsaturated zone were compared to the MTCA screening levels. The full soil gas data set has 181 analytes, with detected results for 158 analytes. A toxicity criterion was available for 48 analytes or their readily available surrogates. Since there was no means to evaluate inhalation risk for the remaining compounds, those 133 compounds were not run in the Johnson and Ettinger model. The majority of these remaining analytes are long carbon chain alkanes and so can be safely assumed to be of low or negligible toxicity.

6.6 Human Health Screening Conclusions

The human health soil screening results for detected analytes that were elevated over background or for which background data was not available are presented in Table 51 (direct contact, unrestricted use [Method B]), Table 52 (protection of groundwater, shallow soil), and Table 53 (protection of groundwater, deep soil). The human health groundwater screening results are shown in Table 54 and the air screening results are shown in Table 55 (unrestricted use [Method B]).

No analytes failed the direct contact screen for soil against any Method B CULs (see Table 51).

The only analyte that failed the shallow soil (0 to 4.6 m [0 to 15 ft] bgs) protection of groundwater screen was Nitrate. The analytes that failed the deep soil (greater than 4.6 m [15 ft] bgs) protection of groundwater screen were hexavalent chromium, methylene chloride, nitrate, and nitrite (see Table 51). Note that several of the methylene chloride exceedances occurred in samples where the analyte was also detected in the associated blank.

The analytes detected in groundwater that exceeded the groundwater CUL were 1,2-dichloroethane-d4, antimony, arsenic, bromofluorobenzene, fluoride, hexavalent chromium, molybdenum, nitrate, toluene-d8, trichloroethene, uranium, and vanadium (see Table 54). Excluding uranium, nearly all detects for these analytes exceeded their respective CULs.

The analytes detected in soil vapor that exceeded the air screening CULs (see Table 54) were 1,1-dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, dichlorofluoromethane, tetrachloroethene, and trichloroethene.

Table 51 Soil Direct Contact, Unrestricted Use (Method B) Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Method B Value (mg/kg)	Noncarc Method B Screen	Carc Method B Value (mg/kg)	Carc Method B Screen
Acetone	67-64-1	µg/kg	13	9	28	19	Approx gamma	7.2E+03	0	NA	NA
Boron, Total	7440-42-8	mg/kg	13	13	1.4	1.2	Student's-t/UCL	1.6E+03	0	NA	NA
Chromium, Total	7440-47-3	mg/kg	13	13	10.2	9.30	Student's-t/UCL	1.2E+04	0	NA	NA
Di-n-butylphthalate	84-74-2	µg/kg	13	1	30	30	detect	8.0E+02	0	NA	NA
Di-n-octyl phthalate	117-84-0	µg/kg	13	1	40	40	detect	1.6E+02	0	7.1E+01	0
Nickel, Total	7440-02-0	mg/kg	13	13	12.1	10.8	Student's-t/UCL	1.6E+02	0	NA	NA
Nitrate	14797-55-8	mg/kg	13	3	5.44	5.44	max detect	5.7E+04	0	NA	NA
Phenol	108-95-2	µg/kg	13	9	330	303	Approx gamma	2.4E+03	0	NA	NA
Silicon, Total	7440-21-3	mg/kg	11	11	482	456	Student's-t/UCL	NA	NA	NA	NA
Strontium, Total	7440-24-6	mg/kg	13	13	34.1	28.5	Student's-t/UCL	4.8E+03	0	NA	NA
Tin, Total	7440-31-5	mg/kg	13	1	0.71	0.71	detect	4.8E+03	0	NA	NA
<p>Note: All depths are shallow. A Screening value of 0 indicates the EPC<Screening Level A Screening value of 1 indicates the EPC>Screening Level NA = Not Applicable</p>											

Table 52 Soil (0 to 4.6 m [0 to 15 ft] bgs) Protection of Groundwater Screening Results

Analyte	CAS ID	Concentration Units	Sample Depth	N	Num Detect	Max Detect	EPC	EPC Type	Groundwater Soil Screen Value (mg/kg)	Groundwater Protection Soil Screen
Acetone	67-64-1	µg/kg	Shallow	13	9	28	19	Approx gamma	7.1E-01	0
Boron, Total	7440-42-8	mg/kg	Shallow	13	13	1.4	1.2	Student's- <i>t</i> UCL	2.0E+01	0
Chromium, Total	7440-47-3	mg/kg	Shallow	13	13	10.2	9.30	Student's- <i>t</i> UCL	2.0E+03	0
Di-n-butylphthalate	84-74-2	µg/kg	Shallow	13	1	30	30	detect	1.6E+01	0
Di-n-octyl phthalate	117-84-0	µg/kg	Shallow	13	1	40	40	detect	3.3E+04	0
Nickel, Total	7440-02-0	mg/kg	Shallow	13	13	12.1	10.8	Student's- <i>t</i> UCL	4.2E+01	0
Nitrate	14797-55-8	mg/kg	Shallow	13	3	5.44	5.44	max detect	2.4E+00	1
Phenol	108-95-2	µg/kg	Shallow	13	9	330	300	Approx gamma	6.6E-01	0
Silicon, Total	7440-21-3	mg/kg	Shallow	11	11	482	456	Student's- <i>t</i> UCL	NA	NA
Strontium, Total	7440-24-6	mg/kg	Shallow	13	13	34.1	28.5	Student's- <i>t</i> UCL	4.8E+02	0
Tin, Total	7440-31-5	mg/kg	Shallow	13	1	0.71	0.71	detect	4.8E+03	0
Note: All depths are shallow. A Screening value of 0 indicates the EPC<Screening Level A Screening value of 1 indicates the EPC>Screening Level NA = Not Applicable										

Table 53 Soil (greater than 4.6 m [15 ft] bgs) Protection of Groundwater Screening Results

Analyte	CAS ID	Concentration Units	Sample Depth	N	Num Detect	Max Detect	EPC	EPC Type	Groundwater Protection Soil Value (mg/kg)	Groundwater Protection Soil Screen
1,1,1-Trichloroethane	71-55-6	µg/kg	Deep	127	18	5	2	Student's-t/UCL	2.2E+00	0
1,1-Dichloroethane	75-34-3	µg/kg	Deep	127	27	9	2	Student's-t/UCL	3.6E-02	0
1,2,4-Trichlorobenzene	120-82-1	µg/kg	Deep	127	3	130	130	max detect	8.6E-01	0
1,2-Dichloroethene (total)	540-59-0	µg/kg	Deep	127	11	78	7.2	BCa bootstrap	2.9E-02	0
2-Butanone	78-93-3	µg/kg	Deep	127	4	12	12	max detect	5.7E-01	0
Acetone	67-64-1	µg/kg	Deep	127	65	330	22	Student's-t/UCL	7.1E-01	0
bis(2-Ethylhexyl)phthalate	117-81-7	µg/kg	Deep	127	25	130	45	Student's-t/UCL	4.1E+01	0
Boron, Total	7440-42-8	mg/kg	Deep	127	125	3.5	1.1	Student's-t/UCL	2.0E+01	0
Butylbenzylphthalate	85-68-7	µg/kg	Deep	127	1	130	130	detect	2.8E+02	0
Carbon Disulfide	75-15-0	µg/kg	Deep	127	1	6	6	detect	4.8E-01	0
Chloroform	67-66-3	µg/kg	Deep	127	74	31	5.9	Approx gamma	3.6E-01	0
Chromium VI	18540-29-9	mg/kg	Deep	127	46	3.6	0.41	Approx gamma	4.5E-03	1
Chromium, Total	7440-47-3	mg/kg	Deep	127	127	51.9	26.3	Student's-t/UCL	2.0E+03	0
cis-1,2-dichloroethene	156-59-2	µg/kg	Deep	127	11	78	7.1	BCa bootstrap	2.8E-02	0
Diethylphthalate	84-66-2	µg/kg	Deep	127	12	300	100	Student's-t/UCL	7.8E+00	0
Di-n-butylphthalate	84-74-2	µg/kg	Deep	127	14	43	32	Student's-t/UCL	1.6E+01	0
Di-n-octyl phthalate	117-84-0	µg/kg	Deep	127	7	180	130	Student's-t/UCL	3.3E+04	0
Freon 113	76-13-1	µg/kg	Deep	127	21	26	3.4	Approx gamma	1.3E+03	0
Methylene Chloride	75-09-2	µg/kg	Deep	127	2	120	120	max detect	8.7E-03	1
Nickel, Total	7440-02-0	mg/kg	Deep	127	127	28.3	17.3	Student's-t/UCL	4.2E+01	0
Nitrate	14797-55-8	mg/kg	Deep	127	95	243	16.8	Approx gamma	2.4E+00	1
Nitrite	14797-65-0	mg/kg	Deep	127	1	2.68	2.68	detect	1.5E-01	1

Table 53 Soil (greater than 4.6 m [15 ft] bgs) Protection of Groundwater Screening Results

Analyte	CAS ID	Concentration Units	Sample Depth	N	Num Detect	Max Detect	EPC	EPC Type	Groundwater Protection Soil Value (mg/kg)	Groundwater Protection Soil Screen
Phenol	108-95-2	µg/kg	Deep	127	7	720	140	NA ¹	6.6E-01	0
Silicon, Total	7440-21-3	mg/kg	Deep	37	37	3820	1580	NA ¹	NA	NA
Strontium, Total	7440-24-6	mg/kg	Deep	127	127	111	31.7	Student's- <i>t</i> UCL	4.8E+02	0
Sulfide	18496-25-8	mg/kg	Deep	127	8	36.7	12.4	Student's- <i>t</i> UCL	NA	NA
Tetrachloroethene	127-18-4	µg/kg	Deep	127	49	6	2	Student's- <i>t</i> UCL	1.6E-02	0
Tin, Total	7440-31-5	mg/kg	Deep	127	77	2.6	0.91	Approx gamma	4.8E+03	0
Trichloroethene	79-01-6	µg/kg	Deep	127	48	170	14	BCa bootstrap	3.8E-02	0
UNKNOWN	UNKNOWN	µg/kg	Deep	1	1	6	6	detect	NA	NA

¹ Gamma-based UCL could not be found so the EPC is the average of the Student's-*t* UCL and the nonparametric UCL.

A Screening value of 0 indicates the EPC<Screening Level

A Screening value of 1 indicates the EPC>Screening Level

NA = Not Applicable

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
1,1,1-Trichloroethane	71-55-6	µg/L	64	14	3	2	Student's-t UCL	1.6E+03	NA	2.0E-01	MCL	2.0E+02	0
1,1-Dichloroethane	75-34-3	µg/L	64	16	5.84	4.02	Approx gamma	1.6E+02	7.7E+00	NA	Carc CUL	7.7E+00	0
1,2,4-Trichlorobenzene	120-82-1	µg/L	64	1	1	1	detect	8.0E+00	NA	7.0E-02	NC CUL	8.0E+00	0
1,2-Dichloroethane-d4	17060-07-0	µg/L	1	1	103	103	detect	NA	4.8E-01	5.0E-03	Carc CUL	4.8E+00	1
1,2-Dichloroethene (total)	540-59-0	µg/L	64	15	4.7	2.7	Approx gamma	7.2E+00	NA	NA	NC CUL	7.2E+00	0
1,4-Dichlorobenzene-d4	1,4-Dichlorobenzene-d4	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA
2-Butanone	78-93-3	µg/L	64	6	7.79	4.89	Student's-t UCL	4.8E+02	NA	NA	NC CUL	4.8E+02	0
Acenaphthene-d10	Acenaphthene-d10	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA
Acetone	67-64-1	µg/L	64	8	10	4	Student's-t UCL	7.2E+02	NA	NA	NC CUL	7.2E+02	0
Aldol Condensate 1	ALDOL_CONDENSATE	µg/L	1	1	9.04	9.04	detect	NA	NA	NA	NA	NA	NA
ALKANE	28776-38-7	µg/L	13	13	8	5	Student's-t UCL	NA	NA	NA	NA	NA	NA
Aluminum, Total	7429-90-5	µg/L	64	45	68.6	28.6	Student's-t UCL	1.6E+03	NA	NA	NC CUL	1.6E+03	0
Antimony, Total	7440-36-0	µg/L	64	5	1.2	0.89	Student's-t UCL	6.4E-01	NA	6.0E-03	NC CUL	6.4E-01	1
Arsenic, Total	7440-38-2	µg/L	64	63	4.8	2.8	Student's-t UCL	4.8E-01	5.8E-02	1.0E-02	NC CUL	4.8E-01	1

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
Barium, Total	7440-39-3	µg/L	64	64	44.7	39.2	Student's-t UCL	3.2E+02	NA	2.0E+00	NC CUL	3.2E+02	0
bis(2-Ethylhexyl)phthalate	117-81-7	µg/L	64	11	28	3.2	Approx gamma	3.2E+01	6.3E+00	6.0E-03	MCL	6.0E+00	0
Boron, Total	7440-42-8	µg/L	64	64	20.3	17.2	Student's-t UCL	3.2E+02	NA	NA	NC CUL	3.2E+02	0
Bromofluorobenzene	460-00-4	µg/L	1	1	100	100	detect	1.6E+01	NA	NA	NC CUL	1.6E+01	1
Cadmium, Total	7440-43-9	µg/L	64	3	0.159	0.159	max detect	8.0E-01	NA	5.0E-03	NC CUL	8.0E-01	0
Calcium, Total	7440-70-2	µg/L	64	64	42400	40000	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Chloride	16887-00-6	mg/L	64	64	10.5	9.02	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Chloroform	67-66-3	µg/L	64	22	23.3	8.70	Student's-t UCL	1.6E+02	NA	8.0E-02	MCL	8.0E+01	0
Chromium VI	18540-29-9	mg/L	64	61	0.2	0.07	Student's-t UCL	4.8E+00	NA	1.0E-01	NC CUL	4.8E+00	1
Chromium, Total	7440-47-3	µg/L	64	64	105	75.2	Student's-t UCL	2.4E+03	NA	1.0E-01	MCL	1.0E+02	0
Chrysene-d12	Chrysene-d12	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA
Cis-1,2-dichloroethene	156-59-2	µg/L	64	15	4.7	2.7	Approx gamma	8.0E+00	NA	7.0E-02	NC CUL	8.0E+00	0
Copper, Total	7440-50-8	µg/L	64	19	7.2	1.7	Approx gamma	6.4E+01	NA	1.3E+00	NC CUL	6.4E+01	0
Cyanide, Total	57-12-5	µg/L	64	4	2.5	2.5	max detect	NA	NA	NA	NA	NA	NA
CYCLOHEXENE	33004-06-7	µg/L	3	3	300	300	max detect	NA	NA	NA	NA	NA	NA

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
Di-n-butylphthalate	84-74-2	µg/L	64	9	0.9	0.7	Student's-t UCL	1.6E+02	NA	NA	NC CUL	1.6E+02	0
Fluoride	16984-48-8	mg/L	64	60	0.45	0.34	NA ¹	9.6E+01	NA	4.0E+00	NC CUL	9.6E+01	1
Freon 113	76-13-1	µg/L	64	12	3.51	2.41	Student's-t UCL	2.4E+04	NA	NA	NC CUL	2.4E+04	0
Iron, Total	7439-89-6	µg/L	64	43	285	84.0	Student's-t UCL	1.1E+03	NA	3.0E-01	MCL	3.0E+02	0
Lead, Total	7439-92-1	µg/L	64	17	2	1	Student's-t UCL	NA	NA	1.5E-02	MCL	1.5E+01	0
Magnesium, Total	7439-95-4	µg/L	64	64	14600	14000	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Manganese, Total	7439-96-5	µg/L	64	50	8	2	Approx gamma	7.5E+01	NA	5.0E-02	MCL	5.0E+01	0
Mercury, Total	7439-97-6	µg/L	64	12	0.189	0.071	Student's-t UCL	4.8E-01	NA	2.0E-03	NC CUL	4.8E-01	0
Methylene Chloride	75-09-2	µg/L	64	8	2.38	1.40	Student's-t UCL	4.8E+01	5.8E+00	5.0E-03	MCL	5.0E+00	0
Molybdenum, Total	7439-98-7	µg/L	64	64	10.6	9.0	Student's-t UCL	8.0E+00	NA	NA	NC CUL	8.0E+00	1
Naphthalene-d8	Naphthalene-d8	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA
Nickel, Total	7440-02-0	µg/L	64	32	3.91	1.60	Approx gamma	3.2E+01	NA	1.0E-01	NC CUL	3.2E+01	0
Nitrate	14797-55-8	mg/L	64	64	21.7	18.0	Student's-t UCL	2.6E+03	NA	1.0E+01	NC CUL	2.6E+03	1
ORGANIC ACID	ORGANIC_ACID	µg/L	3	3	8	8	max detect	NA	NA	NA	NA	NA	NA
Perylene-d12	Perylene-d12	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
Phenanthrene-d10	Phenanthrene-d10	µg/L	1	1	40	40	detect	NA	NA	NA	NA	NA	NA
Phosphate	14265-44-2	mg/L	58	1	0.58	0.58	detect	NA	NA	NA	NC CUL	NA	NA
Potassium, Total	7440-09-7	µg/L	64	64	5430	4910	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Selenium, Total	7782-49-2	µg/L	64	64	4.4	3.0	Student's-t UCL	8.0E+00	NA	5.0E-02	NC CUL	8.0E+00	0
Silicon, Total	7440-21-3	µg/L	64	64	22300	20700	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Silver, Total	7440-22-4	µg/L	64	5	3.2	0.60	Student's-t UCL	8.0E+00	NA	1.0E-01	NC CUL	8.0E+00	0
Sodium, Total	7440-23-5	µg/L	64	64	19700	17200	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
Strontium, Total	7440-24-6	µg/L	64	64	190	180	Student's-t UCL	9.6E+02	NA	NA	NC CUL	9.6E+02	0
SUBSTITUTED PHENOL	SUBSTITUTED_PHENOL	µg/L	3	3	8	8	max detect	NA	NA	NA	NA	NA	NA
Sulfate	14808-79-8	mg/L	64	64	27.5	23.0	Student's-t UCL	NA	NA	NA	NC CUL	NA	NA
TIC: Aldol Condensate 1	TIC:AldolCondensate1	µg/L	4	4	8.58	8.58	max detect	NA	NA	NA	NA	NA	NA
TIC: Alkane 1	TIC:Alkane1	µg/L	10	10	10.4	8.0	Student's-t UCL	NA	NA	NA	NA	NA	NA
TIC: Cyclotetrasiloxane, octamethyl-	541-05-9	µg/L	1	1	4.75	4.75	detect	NA	NA	NA	NA	NA	NA
TIC: Cyclotrisiloxane, hexamethyl	556-67-2	µg/L	1	1	6.32	6.32	detect	NA	NA	NA	NA	NA	NA

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
TIC: Tetrahydrofuran	109-99-9	µg/L	6	6	28.5	28.1	Approx gamma	NA	NA	NA	NA	NA	NA
TIC: Trichloro-1-propene	TIC:Trichloro-1-propene	µg/L	2	2	4.58	4.58	max detect	NA	NA	NA	NA	NA	NA
TIC: Unknown 1	TIC:Unknown1	µg/L	32	32	214	50.8	Approx gamma	NA	NA	NA	NA	NA	NA
TIC: Unknown 10	TIC:Unknown10	µg/L	1	1	26.8	26.8	detect	NA	NA	NA	NA	NA	NA
TIC: Unknown 2	TIC:Unknown2	µg/L	23	23	95.8	23.0	Student's-t UCL	NA	NA	NA	NA	NA	NA
TIC: Unknown 3	TIC:Unknown3	µg/L	15	15	42.5	18.7	Approx gamma	NA	NA	NA	NA	NA	NA
TIC: Unknown 4	TIC:Unknown4	µg/L	12	12	71.1	27.2	Approx gamma	NA	NA	NA	NA	NA	NA
TIC: Unknown 5	TIC:Unknown5	µg/L	6	6	73.4	75.6	Approx gamma	NA	NA	NA	NA	NA	NA
TIC: Unknown 6	TIC:Unknown6	µg/L	3	3	74.7	74.7	max detect	NA	NA	NA	NA	NA	NA
TIC: Unknown 7	TIC:Unknown7	µg/L	2	2	35.9	35.9	max detect	NA	NA	NA	NA	NA	NA
TIC: Unknown 8	TIC:Unknown8	µg/L	2	2	37.5	37.5	max detect	NA	NA	NA	NA	NA	NA
TIC: Unknown 9	TIC:Unknown9	µg/L	2	2	20	20	max detect	NA	NA	NA	NA	NA	NA
TIC:1-butoxy-2-propanol	5131-66-8	µg/L	3	3	11	11	max detect	NA	NA	NA	NA	NA	NA
Tin, Total	7440-31-5	µg/L	64	21	2.5	0.98	Approx gamma	9.6E+02	NA	NA	NC CUL	9.6E+02	0
Titanium, Total	7440-32-6	µg/L	64	57	2.98	1.29	BCa bootstrap	NA	NA	NA	NC CUL	NA	NA

Table 54 Groundwater Screening Results

Analyte	CAS ID	Units	N	Num Detect	Max Detect	EPC	EPC Type	Noncarc Screen (µg/L)	Carc Screen (µg/L)	MCL (mg/L)	Screen Type	GW Screen (µg/L)	GW Screen
Toluene-d8	2037-26-5	µg/L	1	1	102	102	detect	6.4E+01	NA	1.0E+00	ncCUL	6.4E+01	1
Trichloroethene	79-01-6	µg/L	64	16	29.3	10.9	Approx gamma	NA	3.4E+00	5.0E-03	MCL	5.0E+00	1
TRICHLOROPROPENE	35175-85-0	µg/L	1	1	2	2	detect	NA	NA	NA	NA	NA	NA
Unknown	UNKNOWN	µg/L	5	5	40	40	95 Chebyshev	NA	NA	NA	NA	NA	NA
Uranium, Total	7440-61-1	µg/L	64	14	156	10.6	Student's-t UCL	4.8E+00	NA	3.0E-02	ncCUL	4.8E+00	1
Vanadium, Total	7440-62-2	µg/L	64	64	34.6	29.3	Student's-t UCL	1.4E+01	NA	NA	ncCUL	1.4E+01	1
Zinc, Total	7440-66-6	µg/L	64	50	26.7	4.05	Student's-t UCL	4.8E+02	NA	5.0E+00	ncCUL	4.8E+02	0
<p>¹ Gamma-based UCL could not be found so the EPC is the average of the Student's-t UCL and the nonparametric UCL. A Screening value of 0 indicates the EPC<Screening Level A Screening value of 1 indicates the EPC>Screening Level NA = Not Applicable</p>													

Table 55 Air, Unrestricted Use (Method B) Screening Results

Analyte	CAS ID	N	Num Detect	Max Detect	EPC ppbv	EPC Type	Model Result (ppbv)	Method B noncarc Screen (ppbv)	Method B carc Screen (ppbv)	Method B lowest Screen (ppbv)	Method B Air Screen
1,1,1-Trichloroethane	71-55-6	344	324	43000	4100	NA	1.5E+00	4.2E+01	NA	4.2E+01	0
1,1,2,2-Tetrachloroethane	79-34-5	344	0	NA	NA	NA	NA	NA	6.3E-03	6.3E-03	NA
1,1,2-Trichloroethane	79-00-5	344	0	NA	NA	NA	NA	NA	2.9E-02	2.9E-02	NA
1,1-Dichloroethane	75-34-3	344	275	36000	5100	NA	1.9E+00	NA	3.9E-01	3.9E-01	1
1,1-Dichloroethene	75-35-4	344	143	9600	810	NA	3.3E-01	2.3E+00	NA	2.3E+00	0
1,2,4-Trichlorobenzene	120-82-1	344	0	NA	NA	NA	NA	1.2E-02	NA	1.2E-02	NA
1,2,4-Trimethylbenzene	95-63-6	344	0	NA	NA	NA	NA	6.5E-02	NA	6.5E-02	NA
1,2-Dibromoethane	106-93-4	344	0	NA	NA	NA	NA	5.4E-02	5.4E-04	5.4E-04	NA
1,2-Dichloro-1,1,2-Trifluoroethane	354-23-4	264	264	180000	14000	NA	8.7E+00	2.2E+02	NA	2.2E+02	0
1,2-Dichlorobenzene	95-50-1	344	0	NA	NA	NA	NA	1.5E+00	NA	1.5E+00	NA
1,2-Dichloroethane	107-06-2	344	7	93	11	97.5 Chebyshev	4.9E-03	NA	2.4E-02	2.4E-02	0
1,3-Butadiene	106-99-0	1	1	22000	22000	detect	1.4E+01	4.1E-02	3.8E-02	3.8E-02	1
1,3-Dichlorobenzene	541-73-1	344	0	NA	NA	NA	NA	6.1E+00	3.8E-02	3.8E-02	NA
1,4-Dichlorobenzene	106-46-7	344	0	NA	NA	NA	NA	6.1E+00	3.8E-02	3.8E-02	NA
2-Butanone	78-93-3	344	8	58	5.8	97.5 Chebyshev	2.2E-03	7.8E+01	NA	7.8E+01	0
2-Hexanone	591-78-6	344	1	3.2	3.2	detect	1.9E-03	7.8E+00	NA	7.8E+00	0
Acetaldehyde	75-07-0	344	4	29	29	max detect	1.4E-02	2.3E-01	NA	2.3E-01	0
Acetone	67-64-1	344	72	3900	497.6	NA	2.4E-01	6.0E+02	NA	6.0E+02	0
Benzene	71-43-2	344	6	1700	460	NA	1.9E-01	4.3E-01	1.0E-01	1.0E-01	1

Table 55 Air, Unrestricted Use (Method B) Screening Results

Analyte	CAS ID	N	Num Detect	Max Detect	EPC ppbv	EPC Type	Model Result (ppbv)	Method B noncarc Screen (ppbv)	Method B carc Screen (ppbv)	Method B lowest Screen (ppbv)	Method B Air Screen
Benzene, 1,3-Dimethyl-	108-38-3	1	1	2.7	2.7	detect	9.5E-04	7.4E+00	NA	7.4E+00	0
Benzyl Chloride	100-44-7	344	2	14	14	max detect	5.2E-03	8.8E-03	9.9E-03	8.8E-03	0
Bromomethane	74-83-9	344	0	NA	NA	NA	NA	5.9E-02	NA	5.9E-02	NA
Carbon Disulfide	75-15-0	17	17	750	390	Approx gamma	1.7E-01	1.0E+01	NA	1.0E+01	0
Carbon Tetrachloride	56-23-5	344	84	1900	520	NA	2.0E-01	NA	2.6E-02	2.6E-02	1
Chlorobenzene	108-90-7	344	0	NA	NA	NA	NA	5.0E-01	NA	5.0E-01	NA
Chloroform	67-66-3	344	330	160000	15000	NA	6.5E+00	NA	2.2E-02	2.2E-02	1
Chloromethane	74-87-3	344	5	240	31	BCa bootstrap	1.5E-02	2.0E+00	NA	2.0E+00	0
Cis-1,2-Dichloroethene	156-59-2	344	48	460000	28000	NA	1.0E+01	6.9E-01	NA	6.9E-01	1
Cis-1,3-Dichloropropene	10061-01-5	344	0	NA	NA	NA	NA	2.0E-01	1.4E-01	1.4E-01	NA
Cyclohexane	110-82-7	1	1	1.2	1.2	detect	1.1E-04	8.0E+01	NA	8.0E+01	0
Dichlorodifluoromethane	75-71-8	344	253	5100	1200	NA	4.1E-01	1.8E+00	NA	1.8E+00	0
Dichlorofluoromethane	75-43-4	87	87	24000	6500	NA	3.1E+00	2.2E+00	NA	2.2E+00	1
Ethylbenzene	100-41-4	344	3	7.8	7.8	max detect	2.9E-03	1.1E+01	NA	1.1E+01	0
Freon 113	76-13-1	344	332	530000	64000	NA	2.4E+01	1.8E+02	NA	1.8E+02	0
Hexachlorobutadiene	87-68-3	344	0	NA	NA	NA	NA	NA	1.1E-02	1.1E-02	NA
M/P-Xylene	M+P_XYLENE	344	6	17	2.8	BCa bootstrap	1.1E-03	7.4E+00	NA	7.4E+00	0
Methyl Isobutyl Ketone	108-10-1	3	3	61	61	max detect	2.2E-02	3.3E+01	NA	3.3E+01	0
Methylene Chloride	75-09-2	344	43	35000	890	NA	3.9E-01	NA	1.5E+00	1.5E+00	0
O-Xylene	95-47-6	344	2	3.9	3.9	max detect	1.6E-03	7.4E+00	NA	7.4E+00	0
Phenol	108-95-2	18	18	2800	1500	NA	6.7E-01	2.4E+00	NA	2.4E+00	0

Table 55 Air, Unrestricted Use (Method B) Screening Results

Analyte	CAS ID	N	Num Detect	Max Detect	EPC ppbv	EPC Type	Model Result (ppbv)	Method B noncarc Screen (ppbv)	Method B carc Screen (ppbv)	Method B lowest Screen (ppbv)	Method B Air Screen
Styrene	100-42-5	344	1	3.1	3.1	detect	1.1E-03	1.1E+01	NA	1.1E+01	0
Tetrachloroethene	127-18-4	344	179	9900	1100	NA	4.0E-01	1.8E+00	6.2E-02	6.2E-02	1
Toluene	108-88-3	344	12	560	35	99 Chebyshev	1.4E-02	6.1E+01	NA	6.1E+01	0
Trans-1,2-Dichloroethene	156-60-5	344	2	1000	1000	max detect	3.6E-01	6.9E-01	NA	6.9E-01	0
Trans-1,3-Dichloropropene	10061-02-6	344	0	NA	NA	NA	NA	2.0E-01	1.4E-01	1.4E-01	NA
Trichloroethene	79-01-6	344	206	1800000	97000	NA	3.7E+01	NA	2.3E-01	2.3E-01	1
Trichlorofluoromethane (R11)	75-69-4	344	251	22000	3000	NA	1.2E+00	5.7E+00	NA	5.7E+00	0
Vinyl Chloride	75-01-4	344	0	NA	NA	NA	NA	1.8E+00	2.2E-01	2.2E-01	NA
A Screening value of 0 indicates the EPC<Screening Level A Screening value of 1 indicates the EPC>Screening Level NA = Screening Value Not Available											

6.7 Ecological Screening-Level Assessment

To screen chemicals for ecological risk, hazard analyses are based on the degree to which exposure approaches effect levels for ecological receptors. Adverse ecological effects are inferred by the ratio of exposure to effect levels. The ratio is termed a hazard quotient (HQ). Exceedance of the effect level results in an HQ greater than one. Chemicals that have HQs less than one do not require further consideration in the assessment of ecological risk.

The USE Site is slated for industrial use and the Washington Administrative Code requires consideration of wildlife for the screening assessment. For purposes of conservatism, no observed adverse effect levels (NOAELs) are used for wildlife.

A literature review was performed to compile NOAELs for chemicals detected in soil at USE. The compilation includes toxicity information for avian predators and mammalian predators/herbivores that are meant to be representative of receptors at the Hanford Site. Most of the published toxicological data represent results of tests with single chemicals. Toxicity information such as this may be expressed as dietary doses associated with the absence of adverse effects.

The effect levels for wildlife were extensively reviewed and selected based on defined quality criteria. The sources used, in order of preference, are WAC 173-340 900, Table 749-3 and Table 749-5; “Environmental Protection Agency Ecological Soil Screening Levels” (EcoSSLs); Los Alamos National Laboratory ECORISK Database Ecological Screening Values; and, peer-reviewed literature not associated with these preceding toxicity compilations (e.g., *Derivation of Ecotoxicity Thresholds for Uranium*, Sheppard et al. 2005).

Wildlife are exposed to chemicals primarily through oral exposure. The oral exposure model used for wildlife is from the WAC Table 749-4 for a shrew, vole, and robin. This model provides an estimate of the oral exposure associated with a chemical of potential ecological concern (COPEC) concentration in soil and food. Soil ingestion is calculated as a fraction of dietary intake. The concentration in food is based on literature values for uptake into plants or invertebrates from soil. An implicit assumption of this model is that the bioavailability of the COPEC from soil is comparable to the bioavailability of the contaminant in the toxicological experiment. Because little information currently exists on bioavailability conversions, a bioavailability term was not included in the general wildlife exposure model and bioavailability is considered 100 percent. This is an extremely protective approach, appropriate for initial screening of ecological exposure.

There are several chemicals normally found in soil that are typically excluded from ecological screening for several reasons, including that they are non-toxic in soil (nitrate, phosphate, potassium, silicon and sulfate) or that they are considered essential nutrients (calcium, iron, magnesium, and sodium). Aluminum is also not included in the screening assessment because it is not toxic at the circumneutral pH conditions typical of the Hanford Site. In addition to screening soil for ecological toxicity, soil vapor data were screened. The wildlife inhalation pathway may be

relevant at sites with subsurface vapors occurring where biota could potentially be located, such as in the burrows of small mammals. This inhalation-based screening level assessment was performed to examine the potential exposure burrowing mammal exposure to vapor concentrations in soil that could result in adverse ecological effects.

6.7.1 Ecological Screening Conclusions

The screening results for detected analytes in soil are presented in Table 56. Toxicity data and screening value calculations can be found in Appendix J: Summary Tables Supporting the Screening of Target Analytes. The ecological screen utilizes the shallow soil (0 to 4.6 m [0 to 15 ft] bgs) samples because these are the samples relevant to exposure. No analytes elevated over background or not tested against background failed the ecological soil screen. Note that analytes found to be consistent with background have not been carried through to the screen and are not presented in Table 56.

Table 56 Ecological Screening Assessment for Detected Analytes in Soil

Analyte	CAS ID	Conc. Units	N	Num Detect	Max Detect	EPC	EPC Type	Wildlife Soil Screening Value (mg/kg)	Soil Wildlife Screen Results
Acetone	67-64-1	µg/kg	13	9	28	19	Approx gamma	0.4	0
Boron, Total	7440-42-8	mg/kg	13	13	1.4	1.2	Student's-t/UCL	22	0
Chromium, Total	7440-47-3	mg/kg	13	13	10.2	9.29	Student's-t/UCL	67	0
Di-n-butylphthalate	84-74-2	µg/kg	13	1	30	30	detect	0.04	0
Di-n-octyl phthalate	117-84-0	µg/kg	13	1	40	40	detect	1	0
Nickel, Total	7440-02-0	mg/kg	13	13	12.1	10.8	Student's-t/UCL	977	0
Nitrate	14797-55-8	mg/kg	13	3	5.44	5.44	max detect	NA	NA
Phenol	108-95-2	µg/kg	13	9	330	303	Approx gamma	12.3	0
Silicon, Total	7440-21-3	mg/kg	11	11	482	456	Student's-t/UCL	NA	NA
Strontium, Total	7440-24-6	mg/kg	13	13	34.1	28.5	Student's-t/UCL	31.4	0
Tin, Total	7440-31-5	mg/kg	13	1	0.71	0.71	detect	13.2	0
<p>Note: All Depths Are Shallow A Screening value of 0 indicates the EPC<Wildlife Screening Level A Screening value of 1 indicates the EPC>Wildlife Screening Level NA = Wildlife Screening Value Not Available</p>									

6.8 Hazardous Substances to Be Further Considered

Based upon the evaluation, the following hazardous substances have been identified for further evaluation to define their nature and extent in the environment at the USE Site. In some cases constituents were either added or removed to account for variables the screening process was unable to accommodate. In those cases, the RI provides an explanation. While not an official term defined under MTCRA, these hazardous substances requiring further evaluation are referred to as contaminants of potential concern (COPCs).

6.8.1 Soil

No constituents exceeded the unrestricted soil direct-contact screening levels. Nitrate, hexavalent chromium, nitrite, and methylene chloride exceeded the protectiveness of groundwater screening levels (see Table 51 through Table 53). The following hazardous substances were identified in the field investigation and will be considered constituents of potential concern.

- **Nitrate** results were detected in 95 of 127 soil samples. The maximum result was 243 mg/kg, and an EPC of 16.2 mg/kg was calculated; this EPC exceeded the protectiveness of groundwater screening level by almost two times (9.5 mg/kg).
- **Nitrite** was detected in 1 of 127 samples. This single result of 2.68 mg/kg exceeded the protectiveness of groundwater screening level (0.95 mg/kg)
- **Methylene Chloride's** presence was estimated in 2 of 127 samples; these detections (more than 100 µg/kg) exceeded the protectiveness of groundwater screening level of 8.7 µg/kg. As will be discussed in Section 7.0, these two results were flagged "J," estimated detections below the quantitation limit. These results were collocated in a borehole where other samples were flagged as having blank contamination.
- **Hexavalent Chromium** measured in 46 of 127 samples were above the quantitation limit. The maximum result was 3.6 mg/kg, and an EPC of 0.39 mg/kg was calculated. This EPC exceeded the very conservatively estimated protectiveness of groundwater screening level of 0.045 mg/kg (a K_d of 0 was used, because of the observed hexavalent chromium measured in groundwater results).

6.8.2 Groundwater

A total of 12 constituents exceeded unrestricted groundwater use screening levels (see Table 54). The following hazardous substances were identified during long-term monitoring, and will be considered constituents of potential concern. During the evaluation of the EDD, a single detection of 1,2-dichloroethane-d4 was reported. Based upon an evaluation of the hardcopy data package, this result was determined to be a holdover surrogate result in a QC sample and not the result of a measurement in a "real" sample. Therefore, it was removed from the screening process.

Chloroform was also added as a contaminant of potential concern, due to its collocation with trichloroethene results, and its presence in soil gas results. Chloroform was detected in 12 of 32 samples, with a maximum result of 22 µg/L. The EPC calculated for chloroform was 9.66 µg/L, well below the 80 µg/L screening limit.

- **Hexavalent chromium** was observed in all 32 samples with a maximum concentration observed at 100 µg/L. The hexavalent chromium EPC was calculated to be 71.3 µg/L, exceeding the screening level of 48 µg/L.
- **Trichloroethene** was observed in 9 of 32 samples, and had an EPC of 8.4 µg/L (exceeding the screening level of .11 µg/L). The maximum concentration of trichloroethene observed was 27 µg/L.
- **Arsenic** results were observed above the quantitation limit in 31 of 32 samples, with an EPC of 2.8 µg/L. This EPC exceeded the screening level of 0.58 µg/L. The maximum result for arsenic was 4.8 µg/L. As will be discussed in Section 7.0, these arsenic results are consistent with local background concentrations.
- **Uranium** was observed in 4 of 32 samples, with a maximum detection of 156 µg/L. As will be discussed in Section 7.1.1, a single uranium result exceeded the screening level, and this result (from MW-13, an up-gradient well) is not consistent with the samples collected either before or after this result.
- **Antimony** was observed in 5 of 64 samples, with a maximum detection of 1.2 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 0.64 µg/L.
- **Bromofluorobenzene** was observed in one sample with a maximum detection of 100 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 16 µg/L.
- **Fluoride** was observed in 60 of 64 samples with a maximum detection of 450 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 96 µg/L.
- **Molybdenum** was observed in 64 of 64 samples with a maximum detection of 10.6 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 8 µg/L.
- **Nitrate** was observed in 64 of 64 samples with a maximum detection of 21,700 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 2,600 µg/L.
- **Toluene-d8** was observed in 1 of 1 samples with a maximum detection of 102 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 6.4 µg/L.
- **Vanadium** was observed in 64 of 64 samples with a maximum detection of 34.6 µg/L. This value exceeds the noncarcinogenic CLARC screening value of 1.4 µg/L.

6.8.3 Soil Vapor

As shown in Table 55, several soil vapor results exceeded the screening levels developed for soil vapor. The screening levels were based upon ambient air standards. These standards would only be applicable in exposure assumptions for applications such as human occupancy of a below-grade confined space. A total of nine VOCs exceed the residential screening levels.

- **1,1-Dichloroethane** was detected in 275 of 344 samples, with a maximum result of 36 ppm. The 1,1-dichloroethane building concentration value was determined to be 1.9 ppbv. This value exceeded the MTCA Level B screening value of 0.039 ppbv.

- **Benzene** was detected in 6 of 344 samples, with a maximum result of 36 ppm. The benzene building concentration value was determined to be 0.19 ppbv. This value exceeded the MTCA Level B screening value of 0.1 ppbv.
- **Carbon Tetrachloride** was detected in 84 of 344 samples, with a maximum result of 1.9 ppm. The carbon tetrachloride building concentration value was determined to be 0.2 ppbv. This value exceeded the MTCA Level B screening value of 0.026 ppbv.
- **Chloroform** was detected in 330 of 344 samples, with a maximum result of 1.7 ppm. The chloroform building concentration value was determined to be 6.5 ppbv. This value exceeded the MTCA Level B screening value of 0.022 ppbv.
- **Cis-1,2-Dichloroethene** was detected in 48 of 344 samples, with a maximum result of 460 ppm. The cis-1,2-Dichloroethene building concentration value was determined to be 10 ppbv. This value exceeded the MTCA Level B screening value of 0.69 ppbv.
- **Dichlorofluoromethane** was detected in 87 of 87 samples, with a maximum result of 24 ppm. The dichlorofluoromethane building concentration value was determined to be 3.1 ppbv. This value exceeded the MTCA Level B screening value of 2.2 ppbv.
- **Tetrachloroethene** was detected in 179 of 344 samples, with a maximum result of 9.9 ppm. The tetrachloroethene building concentration value was determined to be 0.4 ppbv. This value exceeded the MTCA Level B screening value of 0.062 ppbv.
- **Trichloroethene** was detected in 206 of 344 samples, with a maximum result of 1,800 ppm. The trichloroethene building concentration value was determined to be 37 ppbv. This value exceeded the MTCA Level B screening value of 0.23 ppbv.
- **1,3 Butadiene** was detected in 1 of 1 samples with a concentration of 22,000 ppbv. This value exceeds the MTCA Level B screening values of 0.38 ppbv.

Chloroform and trichloroethene represent the two soil vapor contaminants that are representative marker compounds to carry forward in a discussion of nature and extent of contamination. These two compounds represent the most widespread hazardous substances present in soil vapor underlying the USE site.

6.9 Analysis of Uncertainties

6.9.1 Uncertainties Related to Exposure Risk

Estimating and evaluating health risk from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge, so simplifying and conservative assumptions must be made to quantify health risks. Some key areas of uncertainty evaluated in the preparation of this document are listed below.

- **Data quality limitations.** Although every effort was made to ensure all data that was collected was of the necessary quality level appropriate for screening level decisions, there were instances where the data quality was impacted for a variety of potential reasons. The most common of these was contamination of the sample either during transport to the analytical laboratory or contamination during the analytical analysis process itself. These

instances present risks of a type II error, indicating that contamination is present at the site, when that contamination is not really present at the site. Of particular concern are those samples where only one detect is present in the dataset and there is insufficient additional data points to make a true assessment of the extent of the contamination, if any, at the site. Of the over 70,000 samples collected for this effort less than one half of one percent were reject, and less than 8 percent of been qualified as estimated measurements.

- **Toxicity Data Gaps.** A variety of sources were utilized in selecting the appropriate concentration levels for exposure risk for the various contaminants studies during this effort. The majorities of these risk exposure levels came from MTCA and are based upon estimated exposure responses for particular chemicals. These are generally conservative estimates based upon toxicity studies that are formulated to capture the exposure of the most sensitive receptor. For many chemicals, these toxicity studies do not exist and toxicity levels are established by comparison to the effects of other similar chemicals. These uncertainties are handled in the conservative hazardous concentration levels.
- **Exposure Assumptions.** Numerous parameters and assumptions are present in the calculation of exposure point concentrations. These assumptions are documented in the subsections pertaining to each calculation and are based upon the guidance model provided in MTCA. These calculations assume a standard population and actual populations that encounter the hazard may have a slightly different set of average parameter values. The conservative nature of the developed models within MTCA provides confidence that the calculated exposure levels will be appropriate for general population exposures.

6.9.2 Uncertainty Related to Screening Level Assessment of Analytes Not Detected in Soil or Groundwater.

While the screening assessments in this memorandum focus on detected analytes, some analysis was performed for analytes that were never detected. From previous work performed for another client in Washington, Neptune had recently calculated human health screening levels for several analytes not detected in soil or groundwater. For these select analytes, the estimated quantitation limits (EQLs) were compared to the human health screening levels as a check to verify that nondetected analytes are not potentially still contaminants of potential concern (COPCs) for this site. Unfortunately, not all detection limits were comfortably below their human health screening levels. For those that failed this screen, the EQLs were compared to the reporting limits (RLs) reported in Appendix A of the SAP (VET-1405-PLN-03) to identify any potential detection limit issues. The discussions below pertain only to the group of analytes for which screening levels were available.

6.9.3 Soil, Unrestricted Use (Method B)

Out of 157 analytes that were not detected, Benzo(a)pyrene was the only non-detected analyte that had EQLs greater than one of the unrestricted use screening levels. All of the soil EQLs for Benzo(a)pyrene were greater than the Method B carcinogenic screening level of 137 µg/kg. Analytic method 8270C produced an EQL in the range of 350 µg/kg to 360 µg/kg for Benzo(a)pyrene soil measurements. The soil RL for PAHs, reported in Appendix A of the SAP (VET-1405-PLN-03), is 0.5 to 2 µg/kg. This is a clear example of the analytical results not

meeting the intent of the RLs proposed by the DQOs, and not reaching an adequate sensitivity for risk screening.

6.9.4 Soil, Protective of Groundwater

The analytes that had no detects in deep soil (greater than 4.6 m [15 ft] bgs), but had EQLs greater than the available soil protective of groundwater screening level are listed in Table 57. For 1,1,2,2-Tetrachloroethane, 19 of the 127 EQLs exceed the DQO RL range. In all of the other cases, all of the EQLs exceed the RL range.

**Table 57 Nondetected Analytes in Deep Soil
with Detection Limits Greater than the Protection of Groundwater Screening Level**

Analyte	CAS ID	Conc. Units	N	Min EQL	Max EQL	GW Protection Soil Screening (mg/kg)	Number Greater Than screening	DQO RL (µg/kg)
1,1,2,2-Tetrachloroethane	79-34-5	µg/kg	127	4	260	1.3E-03	127	5-20
2-Methylnaphthalene	91-57-6	µg/kg	126	330	1400	6.0E-01	1	0.5-2
Carbazole	86-74-8	µg/kg	126	330	1400	9.4E-01	126	0.5-2
Diethylether	60-29-7	µg/kg	127	7	520	2.1E-01	9	Not listed
Isophorone	78-59-1	µg/kg	127	330	1400	1.8E-01	127	100-200
Pentachlorophenol	87-86-5	µg/kg	125	1700	6900	3.8E-02	125	100-200

6.9.5 Groundwater

For those analytes with groundwater screening levels available, those with no detects and EQLs greater than their human health groundwater screening are listed in Table 58. The PAHs and Pentachlorophenol did not have EQLs that met their RLs.

**Table 58 Nondetected Analytes in Groundwater
with EQLs greater than the Human Health Groundwater Screening Level**

Analyte	CAS ID	Conc. Units	N	Min EQL	Max EQL	GW Screen Value (µg/L)	Number Greater Than CUL	DQO RL (µg/L)
1,1,2,2-Tetrachloroethane	79-34-5	µg/L	64	1	5	2.2E-01	64	1-5
2-Methylnaphthalene	91-57-6	µg/L	64	2	10	3.2E+00	56	0.01-0.2
Aroclor-1242	53469-21-9	µg/L	63	0.1	0.4	2.2E-01	57	0.03-1
Aroclor-1248	12672-29-6	µg/L	63	0.1	0.4	2.2E-01	57	0.03-1

**Table 58 Nondetected Analytes in Groundwater
with EQLs greater than the Human Health Groundwater Screening Level**

Analyte	CAS ID	Conc. Units	N	Min EQL	Max EQL	GW Screen Value (µg/L)	Number Greater Than CUL	DQO RL (µg/L)
Aroclor-1254	11097-69-1	µg/L	63	0.1	0.4	3.2E-02	57	0.03-1
Aroclor-1260	11096-82-5	µg/L	63	0.1	0.4	2.2E-01	57	0.03-1
Aroclor-1262	37324-23-5	µg/L	9	0.1	0.4	2.2E-01	8	0.03-1
Benzo(a)anthracene	56-55-3	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Benzo(a)pyrene	50-32-8	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Benzo(b)fluoranthene	205-99-2	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Benzo(k)fluoranthene	207-08-9	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Carbazole	86-74-8	µg/L	64	2	10	4.4E+00	56	0.01-0.2
Chrysene	218-01-9	µg/L	64	2	10	1.2E+00	64	0.01-0.2
Cobalt, Total	7440-48-4	µg/L	64	0.125	0.5	4.8E-01	56	5
Dibenzo(a,h)anthracene	53-70-3	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Dibenzofuran	132-64-9	µg/L	64	2	10	3.2E+00	56	0.01-0.2
Di-n-octyl phthalate	117-84-0	µg/L	64	2	10	6.3E+00	56	1-5
Indeno(1,2,3-cd)pyrene	193-39-5	µg/L	64	2	10	1.2E-01	64	0.01-0.2
Nitrite	14797-65-0	mg/L	57	0.25	2.5	1.6E+02	57	100
Pentachlorophenol	87-86-5	µg/L	64	8	50	1.0E+00	64	1-5
Tetrachloroethene	127-18-4	µg/L	64	1	5	8.1E-01	64	1-5
Thallium, Total	7440-28-0	µg/L	64	0.75	3.75	1.3E-01	64	50

6.10 Recommendations and Limitations of this Screening Level Risk Assessment

Based on the human health screening assessment, there are several issues that are in need of additional consideration. Several analytes failed the screen for soil concentrations protective of groundwater, and for direct groundwater ingestion as well. More notably, there are a number of analytes that significantly fail the air screen based on the soil gas data.

For the ecological screening assessment, no analytes failed the soil screen. Again, the simplest screen may not be appropriate for this site, and further thought should be given to its applicability.

One issue of potential concern is the presence of some chemicals in the blank samples, so that the concentrations of those chemicals in the site samples may not be related to actual conditions at the site. Another important issue that warrants further investigation is the level of sensitivity reached

in the analytical results. For those analytes detected at the site, it seems that the sensitivity was sufficient. However, for some of the analytes for which there were analyses, but that were not detected at the site, there is a question of whether the sensitivity of the analyses was adequate. An investigation of the detection levels in relation to the proposed RLs from the DQOs, and to the screening values should be considered to ensure that the chemical analyses were adequate to identify any analytes of potential concern at the site.

In conclusion, identification of chemicals that fail this screen is not necessarily an indication that there is actually an unacceptable risk posed by those analytes at the site. However, it is also not reasonable to assume that there are not any unacceptable risks based on this screening assessment. Further assessment should be conducted that makes clear whether or not the analytes that failed this screening assessment are actually present at levels of concern for human health and the environment in the area of this site.

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7.0 Nature and Extent of Contamination

This chapter describes the nature and extent of hazardous substances identified in Section 6.8 as requiring further evaluation. The following subsections describe the presence and extent of contamination at the USE Site. This section will also describe the source areas for these contaminants. This discussion is organized in the following manner:

- Groundwater Contamination
- Soil Contamination
- Soil Vapor Contamination

Within these three subsections, the previously identified COPCs will be characterized and attributed to a source. These discussions will be framed in the context of the project Decision Units. Section 7.4 provides an overview of contamination migration and source areas.

7.1 Groundwater Contamination

Section 6.8.1 identified twelve COPCs that exceeded screening levels:

- Arsenic
- Uranium
- Hexavalent chromium
- Trichloroethene
- Antimony
- Fluoride
- Molybdenum
- Nitrate
- Vanadium
- 1,2-Dichloroethane-d4
- Bromofluorobenzene
- Toluene-d8

Two of the COPCs listed above (uranium and arsenic) are anomalous, and will continue to be monitored and evaluated. Three of the COPCs listed above (1,2-Dichloroethane-d4, Bromofluorobenzene, and Toluene-d8) are also anomalous and given sites operations and the chemical typically utilized, these three chemicals are unlikely. Since the screening assessment for these COPCs was based solely upon a single sample and these compounds were not monitored for, no nature and extent plots will be prepared for these three compounds. Not all five of these anomalous COPCs will be considered hazardous substances driving cleanup alternative development in the feasibility study unless there is a negative change in current monitoring trend or additional data is brought forward. Section 7.1.1 describes these anomalous COPCs. Section 7.1.2 describes the remaining eight COPCs that are present in the groundwater decision unit.

7.1.1 Anomalous COPCs Present in Groundwater

The concentrations of arsenic seen in groundwater during long-term monitoring activities are consistent with background concentrations observed in other wells located on the Hanford Central Plateau (Figure 42). Long-term monitoring was conducted at the USE Site to collect and trend arsenic results. As apparent in Figure 43, arsenic results in groundwater are relatively consistent, with only the 4th quarter data collected in MW#8 showing an inconsistent behavior. Based upon

these results and that several of the measurements are over the MTCA level B groundwater limit of 2.77 ppb, arsenic will be considered in the feasibility study.

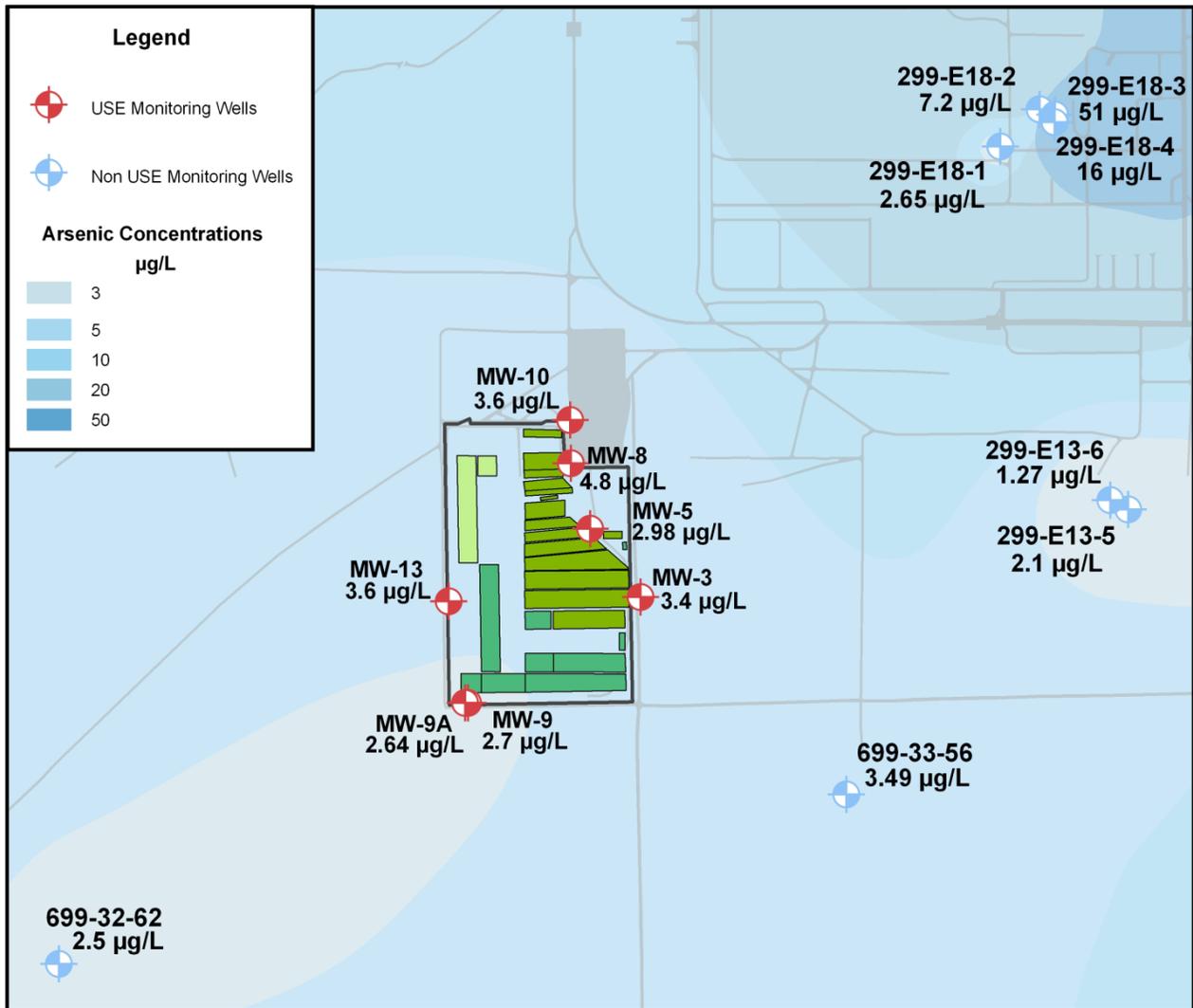


Figure 42 Arsenic Results in USE and Nearby Non-USE Wells

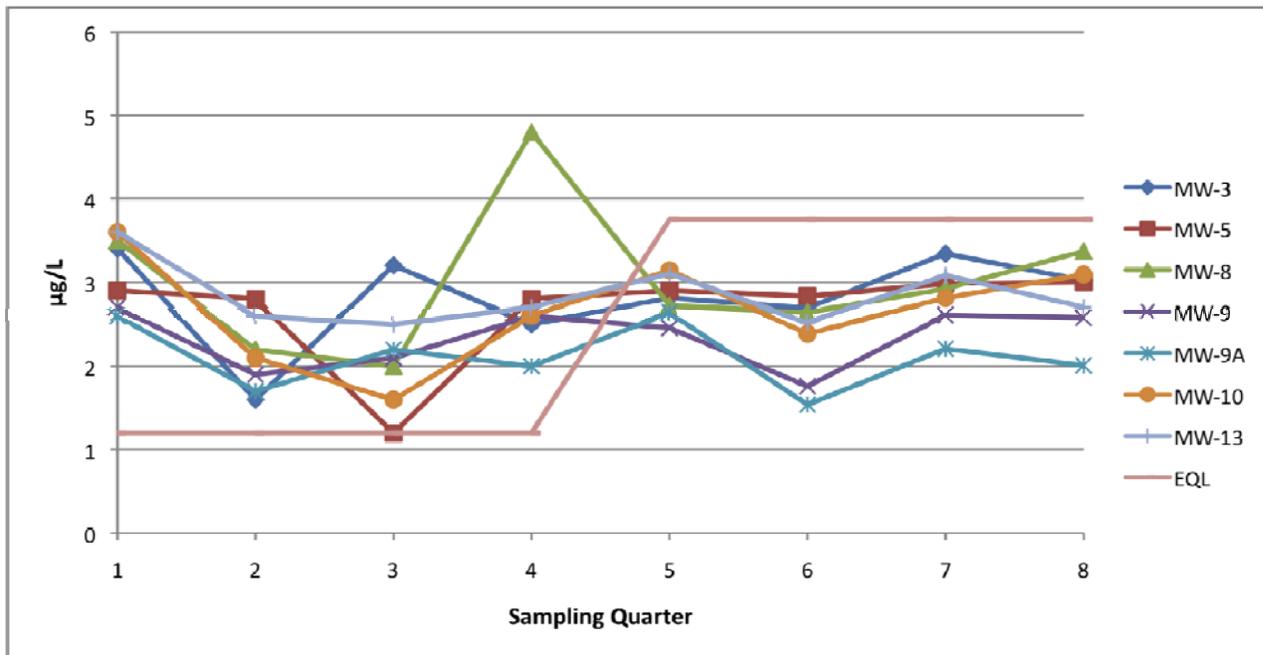


Figure 43 Arsenic Quarterly Long-Term Monitoring Data

As mentioned in Section 6.8.1, there was one observation of uranium in groundwater during long-term monitoring activities exceeding the screening level. This result from up-gradient well MW-13 was significantly higher (156 µg/L) than the screening level used (30 µg/L). Through an evaluation of the laboratory data and discussions with laboratory personnel, this result was unable to be dismissed as a laboratory error. The result in question was from the third quarter of monitoring. The previous two quarter’s results were non-detects, as were all five subsequent quarters of monitoring data. In fact, a field duplicate was taken at the same time as the sample for which the high detection was observed. The field duplicate was consistent with the other data (non-detect). Figure 44 presents the uranium monitoring data from MW-13. Figure 45 presents the Uranium quarterly data for all the wells with the anomalous data point from MW-13 removed, and clearly shows that Uranium is consistently below the MTCA level B groundwater screening level. Based upon this data uranium will not be considered in the feasibility study.

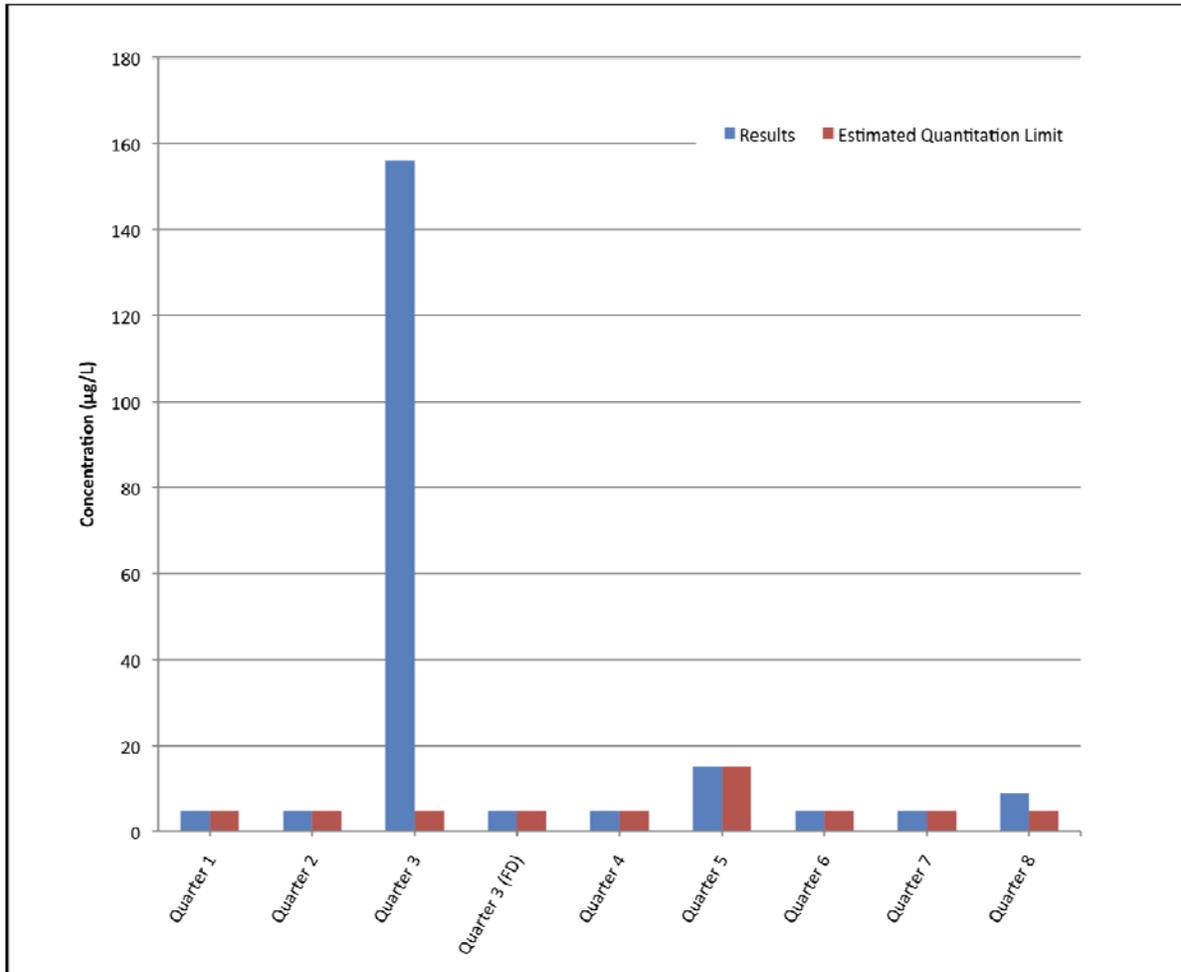


Figure 44 Uranium Concentrations in Groundwater at MW-13

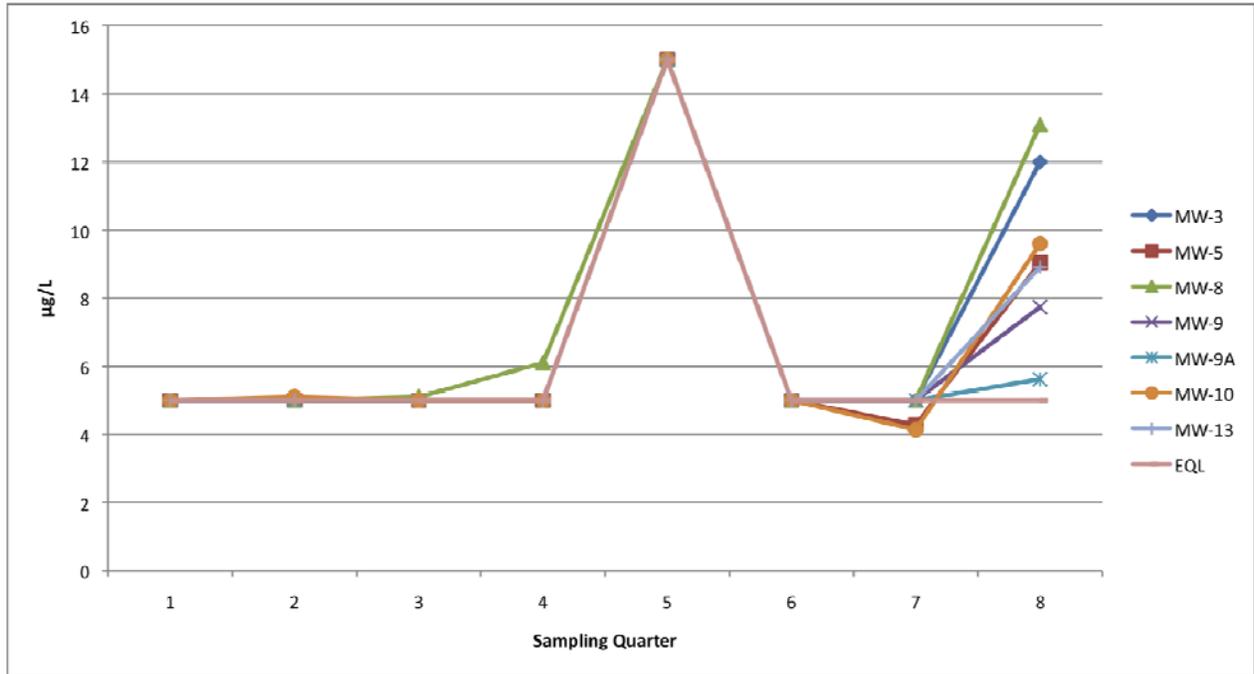


Figure 45 Uranium Data for all Monitoring Wells

7.1.2 Hazardous Substances in the Groundwater Decision Unit

Hexavalent chromium is seen in groundwater at concentrations ranging from 24 to 100 µg/L, one outlier at 200 µg/L (MW-5 during the 5th quarter) as shown in Figure 46. The outlier return to much more consistent values during the 6th quarter. The average concentration over the 8 quarters, with the one outlier removed was of 59 µg/L, and the median concentration was 60 µg/L. No non-detects were reported. The maximum reported concentrations observed in project wells are presented in Figure 47. While the data are not suitably developed to prepare meaningful contours, hexavalent chromium does not appear in either nearby down-gradient or up-gradient wells, suggesting the data is in fact, related to site operations. This is consistent with the observation of hexavalent chromium in the vadose zone. The likely source of hexavalent chromium appears to be from leaks or discharges from the resin tanks (Section 7.2.2).

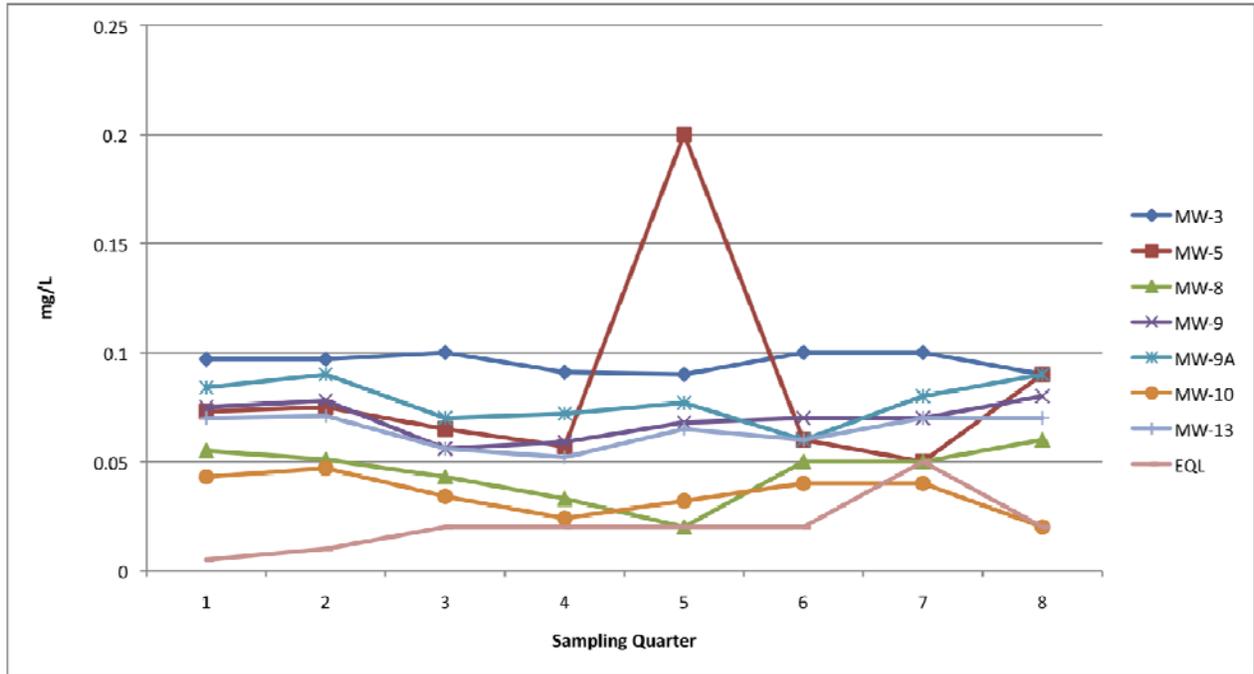


Figure 46 Hexavalent Chrome Quarterly Data

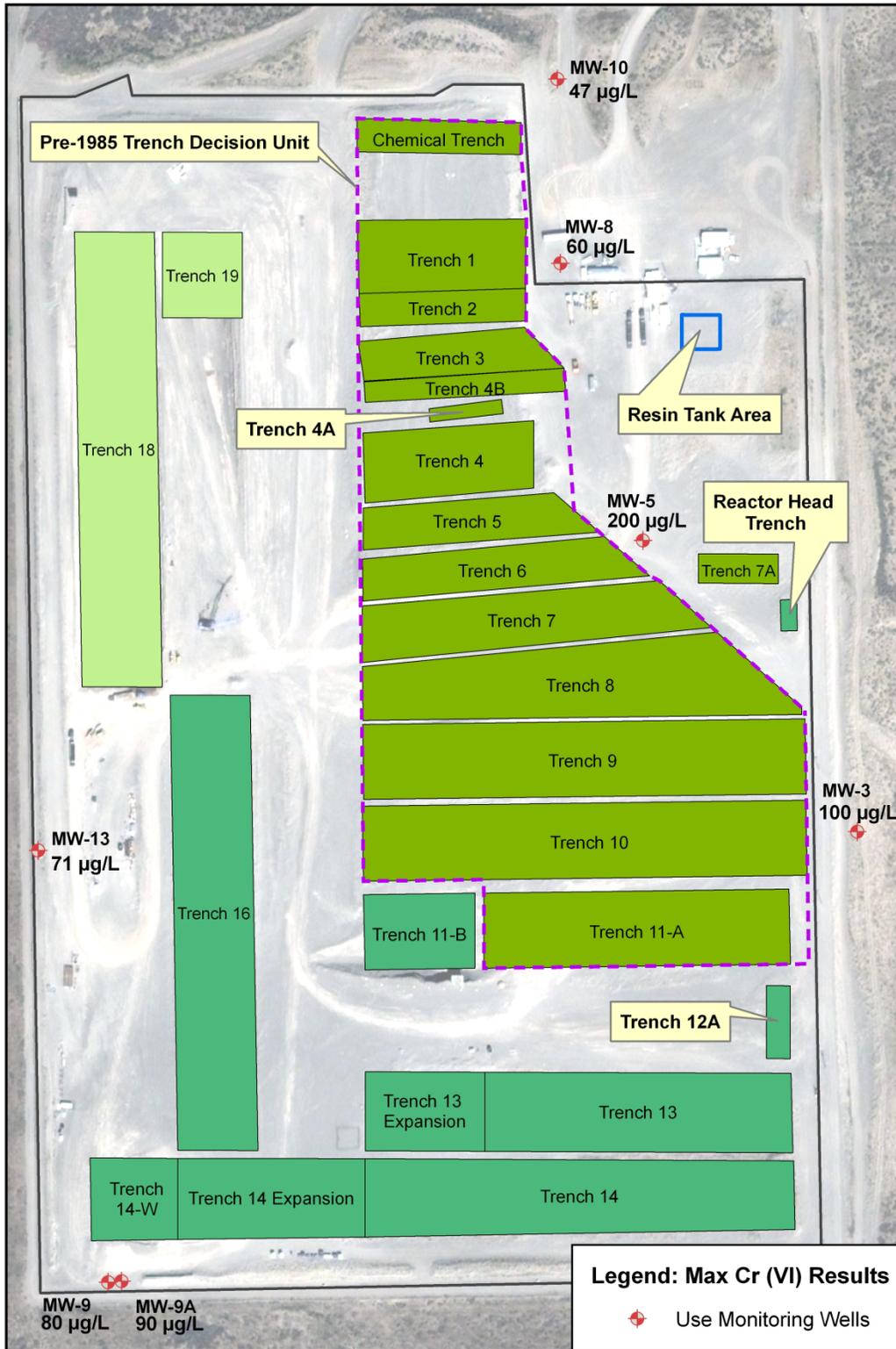


Figure 47 Maximum Observed Hexavalent Chromium Concentrations in Groundwater

Trichloroethene is seen in groundwater at concentrations ranging from non-detect to 29.3 µg/L, with a median concentration of 5 µg/L, and a mean concentration of 7.5 µg/L as shown in Figure 48. There were 16 detections in 56 samples, with a detection limit of 5 µg/L. All detections were in MW-3 or MW-5. Figure 49 depicts the distribution of trichloroethene in USE wells. The highest concentrations and only detections reported are consistently in MW-3 and MW-5. Concentrations in project wells appear stable (Figure 49). No trichloroethene was reported in nearby offsite wells. As with chloroform (reported below), the source for trichloroethene in groundwater is likely releases from trenches in the northern-central portion of the pre-1985 Trench Decision Unit.

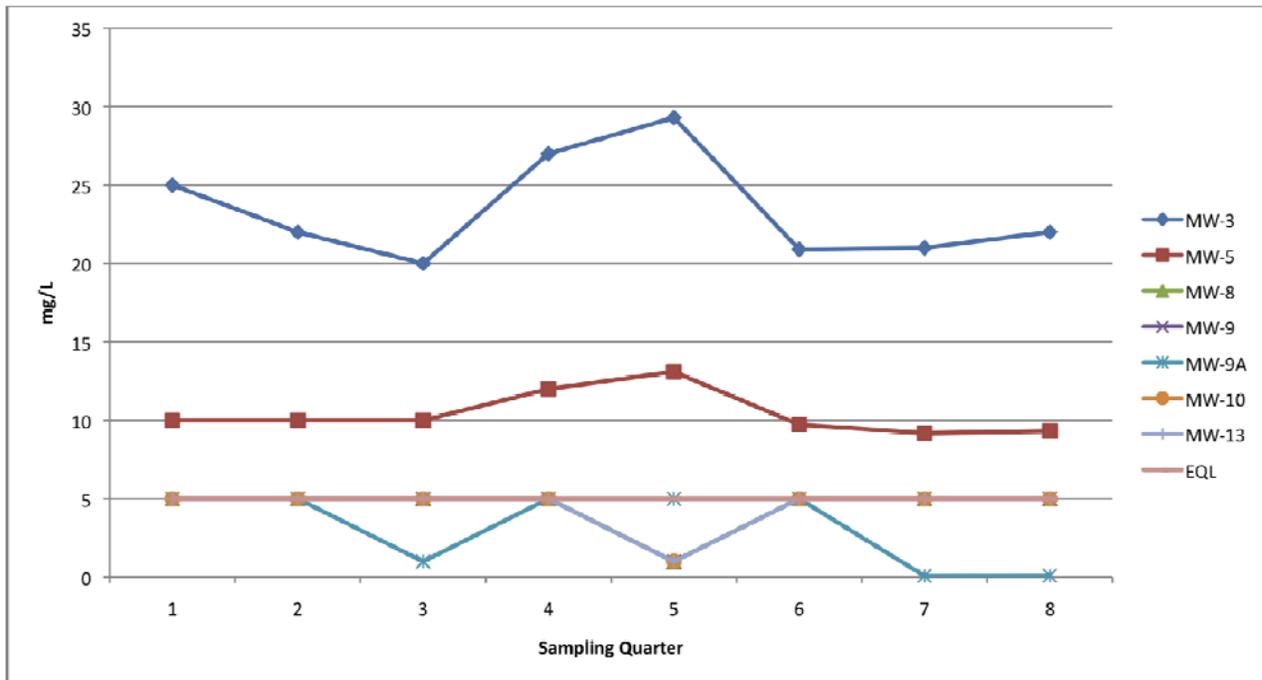


Figure 48 Trichloroethene Monitoring Trends in USE Wells

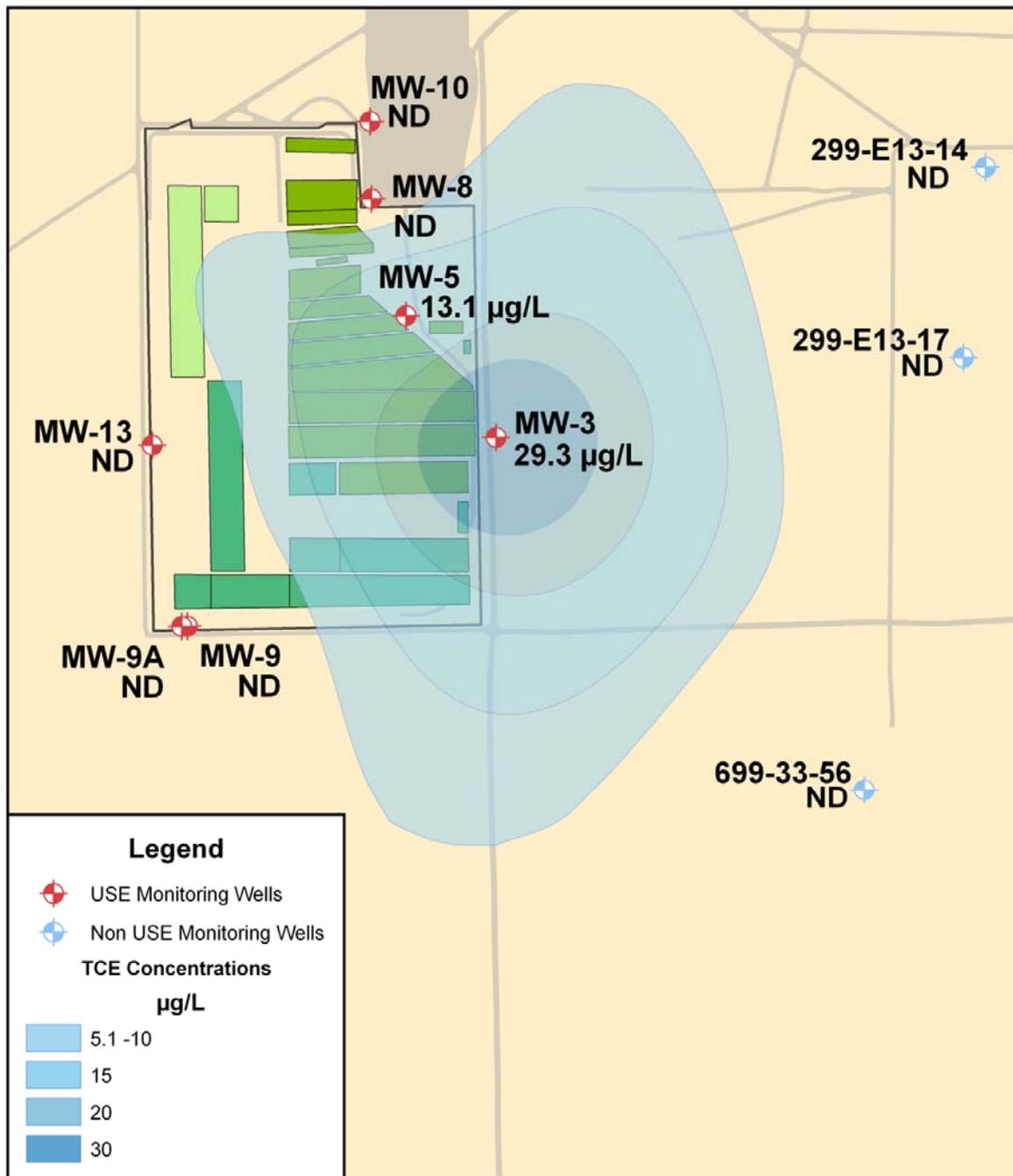


Figure 49 Trichloroethene Concentrations in Groundwater

Chloroform is seen in groundwater at concentrations ranging from non-detect to 23.2 µg/L, with a median concentration of 5 µg/L, and a mean concentration of 8.3 µg/L as shown in Figure 50. There were 16 detections in 56 samples, with a detection limit of 5 µg/L. Figure 51 depicts the

distribution of chloroform in USE wells. The highest concentrations reported are consistently in MW-3 and MW-5. Concentrations in project wells appear stable (Figure 51). No chloroform was reported in nearby offsite wells. As with trichloroethene (reported above), the source for chloroform in groundwater is likely releases from trenches in the northern-central portion of the pre-1985 Trench Decision Unit.

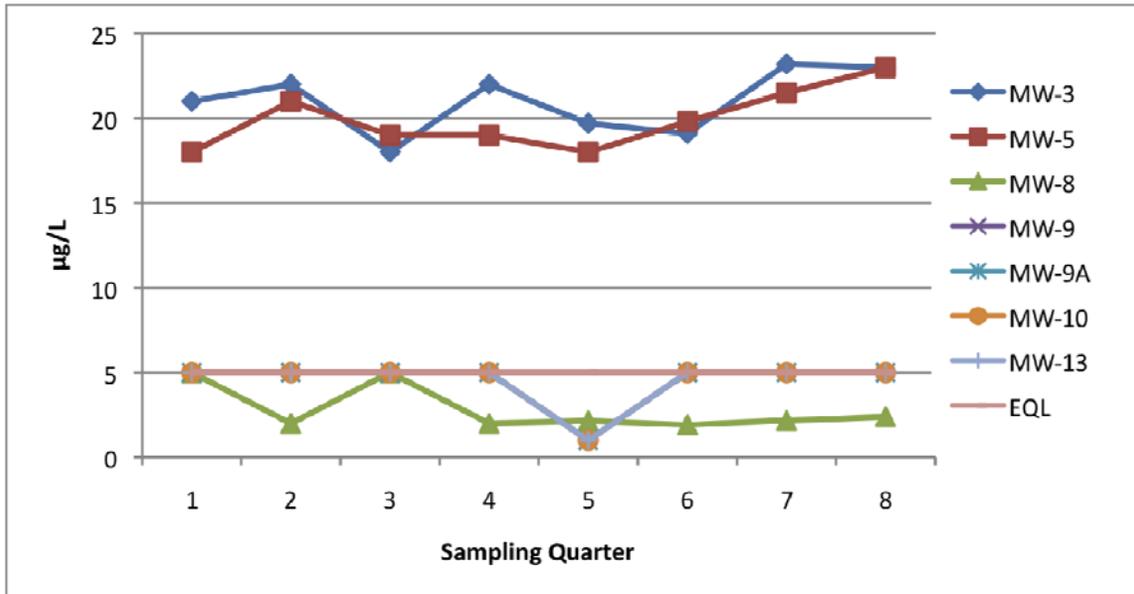


Figure 50 Chloroform Monitoring Trends in USE Wells

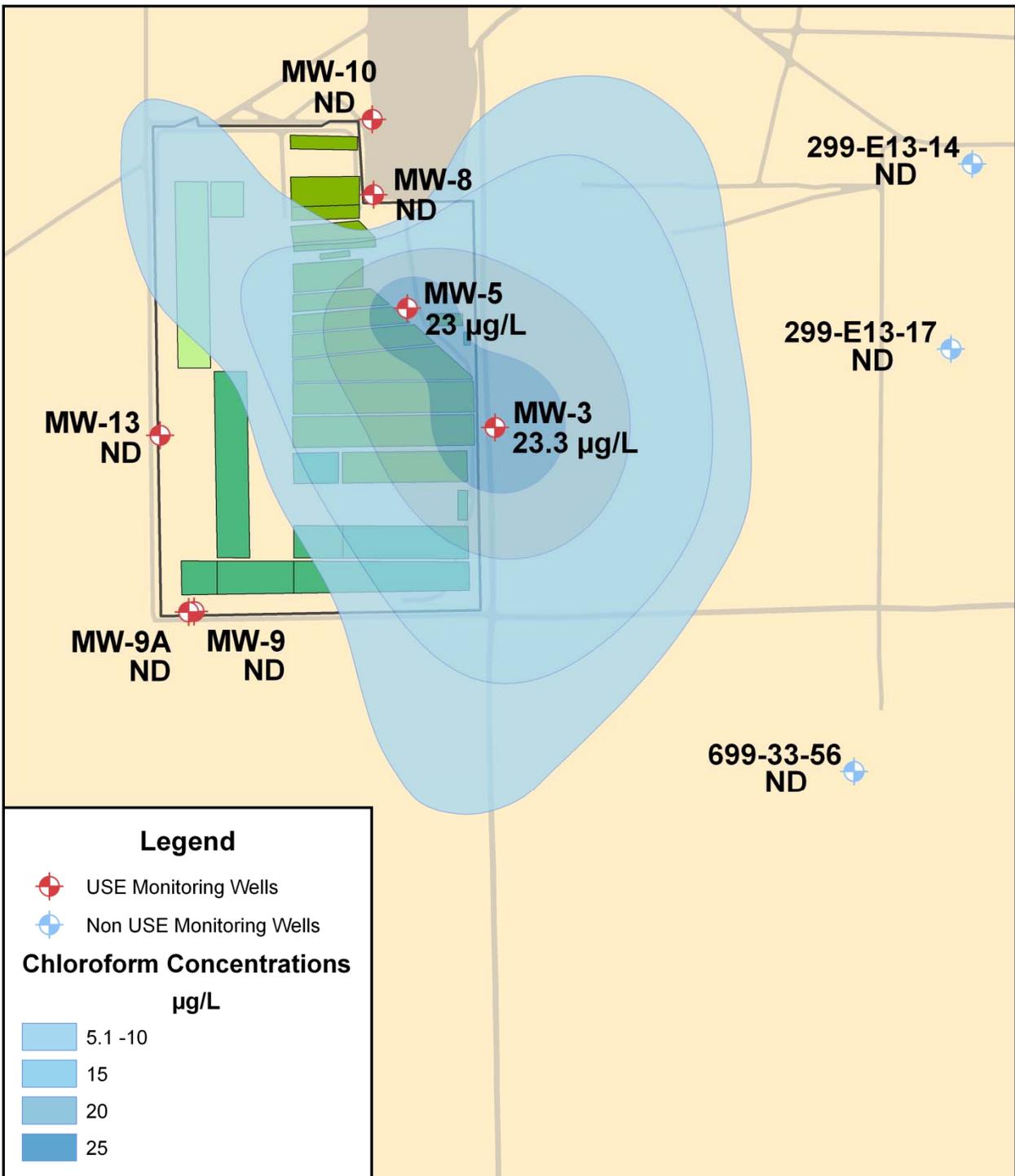


Figure 51 Chloroform Concentrations in Groundwater

The remaining five potential ground water contaminants (antimony, molybdenum, fluoride, nitrate, and vanadium) all have some common occurrence on the Central Plateau of the Hanford Site and were not typically found at the USE Site in the soils. Of these five, only nitrate was above background in the site soils. Groundwater background analysis was not performed due to existing plumes that extended under the USE Site from other portions of the Hanford Site. As presented below, a comparison of the maximum concentrations detected during this RI Report as well as background groundwater values from both up and down gradient wells on the Hanford Site is made (*Hanford Site Groundwater Monitoring for Fiscal Year 2008*, DOE/RL-2008-66). These contaminants will be further evaluated in the FS Report in response to how the proposed treatment alternates will affect each contaminate.

- **Antimony** was observed in 5 of 64 samples, with a maximum detection of 1.2 µg/L and a median of 0.63 µg/L. Hanford background groundwater levels in nearby wells were 32 to 60 µg/L.
- **Fluoride** was observed in 60 of 64 samples with a maximum detection of 450 µg/L and a mean of 330 µg/L. Fluoride concentrations in nearby offsite wells ranged from 89 µg/L to 450 µg/L.
- **Molybdenum** was observed in 64 of 64 samples with a maximum detection of 10.6 µg/L with a mean of 8.84 µg/L.
- **Nitrate** was observed in 64 of 64 samples with a maximum detection of 21,700 µg/L and a mean of 17,580 µg/L. Nitrate concentrations in nearby offsite wells ranged from 12,800 µg/L to 19,400 µg/L. Other wells on the central Plateau have concentrations in the range of 30,000 µg/L to 45,000 µg/L.
- **Vanadium** was observed in 64 of 64 samples with a maximum detection of 34.6 µg/L and a mean of 28.66 µg/L. Hanford background groundwater levels in nearby wells were 12 µg/L to 28.9 µg/L.

7.2 Soil Contamination

Section 6.8.1 identified four COPCs that exceeded screening levels. In all cases, only the protectiveness of groundwater screening level was exceeded.

- Hexavalent chromium
- Nitrate
- Nitrite
- Methylene chloride

Two of these COPCs (nitrite and methylene chloride) are anomalous. These COPCs will not be considered hazardous substances driving cleanup alternative development in the feasibility study, though any alternative evaluated will consider these contaminants. Section 7.2.1 describes these anomalous COPCs. Section 7.2.2 describes the COPCs present in the Resin Tank Area Decision Unit, and Section 7.2.3 describes the COPCs present in the pre-1985 Trench Area Decision Unit.

7.2.1 Anomalous COPCs Present in Soil

Five samples in Borehole B-15 (at the east end of Trench 4B, inside the pre-1985 Trench Decision Unit, Figure 20) were collected at the depths of 45, 49, 55, 65, and 90 feet bgs. Table 59 presents the methylene chloride results for this borehole. Noteworthy elements include:

- A very high quantitation limit was reported in this borehole.
- The results from the first two intervals were flagged during data validation as estimates because of quality control issues.
- The remaining intervals were also flagged because of blank contamination.

Table 59 Methylene Chloride Results in Borehole B-15

Depth (ft)	Sample	Method	Result	EQL	Units	Q	V	Reason
45	B006	8260B	120	240	ug/kg	J	J	No LCS
49	B007	8260B	110	220	ug/kg	J	J	No LCS
55	B008	8260B	120	230	ug/kg	JB	UJ	Blank
65	B009	8260B	150	240	ug/kg	JB	UJ	Blank
90	B010	8260B	20	20	ug/kg	JB	UJ	Blank

EQL — Estimated Quantitation Limit (Reporting Limit)

J — Estimated detection below the quantitation limit

Q — Lab applied data qualifier

UJ — Estimated non-detection below the quantitation limit

V — Validator applied qualifier

Since these are estimated detections (the quantitation limit was very high for all samples in this borehole, potentially due to blank contamination), and methylene chloride is a very common laboratory contaminant, it is likely these results are due to laboratory contamination, but this could not be verified during the laboratory evaluation of the issue. Data in other nearby boreholes did not reflect similar concentrations.

In consideration of these results, methylene chloride results in this borehole are anomalous, and methylene chloride will be treated as discussed in the previous section (not considered a hazardous substance driving cleanup alternative development in the feasibility study, though any alternative evaluated will consider this contaminant).

There was a single detection (Sample B128) of nitrite in soils of the Resin Tank Area Decision Unit (Boring B-3). The median concentration reported was 1.2 mg/kg, and the mean concentration was 1.3 mg/kg. The measured concentration reported in the sample was 2.68 mg/kg, exceeding the screening level used in Section 6.8.1. Because nitrite is typically reactive in the environment, and there was only a single reported “detected” measurement of nitrite, this result is likely anomalous.

Nitrate and nitrite are compounds that both contain a nitrogen atom bonded with oxygen atoms. Nitrate and Nitrite are readily converted from one another in nature, and since both are anions they

tend to bond with cations to achieve a chemically stable configuration. Nitrates are naturally present in soil, and bacteria convert nitrogen to nitrate as part of the nitrogen cycle.

Microorganisms naturally convert nitrate or an ammonium ion to nitrite, and this reaction occurs naturally in soil as well as the digestive tract of humans and animals (“*Human Health Fact Sheet*,” ANL, 2005). Nitrates are used to manufacture fertilizer, glass, and explosives. Nitrites are typically used as a food preservative. The detection of nitrate and nitrite are not unusual in that they are naturally occurring in the biologic nitrogen cycle. However, the single detection above the screening level is likely not a true measure of nitrite within soil at the USE Site.

Therefore nitrite will be treated as discussed in the previous section (not considered a hazardous substance driving cleanup alternative development in the feasibility study, though any alternative evaluated will consider this contaminant).

7.2.2 Hazardous Substances in the Resin Tank Area Decision Unit

Hexavalent chromium was identified in 46 of 127 soil samples. The median concentration reported was 0.1 mg/kg, and the mean concentration observed was 0.32 mg/kg. The maximum concentration measured was 3.6 mg/kg. Twenty-three (23) of these observations were in the Resin Tank Area Decision Unit (including the maximum reported result). Table 60 reports the detections reported in the Resin Tank Area. It should be noted that there were no detections in the shallow soil samples. Figure 52 illustrates the extent of hexavalent chromium contamination in this decision unit. It should be observed that the highest concentrations measured are relatively close to the bottoms of the resin tanks, suggesting that these tanks are the source of hexavalent chromium.

Nitrate was identified in 95 of 127 of the deep soil samples and 3 of 13 in the shallow soil samples. The median concentration reported was 6 mg/kg, and the mean concentration observed was 11.78 mg/kg. The maximum concentration measured was 243 mg/kg. Of the shallow samples, the maximum detected concentration was 5.44 mg/kg. Thirty-six (36) of these observations were in the Resin Tank Area Decision Unit (including the maximum reported result). Table 61 reports the detections reported in the Resin Tank Area. Figure 53 illustrates the extent of nitrate contamination in this decision unit. It should be observed that the highest concentrations measured are relatively close to the bottoms of the resin tanks, suggesting that these tanks are the source of nitrate. This also explains the apparent collocation of nitrate and hexavalent chromium concentration.

**Table 60 Detections of Hexavalent Chromium in Resin Tank Area Soil
(Screening Level of 0.0045 mg/kg)**

Location	Depth (ft)	Sample	Method	Result	EQL	Units	Q	V
B-1	20	B143	7196A	0.22	0.21	MG/KG		
B-2	14	B147	7196A	1.1	0.22	MG/KG		
B-4	20	B133	7196A	0.4	0.21	MG/KG		
B-8	20	B110	7196A	0.25	0.24	MG/KG		
B-3	24	B129	7196A	0.28	0.22	MG/KG		J
B-4	24	B135	7196A	0.34	0.21	MG/KG		
B-5	24	B124	7196A	3.6	0.21	MG/KG		
B-6	24	B140	7196A	0.59	0.21	MG/KG		
B-7	24	B118	7196A	0.58	0.21	MG/KG		
B-8	24	B111	7196A	0.21	0.21	MG/KG		
B-1	25	B144	7196A	1	0.22	MG/KG		
B-2	18	B148	7196A	0.82	0.22	MG/KG		
B-7	26	B119	7196A	0.86	0.21	MG/KG		
B-1	30	B145	7196A	0.3	0.21	MG/KG		
B-2	21	B149	7196A	2.1	0.21	MG/KG		
B-5	30	B125	7196A	0.38	0.21	MG/KG		
B-6	30	B141	7196A	0.26	0.21	MG/KG		
B-7	30	B121	7196A	0.22	0.21	MG/KG		
B-8	30	B112	7196A	0.36	0.21	MG/KG		
B-4	34	B138	7196A	0.22	0.21	MG/KG		
B-5	34	B126	7196A	0.32	0.21	MG/KG		
B-1	35	B146	7196A	1.3	0.22	MG/KG		
B-2	25	B150	7196A	2.2	0.21	MG/KG		

EQL — Estimated Quantitation Limit (Reporting Limit)
 J — Estimated detection below the quantitation limit

V — Validator applied qualifier
 Q — Lab applied data qualifier

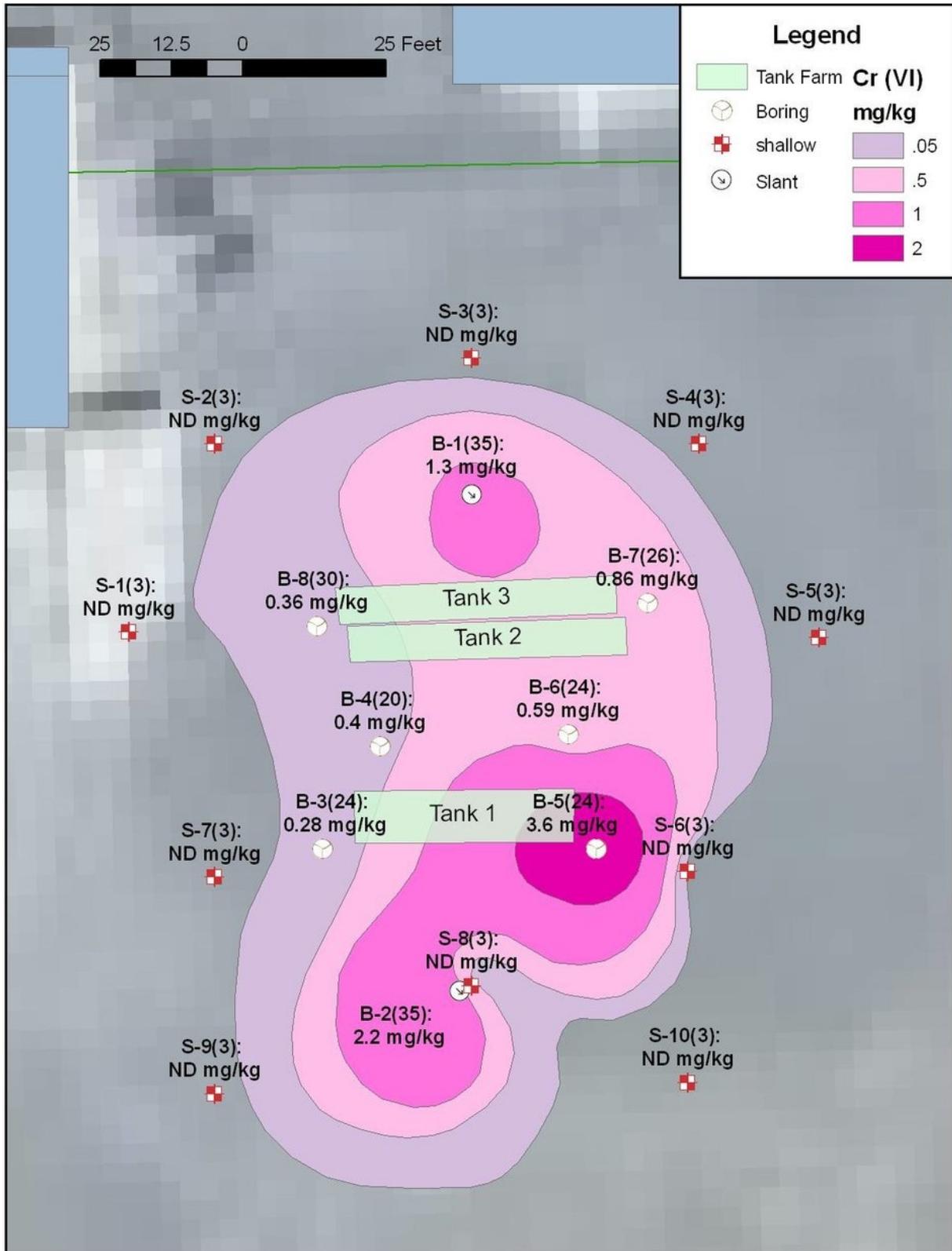


Figure 52 Distribution of Hexavalent Chromium in Resin Tank Area Soils

**Table 61 Detections of Nitrate in Resin Tank Area Soils
 (Screening Level of 2.4 mg/kg)**

Location	Depth (ft)	Sample	Method	Result	EQL	Units	Q	V
B-3	3	B127	9056	3.56	2.54	MG/KG		
B-7	3	B115	9056	3.36	2.35	MG/KG		
S-3	3	S10	9056	5.44	2.42	MG/KG		
B-1	20	B143	9056	13.2	2.55	MG/KG		
B-2	14	B147	9056	24.7	2.63	MG/KG		
B-3	20	B128	9056	22.1	2.54	MG/KG		
B-4	20	B133	9056	13.9	2.27	MG/KG		
B-5	20	B123	9056	7.2	2.46	MG/KG		
B-6	20	B139	9056	17.2	2.51	MG/KG		
B-7	20	B116	9056	18.7	2.34	MG/KG		
B-8	20	B110	9056	13.9	2.95	MG/KG		
B-3	24	B129	9056	16.5	2.56	MG/KG		
B-4	24	B135	9056	11.3	2.49	MG/KG		
B-5	24	B124	9056	243	12.9	MG/KG		
B-6	24	B140	9056	42	2.38	MG/KG		
B-7	24	B118	9056	41.6	2.63	MG/KG		
B-8	24	B111	9056	10.8	2.45	MG/KG		
B-1	25	B144	9056	20.7	2.49	MG/KG		
B-2	18	B148	9056	66.9	2.76	MG/KG		
B-7	26	B119	9056	7.34	2.37	MG/KG		
B-1	30	B145	9056	4.29	2.37	MG/KG		
B-2	21	B149	9056	19.2	2.54	MG/KG		
B-3	30	B131	9056	19.6	2.7	MG/KG		
B-4	30	B137	9056	8.61	2.18	MG/KG		
B-5	30	B125	9056	28.7	2.35	MG/KG		
B-6	30	B141	9056	26.4	2.45	MG/KG		
B-7	30	B121	9056	5.14	2.58	MG/KG		
B-8	30	B112	9056	6.29	2.81	MG/KG		
B-3	34	B132	9056	20.4	2.39	MG/KG		
B-4	34	B138	9056	14.6	2.35	MG/KG		
B-5	34	B126	9056	38.4	2.42	MG/KG		
B-6	34	B142	9056	30.6	2.53	MG/KG		
B-7	34	B122	9056	5.27	2.44	MG/KG		
B-1	35	B146	9056	12.8	2.56	MG/KG		
B-2	25	B150	9056	15.6	2.55	MG/KG		
B-8	36	B114	9056	8.56	2.41	MG/KG		

EQL — Estimated Quantitation Limit (Reporting Limit)

J — Estimated detection below the quantitation limit

Q — Lab applied data qualifier

V — Validator applied qualifier

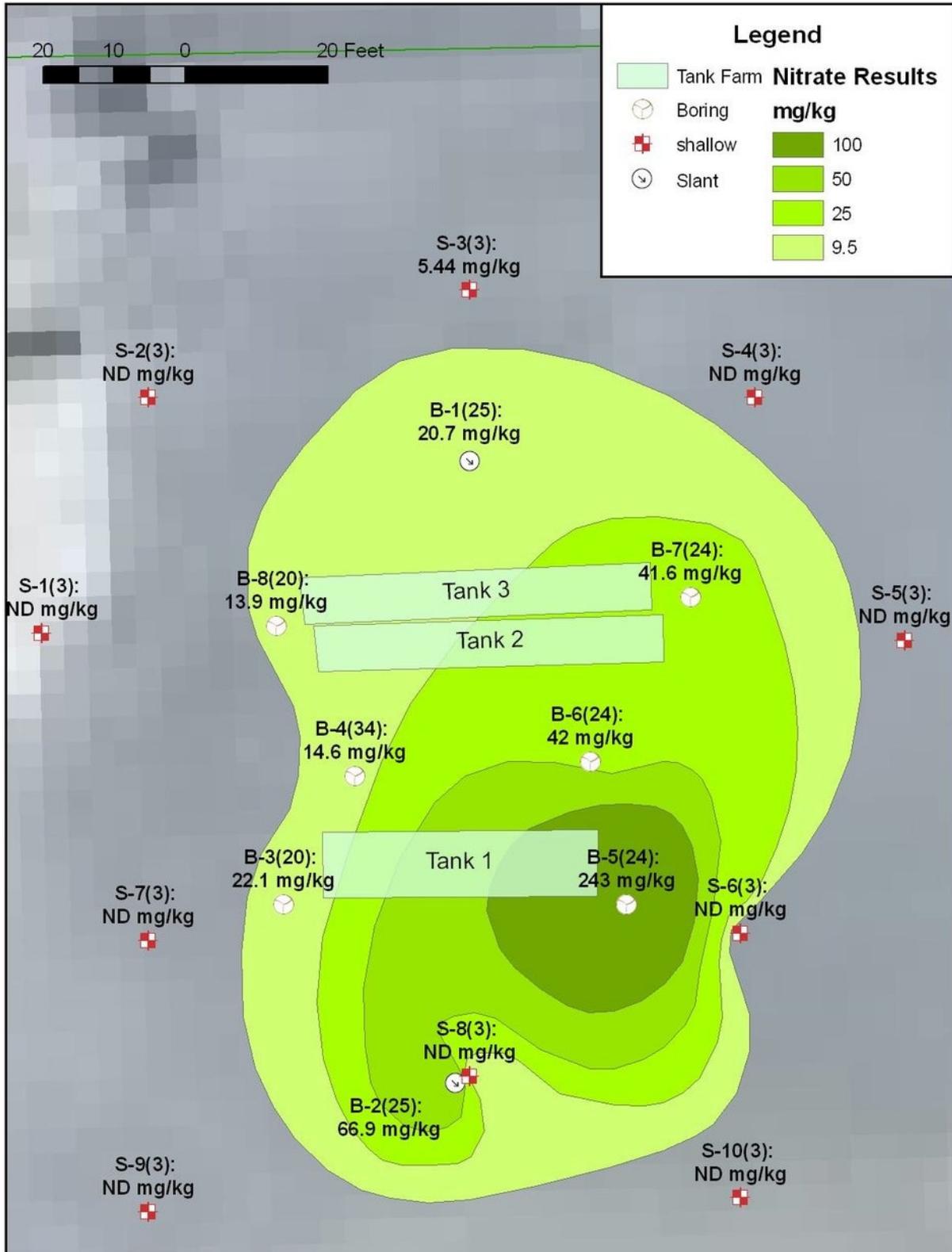


Figure 53 Distribution of Nitrate in Resin Tank Area Soils

7.2.3 Hazardous Substances in the Pre-1985 Trench Area Decision Unit

Both hexavalent chromium and nitrate are present in the soils of the pre-1985 Trench Unit (Table 62 and Table 63). However, the concentrations are lower than those found in the Resin Tank Area, and the depths these substances are encountered are deeper than those found in the Resin Tank Area. Both of these considerations suggest the contaminants likely originated in the Resin Tank Area, and then spread into the deeper vadose zone underlying the pre-1985 Trench Decision Unit. With its higher mobility, hexavalent chromium also impacted groundwater. Figure 54, Figure 55, and Figure 56 describe hexavalent chromium concentrations in the shallow, middle, and deep vadose zone, while Figure 57, Figure 58, and Figure 59 describe nitrate concentrations in the shallow, middle, and deep vadose zone. Shallow vadose zone soils are those less than 45 ft bgs (coincident with most trench bottoms), middle vadose zone soils are those between 45 and 65 feet bgs (coincident with the occurrence of the paleosol described in Section 3.2), and deep vadose zone soils are those deeper than 65 ft bgs.

Table 62 Detections of Hexavalent Chromium in the Pre-1985 Trench Area Soils (Screening Level of 0.0045 mg/kg)

Location	Depth (ft)	Sample	Method	Result	EQL	Units	Q	V
B-12	76	B083	7196A	0.85	0.23	MG/KG		
B-15	55	B008	7196A	0.27	0.21	MG/KG		
B-15	65	B009	7196A	0.24	0.21	MG/KG		
B-17	41	B068	7196A	0.84	0.21	MG/KG		
B-18	54	B077	7196A	0.33	0.21	MG/KG		
B-19	30	B011	7196A	0.76	0.21	MG/KG		
B-19	50	B014	7196A	1	0.21	MG/KG		
B-19	73	B016	7196A	0.49	0.21	MG/KG		
B-21	30	B017	7196A	0.58	0.2	MG/KG		
B-21	32	B018	7196A	0.56	0.2	MG/KG		
B-21	40	B021	7196A	0.31	0.2	MG/KG		
B-21	50	B022	7196A	1.4	0.21	MG/KG		
B-22	40	B024	7196A	0.74	0.2	MG/KG		
B-22	42	B025	7196A	0.22	0.21	MG/KG		
B-22	50	B028	7196A	0.26	0.21	MG/KG		
B-22	85	B030	7196A	0.21	0.21	MG/KG		
B-24	54	B107	7196A	0.83	0.2	MG/KG		
B-24	65	B108	7196A	0.31	0.21	MG/KG		
B-25	50	B037	7196A	0.93	0.21	MG/KG		
B-25	54	B039	7196A	0.23	0.21	MG/KG		
B-26	45	B042	7196A	0.26	0.2	MG/KG		
B-26	54	B044	7196A	1.8	0.2	MG/KG		
B-26	65	B045	7196A	0.25	0.2	MG/KG		

EQL — Est. Quantitation Limit (Reporting Limit)

Q — Lab applied data qualifier

V — Validator applied qualifier

**Table 63 Detections of Nitrate in the Pre-1985 Trench Area Soils
 (Screening Level of 2.4 mg/kg)**

Location	Depth (ft)	Sample	Method	Result	EQL	Units	Q	V
B-10	22	B090	9056	15.5	2.71	MG/KG		
B-10	26	B091	9056	6.54	2.48	MG/KG		
B-10	32	B093	9056	11.5	2.47	MG/KG		
B-10	42	B094	9056	127	2.56	MG/KG		
B-11	20	B001	9056	17	2.57	MG/KG		
B-11	25	B002	9056	15.3	2.88	MG/KG		
B-11	30	B003	9056	7.03	2.35	MG/KG		
B-11	40	B004	9056	3.82	2.16	MG/KG		
B-11	65	B005	9056	7.8	2.81	MG/KG		
B-12	31	B079	9056	9.75	2.64	MG/KG		
B-12	37	B080	9056	7.22	2.36	MG/KG		
B-12	41	B081	9056	6.43	2.31	MG/KG		
B-12	51	B082	9056	6.19	2.53	MG/KG		
B-12	76	B083	9056	21.3	2.29	MG/KG		
B-13	50	B102	9056	3.21	2.49	MG/KG		
B-13	75	B103	9056	3.23	2.47	MG/KG		
B-14	45	B084	9056	6.16	2.35	MG/KG		
B-14	49	B085	9056	5.69	2.57	MG/KG		
B-14	55	B087	9056	3.54	2.59	MG/KG		
B-15	45	B006	9056	14.7	2.46	MG/KG		
B-15	49	B007	9056	9.16	2.24	MG/KG		
B-15	55	B008	9056	15.9	2.29	MG/KG		
B-15	65	B009	9056	6.07	2.52	MG/KG		
B-15	90	B010	9056	9.28	2.54	MG/KG		J
B-16	32	B060	9056	6.04	2.55	MG/KG		
B-16	38	B061	9056	4.57	2.55	MG/KG		
B-16	42	B062	9056	5.79	2.48	MG/KG		
B-16	52	B063	9056	4.38	2.29	MG/KG		
B-16	77	B064	9056	3.65	2.5	MG/KG		
B-17	31	B065	9056	10.9	2.5	MG/KG		
B-17	35	B066	9056	5.85	2.36	MG/KG		
B-17	41	B068	9056	6.96	2.4	MG/KG		
B-17	76	B070	9056	6.23	2.34	MG/KG		
B-18	34	B071	9056	24.7	2.42	MG/KG		J
B-18	36	B072	9056	7.32	2.63	MG/KG		J
B-18	38	B073	9056	22.7	2.71	MG/KG		J
B-18	44	B075	9056	6.52	2.59	MG/KG		J
B-18	54	B077	9056	14	2.4	MG/KG		J

**Table 63 Detections of Nitrate in the Pre-1985 Trench Area Soils
 (Screening Level of 2.4 mg/kg)**

Location	Depth (ft)	Sample	Method	Result	EQL	Units	Q	V
B-18	79	B078	9056	4.53	2.5	MG/KG		J
B-19	40	B013	9056	3.12	2.61	MG/KG		J
B-19	50	B014	9056	4.48	2.22	MG/KG		J
B-19	73	B016	9056	3.95	2.49	MG/KG		J
B-20	30	B031	9056	6.54	2.54	MG/KG		
B-20	77	B035	9056	5	2.61	MG/KG		
B-21	30	B017	9056	3.25	2.6	MG/KG		J
B-21	32	B018	9056	3	2.55	MG/KG		J
B-21	36	B020	9056	6.17	2.32	MG/KG		
B-21	40	B021	9056	4.2	2.47	MG/KG		
B-21	50	B022	9056	10	2.37	MG/KG		
B-21	75	B023	9056	3.38	2.57	MG/KG		
B-22	85	B030	9056	3.38	2.4	MG/KG		
B-23	40	B047	9056	7.47	2.55	MG/KG		
B-23	42	B048	9056	2.8	2.59	MG/KG		
B-24	45	B104	9056	4.19	2.42	MG/KG		
B-24	50	B105	9056	3.27	2.48	MG/KG		
B-25	50	B037	9056	15.4	4.72	MG/KG		
B-25	54	B039	9056	19.8	5	MG/KG		
B-25	65	B040	9056	6.23	4.71	MG/KG		
B-26	45	B042	9056	3.02	2.46	MG/KG		
B-26	50	B043	9056	2.47	2.35	MG/KG		
B-26	54	B044	9056	2.74	2.57	MG/KG		
B-26	65	B045	9056	2.62	2.52	MG/KG		

EQL — Estimated Quantitation Limit (Reporting Limit)

Q — Lab applied data qualifier

V — Validator applied qualifier

J — Estimated detection below the quantitation limit

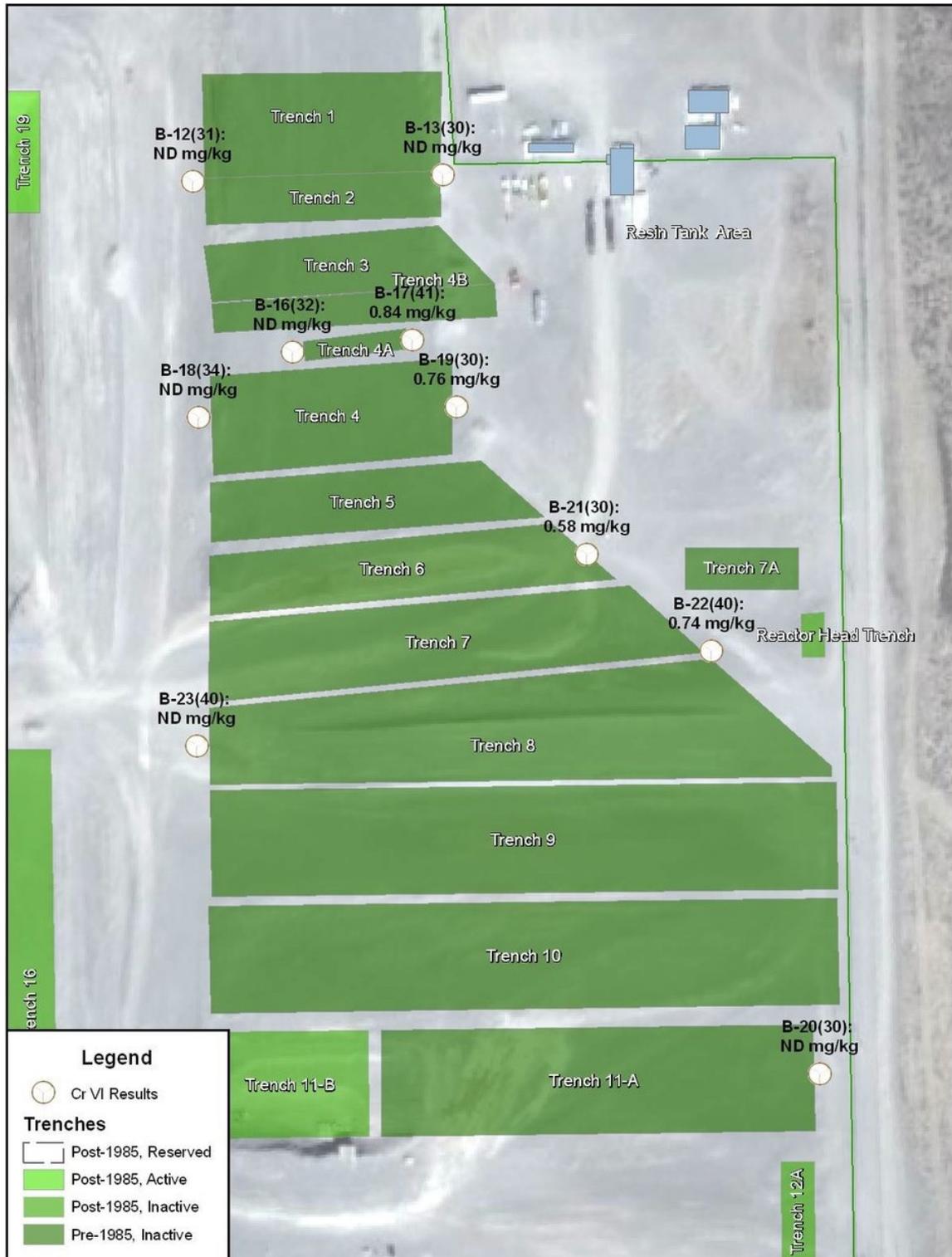


Figure 54 Distribution of Shallow Zone Hexavalent Chromium in the Pre-1985 Trench Area

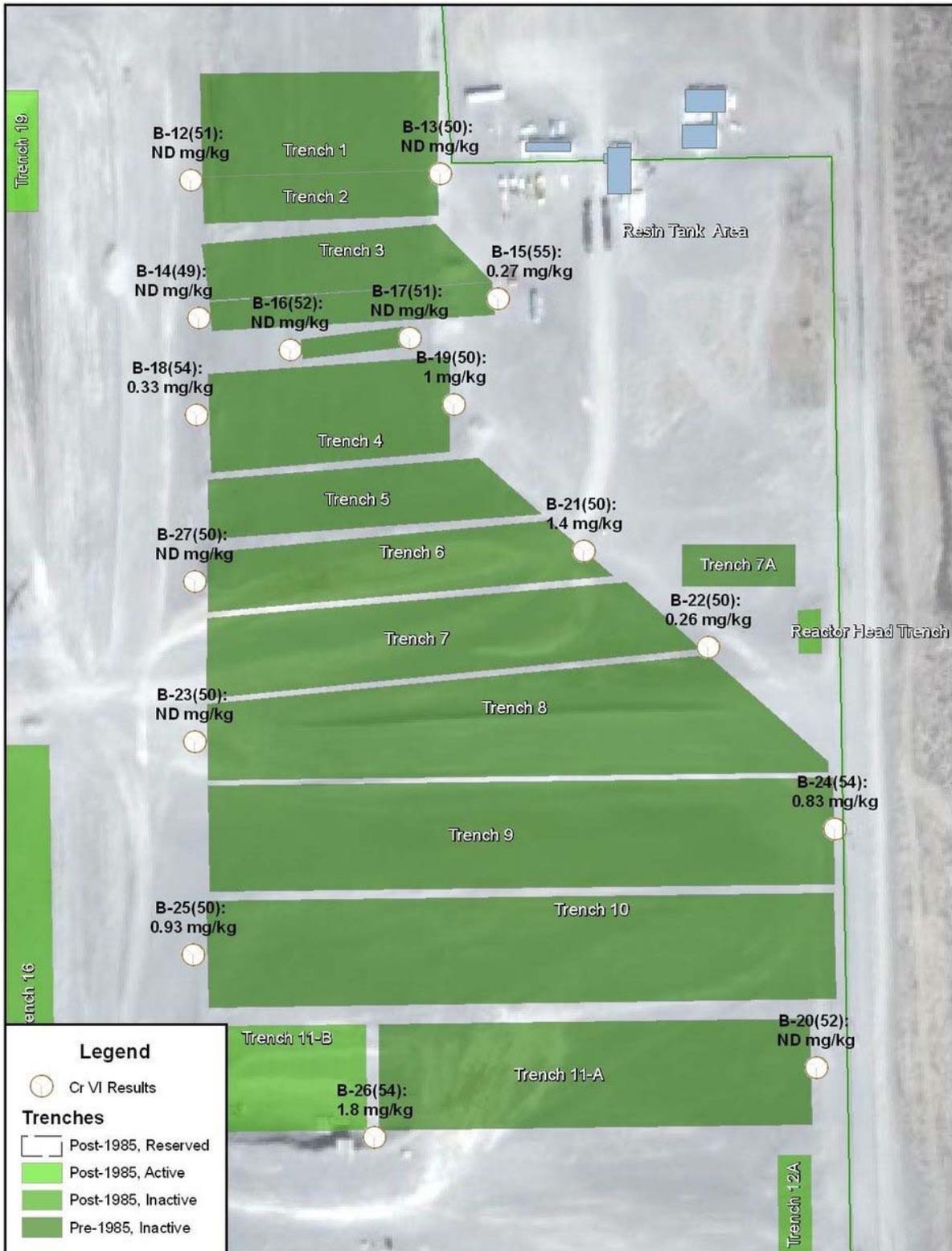


Figure 55 Distribution of Middle Zone Hexavalent Chromium in the Pre-1985 Trench Area

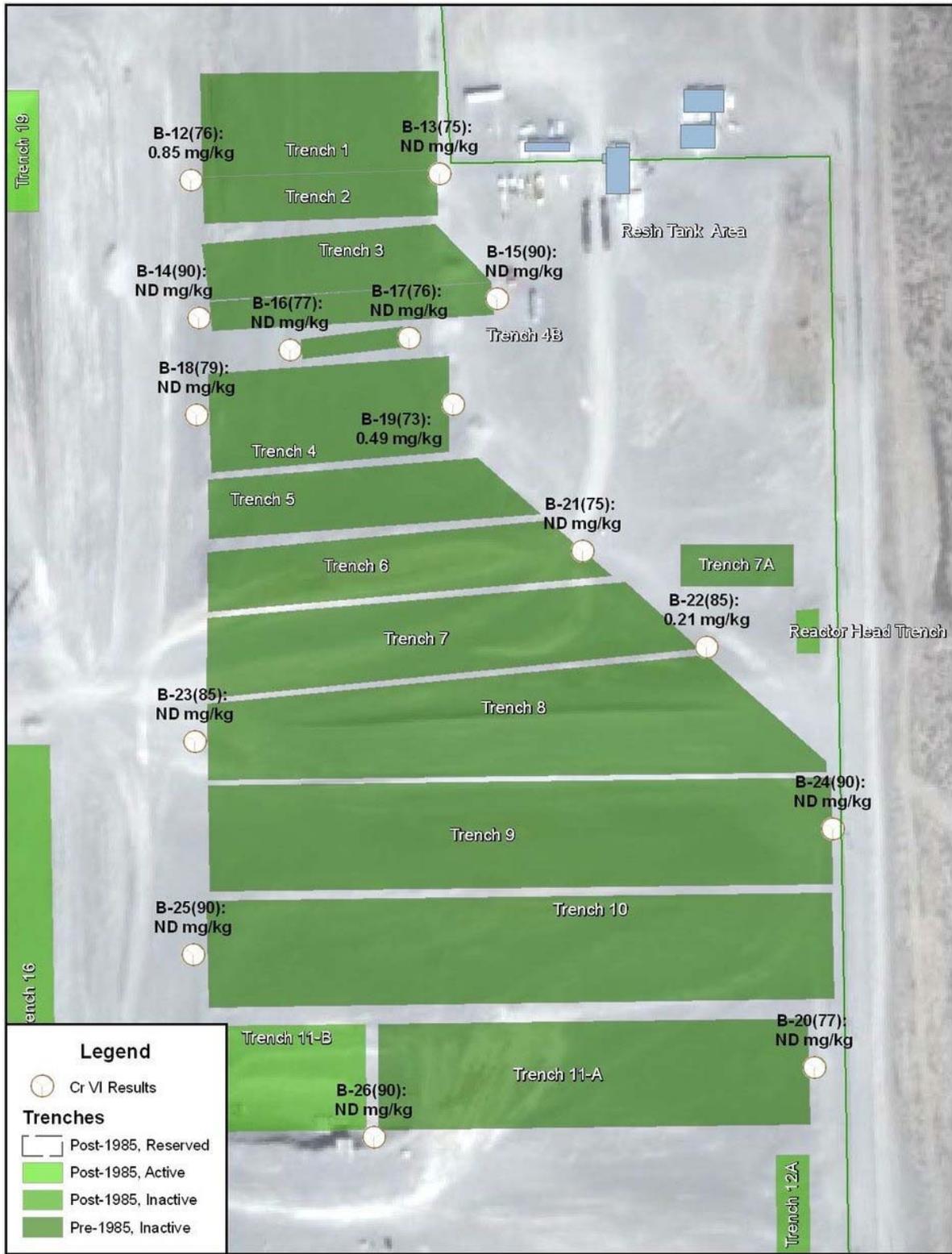


Figure 56 Distribution of Deep Zone Hexavalent Chromium in the Pre-1985 Trench Area

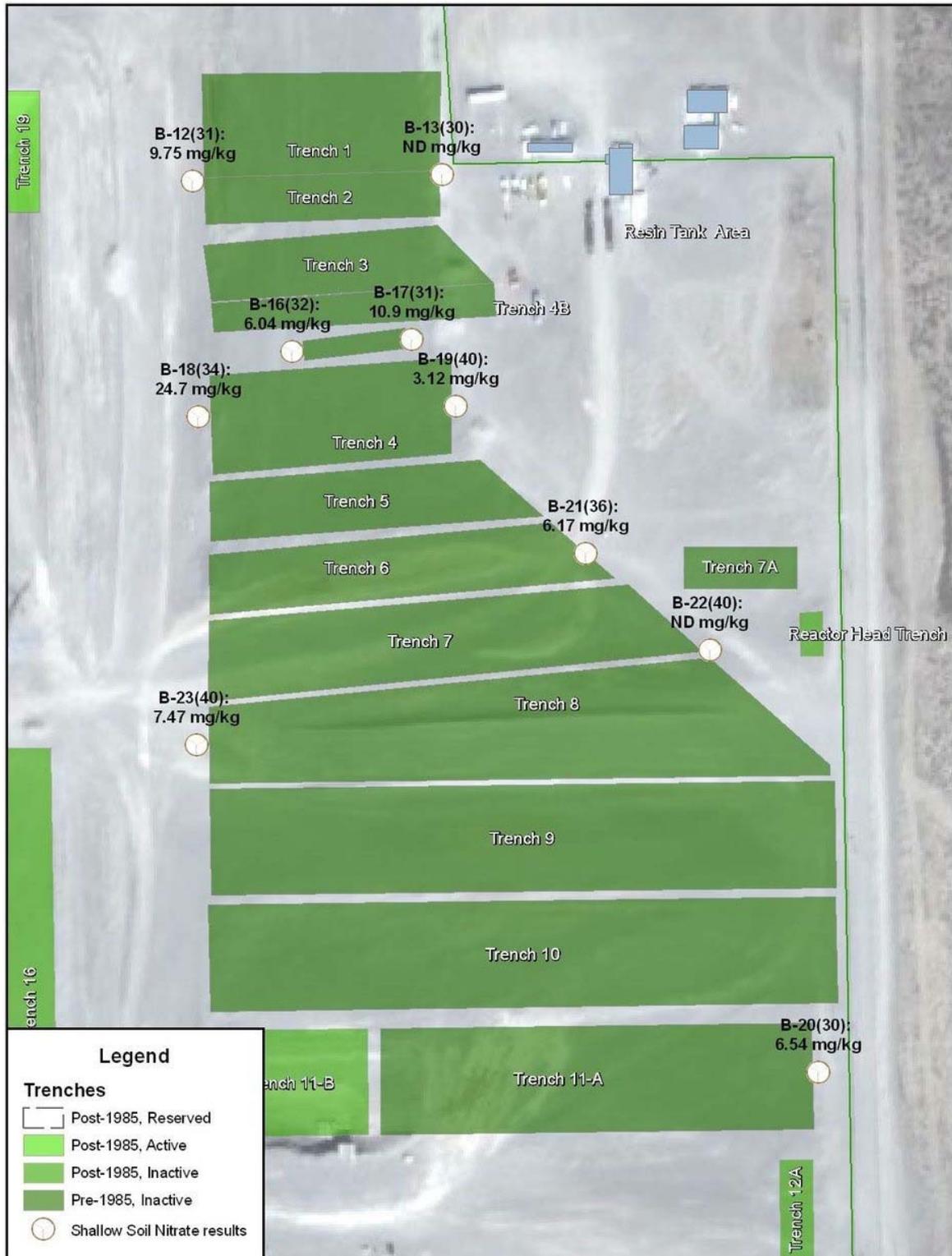


Figure 57 Distribution of Shallow Zone Nitrate in the Pre-1985 Trench Area

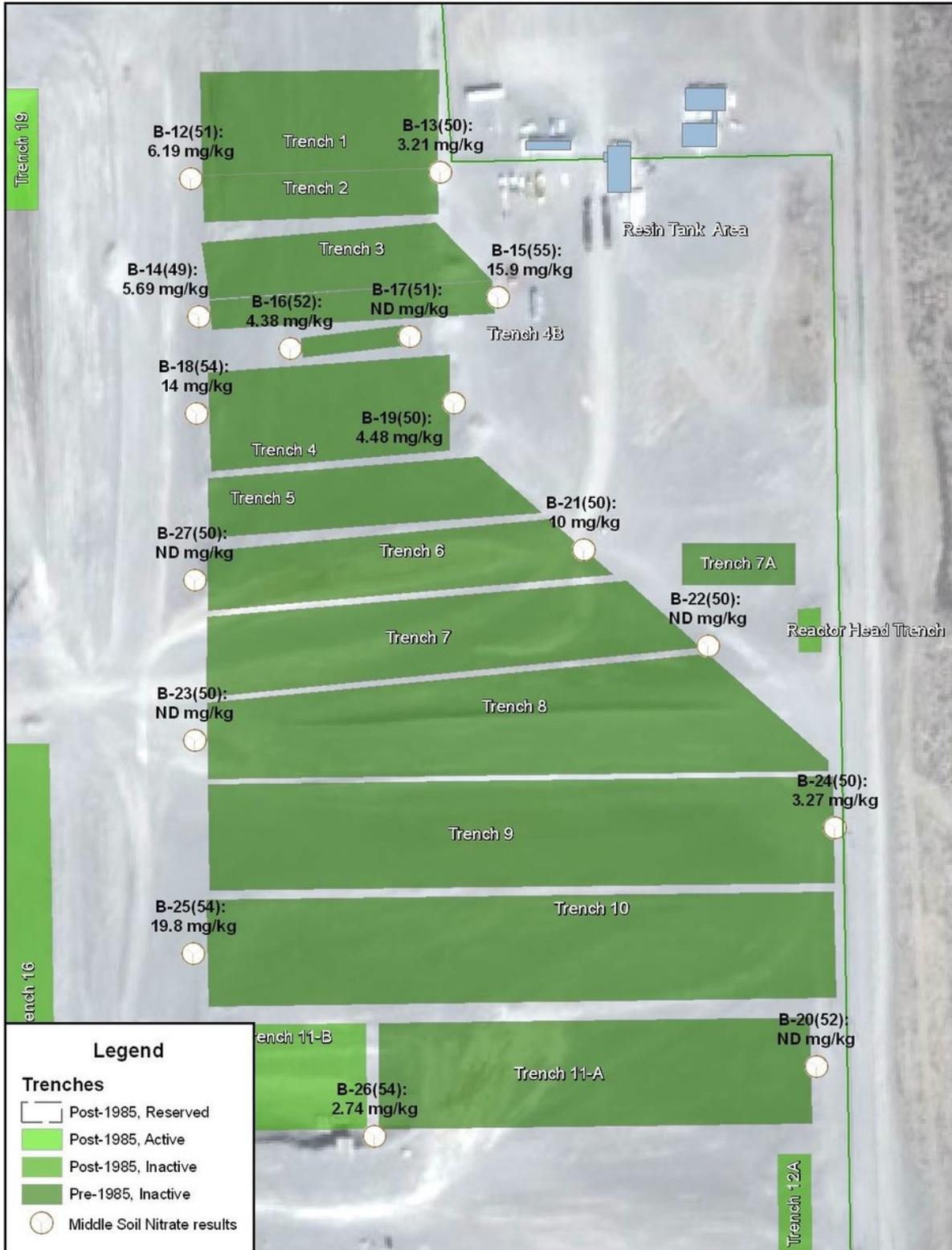


Figure 58 Distribution of Middle Zone Nitrate in the Pre-1985 Trench Area

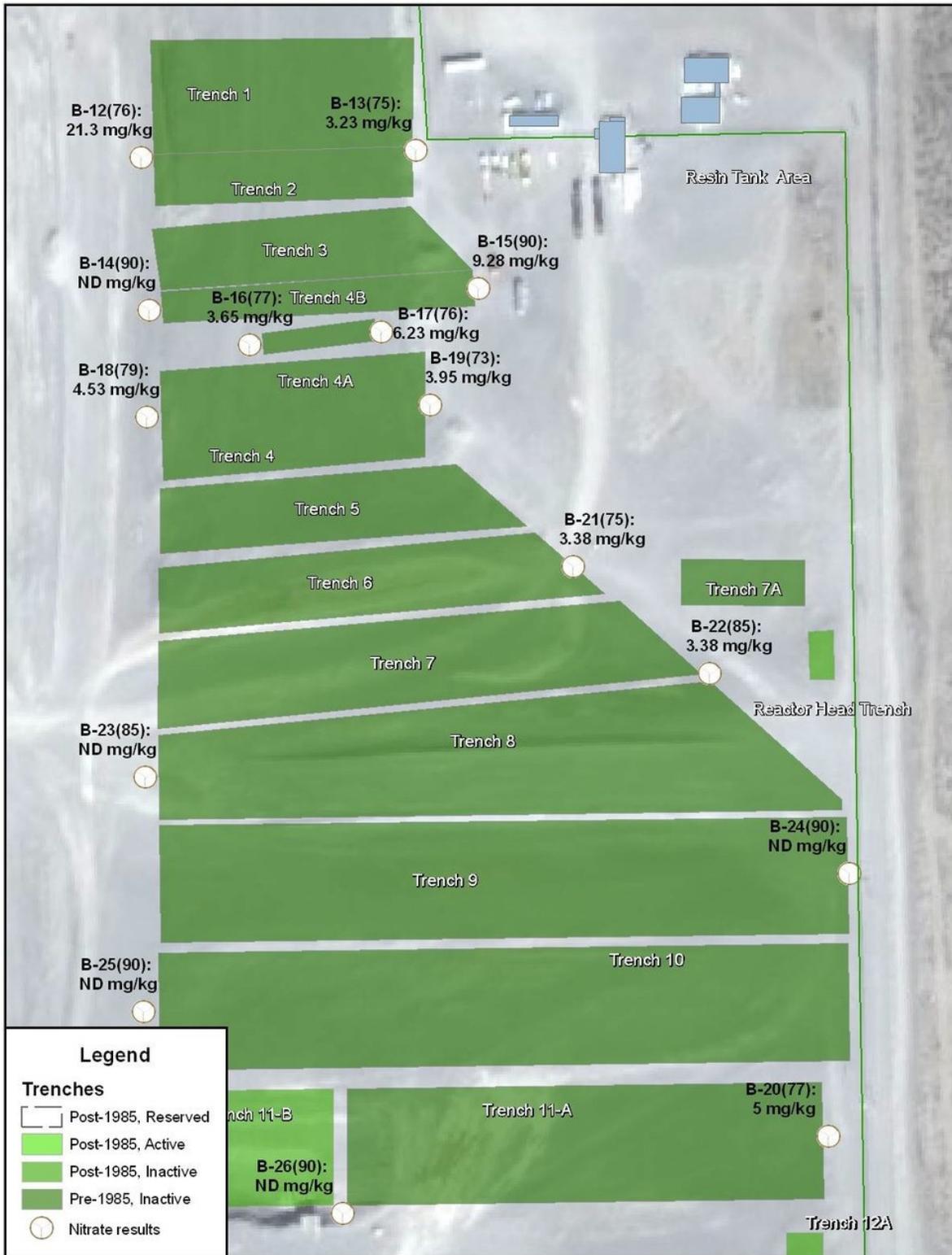


Figure 59 Distribution of Deep Zone Nitrate in the Pre-1985 Trench Area

7.3 Soil Vapor Contamination

Several chlorinated and fluorinated hydrocarbons are present in soil vapors around the pre-1985 Trench Area. As described in Section 6.8.3, eight exceeded the conservative ambient air screening standards using the EPA's Johnson and Ettinger model, SG-Screen, Version 3.1, February 2004. Section 6.8.3 recommended carrying forward two hazardous substances for assessment of nature and extent:

- Chloroform was identified in 330 of 344 soil vapor samples (Appendix F: Soil Gas Sample Results). The median concentration reported was 2 ppm, and the mean concentration observed was 8.6 ppm. The maximum concentration measured was 160 ppm. Figure 60 through Figure 62 illustrates the areas with the highest reported concentrations of chloroform in soil vapors. While chloroform results in soil samples were below screening criteria, there were 74 detections of chloroform in 127 soil samples. The reported concentrations ranged between non-detect to a maximum concentration of 31 µg/kg. The median concentration reported was 3 µg/kg, while the mean concentration was 13 µg/kg.
- Trichloroethene was identified in 206 of 344 soil vapor samples (Appendix F: Soil Gas Sample Results). The median concentration reported was 0.48 ppm, and the mean concentration observed was 40.6 ppm. The maximum concentration measured was 1,800 ppm. Figure 63 through Figure 65 illustrates the areas with the highest reported concentrations of trichloroethene in soil vapors. While trichloroethene results in soil samples were below screening criteria, there were 48 detections of trichloroethene in 127 soil samples. The reported concentrations ranged between non-detect to a maximum concentration of 170 µg/kg. The median concentration reported was 2.5 µg/kg, while the mean concentration was 17 µg/kg.

As can be seen, the highest concentrations reported tend to be in the southeastern portion of the pre-1985 Trench Area. Within the Hanford formation, soil vapor concentrations can be seen large distances from potential source areas (as observed in the 200-PW-1/3/6 Operable Unit, [DOE/RL-2006-51]). Relatively small quantities of source material held within fine-grained units (such as lenses of silt) can generate large quantities of volatile organic soil vapors.

When the soil vapors are measured in close proximity to potential source materials, the observed concentrations are high. Based upon the very high reported results observed at the USE Site, the measured concentrations are consistent with small amounts of hazardous substances that have been released from emplaced wastes in the pre-1985 Trench Area.



Figure 60 Distribution of Shallow Chloroform in Soil Vapors



Figure 61 Distribution of Middle Chloroform in Soil Vapors

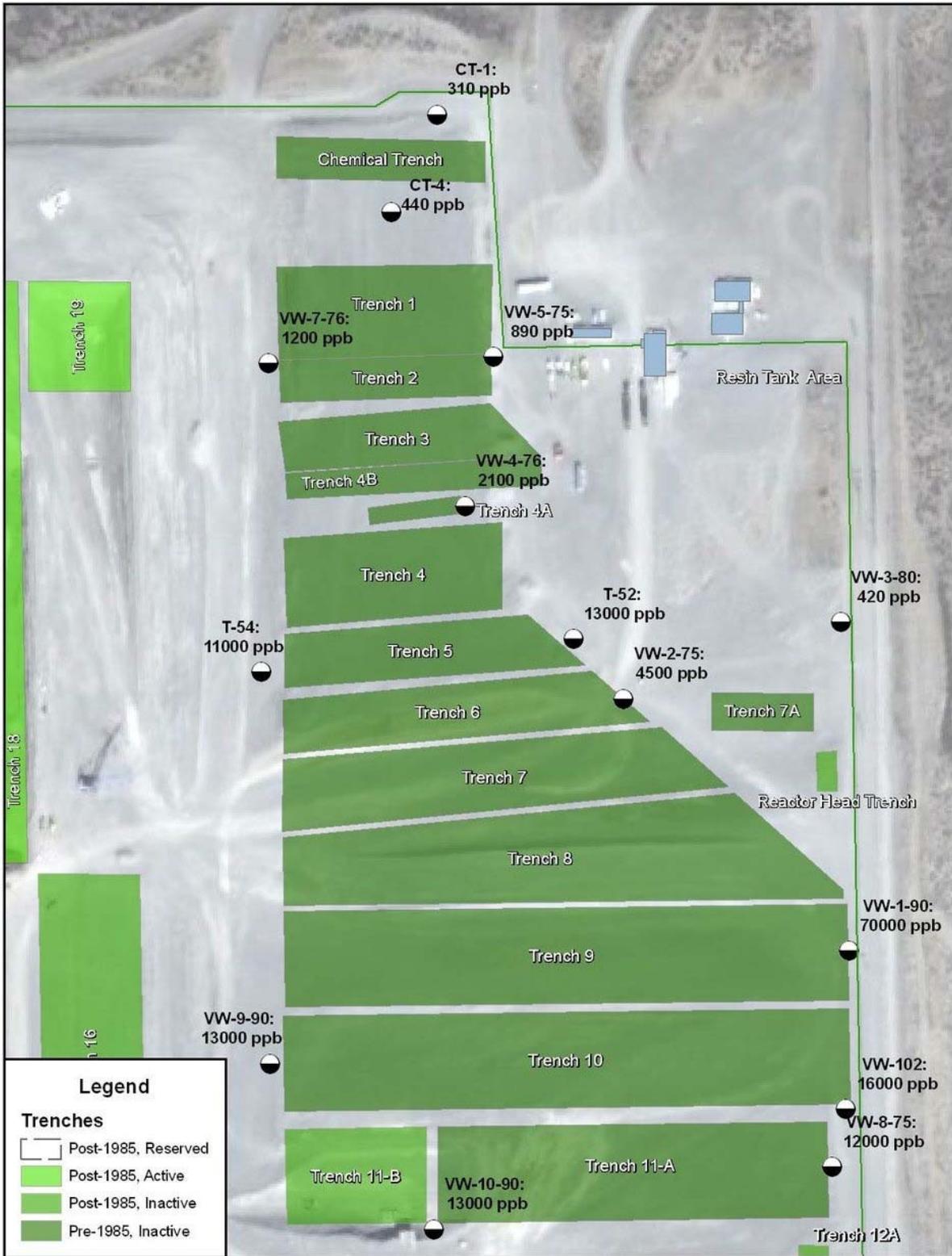


Figure 62 Distribution of Deep Chloroform in Soil Vapors



Figure 63 Distribution of Shallow Trichloroethene in Soil Vapors



Figure 64 Distribution of Middle Trichloroethene in Soil Vapors

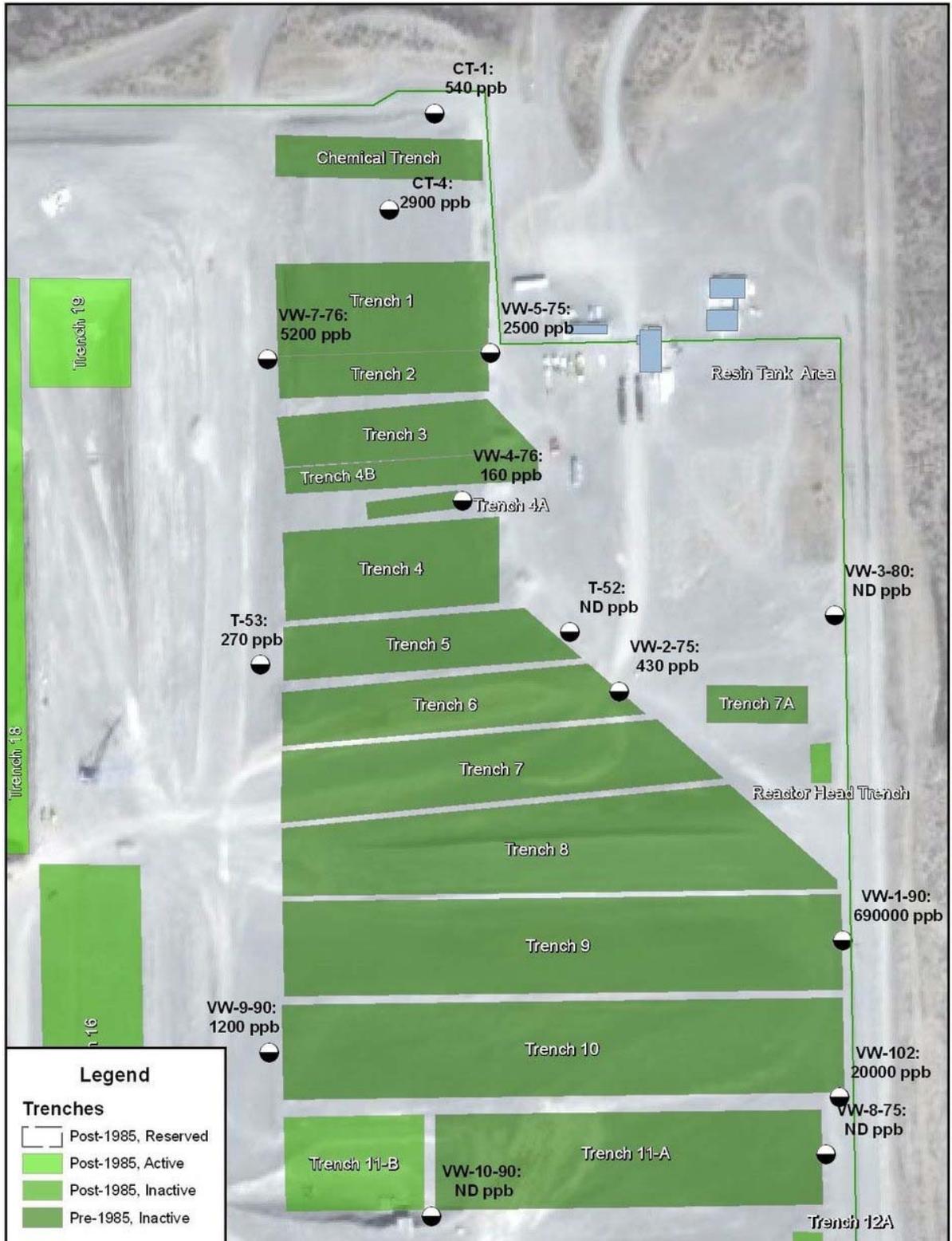


Figure 65 Distribution of Deep Trichloroethene in Soil Vapors

7.4 Source Area and Contaminant Migration Discussion

As can be seen in the previous sections, hazardous substances have been contributed or released during site operations and contaminated site soils and groundwater. This section briefly describes the extent and source of each contaminant.

Hexavalent chromium and nitrate were released during leaks or discharges from the resin tanks. The primary release mechanism was not the sudden snowmelt events, because shallow soil samples did not contain detectable quantities of hexavalent chromium. These materials migrated through the vadose zone, in a westerly and southwesterly direction as they migrated deeper. This is supported by the decreasing concentrations of hexavalent chromium and nitrate in the soil as the distance from the resin tanks is increased. Nitrate results in groundwater are lower than the screening level, while hexavalent chromium results in groundwater indicate that tank releases did impact groundwater. Considering the extremely low K_d (high mobility) of hexavalent chromium and the low concentrations found on this project (less than 3.6 mg/kg), a significant mass of hexavalent chromium does not remain in the soil column.

Chloroform and trichloroethene results were seen above soil vapors screening values, and in groundwater above screening levels. The most likely sources of these hazardous substances are from leaking waste packaging in the pre-1985 Trench Area. Simple analytical estimates of groundwater movement suggest the source of chloroform and trichloroethene was from trenches in the north-central portion of the pre-1985 Trench Area. Relatively stable monitoring trends suggest source material is not being actively contributed to groundwater. Potentially, soil vapor is the mechanism contributing material to groundwater. If this is the case, continued monitoring will provide the data necessary to determine whether groundwater and soil vapor concentrations are in equilibrium.

In addition to chloroform and trichloroethene, several other soil vapors exceed the EPA's Johnson and Ettinger model, SG-Screen, Version 3.1, February 2004 screening levels. The most likely source of these materials is small quantities of laboratory solvents and wastes disposed of in the pre-1985 Trench Area. Insignificant quantities reported in soil sample results or in groundwater, results suggest these measurements are indicative of material near or within the trenches themselves.

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8.0 Conclusions

This RI describes data collected during both an initial field investigation as well as two-year (8 quarters) soil vapor and ground monitoring program. The results presented in this RI report will aid in the development of the FS where remedial alternatives will be considered for the USE Site. Certain analytes have been evaluated and determined to be anomalous in soil and groundwater. The FS will build upon the data and trends presented in this RI Report to develop various remedial alternatives that will be evaluated in the FS Report.

As was described in Section 3.0, in early to mid 2008, a field investigation was completed to characterize the nature and extent of soil contamination in the pre-1985 Trench Area Decision Unit and the Resin Tank Area Decision Unit. Other activities included the installation of thirty vadose zone soil gas-monitoring wells, and the completion of civil, borehole camera, and well deviation surveys in USE groundwater monitoring wells.

In addition to the field investigation, long-term monitoring activities commenced February (groundwater) and June (soil vapor) 2008 (Section 4.0). Long-term monitoring activities included collecting quarterly groundwater samples in the USE wells for 8 consecutive quarters. Activities also included the quarterly collection of soil vapor samples from 41 USE Site vadose zone soil gas monitoring wells for 8 consecutive quarters. This report documents both the initial field investigation and all eight quarters of the monitoring program.

As of the issuance of this remedial investigation report, more than 70,600 results have been reported for field investigation and long-term monitoring activities. Of these results, less than 8 percent have been qualified as estimated measurements, and less than one-half percent of the project results have been rejected. Of the results reported by the laboratories as quantifiable measurements, less than 1 percent were qualified during data validation as non-detects due to QC issues. The two-tiered data validation approach was effective in implementing the Level A and C data validation required by the QAPjP. The data are well formed and appropriate; meeting project data quality objectives. The dataset is usable and sufficient for project decision-making purposes.

Using project data, human health and ecological screening assessments were completed to identify hazardous substances which required further evaluation as part of the RI. The first step of the assessment was to compare site soil concentrations to background concentrations. Analytes found to have concentrations consistent with background levels were not carried forward in the screening assessment. The screening assessments proceeded by comparing an EPC to the appropriate screening level. Exposure point concentrations calculated from values reported in the USE soil, groundwater, and soil gas data sets were compared to the MTCA screening levels to identify possible risk drivers. Exposure point concentrations calculated using soil data from within a 0 to 4.6 m (0 to 15 ft) depth interval were compared to direct-contact (Method B) MTCA screening levels, as directed in WAC 173-340-740(6). For groundwater protection, exposure point

concentrations calculated using soil and data from throughout the unsaturated zone were compared to the MTCA screening levels.

For vapor inhalation, indoor air concentrations modeled from exposure point concentrations calculated using soil gas data from throughout the unsaturated zone were compared to the MTCA screening levels. The full soil gas data set has 181 analytes, with detected results for 158 analytes. Toxicity criteria was available for 48 analytes or their readily available surrogates. Since there was no means to evaluate inhalation risk for the remaining compounds, those 133 compounds were not run in the Johnson and Ettinger model. The majority of these remaining analytes are long carbon chain alkanes and so can be safely assumed to be of low or negligible toxicity.

The analytes detected in groundwater that exceeded the groundwater CUL were 1,2-dichloroethane-d4, antimony, arsenic, bromofluorobenzene, fluoride, hexavalent chromium, molybdenum, nitrate, toluene-d8, trichloroethene, uranium, and vanadium (see Table 54). Excluding uranium, nearly all detects for these analytes exceeded their respective CULs.

The only analyte that failed the shallow soil (0 to 4.6 m [0 to 15 ft] bgs) protection of groundwater screen was Nitrate (see Table 52). The analytes that failed the deep soil (greater than 4.6 m [15 ft] bgs) protection of groundwater screen were hexavalent chromium, methylene chloride, nitrate, and nitrite (see Table 53). Note that several of the methylene chloride exceedances occurred in samples where the analyte was also detected in the associated blank.

No analytes failed the direct contact screen for soil against any Method B CULs (see Table 51).

The analytes detected in soil vapor that exceeded the air screening CULs (see Table 55) were 1,1-dichloroethane, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, dichlorofluoromethane, tetrachloroethene, and trichloroethene.

Nitrite (soil), methylene chloride (soil), arsenic (groundwater), uranium (groundwater) 1,2-dichloroethane-d4 (groundwater), bromofluorobenzene (groundwater), and toluene-d8 (groundwater) were evaluated and found to be anomalous substances which would not drive the development of cleanup alternatives, but would be considered if monitoring suggested these results merit further evaluation. These analytes will be considered secondary COCs moving forward into the FS.

Hexavalent chromium and nitrate were released during leaks or discharges from the resin tanks. The primary release mechanism was not the sudden snowmelt events, because shallow soil samples did not contain detectable quantities of hexavalent chromium. These materials migrated through the vadose zone, in a westerly and southwesterly direction as they migrated deeper. This is supported by the decreasing concentrations of hexavalent chromium and nitrate in the soil as the distance from the resin tanks is increased. Nitrate results in groundwater are lower than the screening level, while hexavalent chromium results in groundwater indicate that resin tank releases

did impact groundwater. Considering the extremely low K_d (i.e., high mobility) of hexavalent chromium and the low concentrations found on this project (less than 3.6 mg/kg), a significant mass of hexavalent chromium does not remain in the soil column.

Chloroform and trichloroethene results were seen above screening levels in soil vapors, in soil below screening values, and in groundwater above screening levels. The most likely sources of these hazardous substances are from leaking waste packaging in the pre-1985 Trench Area. Simple analytical estimates of groundwater movement suggest that the source of chloroform and trichloroethene was from trenches in the north-central portion of the pre-1985 Trench Area. Relatively stable monitoring trends suggest source material is not being actively contributed to groundwater. Potentially, soil vapor is the mechanism contributing material to groundwater. If this is the case, continued monitoring will provide the data necessary to determine whether groundwater and soil vapor concentrations are in equilibrium.

8.1 Data Quality Assessment

Evaluation of the dataset and validation results shows project data are of sufficient quality to support a feasibility study.

8.2 Remediation Determination

Based upon the results of this remedial investigation, there are concentrations of hazardous substances in soil and groundwater related to discharges from the resin tanks and wastes emplaced in the pre-1985 trenches. Since these substances are present at concentrations greater than the human health-based and ecological screening levels, it is necessary to conduct a feasibility study to determine whether cleanup actions are warranted.

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9.0 Acronyms

AEA	<i>Atomic Energy Act</i>
AEC	Atomic Energy Commission
ALE	Arid Lands Ecology
ANL	Argonne National Laboratory
CaCO ₃	Calcium Carbonate
California Nuclear	California Nuclear, Inc.
CCU	Cold Creak unit
CLUP	Comprehensive Land Use Plan
COC	Chain of custody
COPC	Constituent of potential concern
COPEC	Chemical of potential ecological concern
CPF	Carcinogenic potency factor
CUL	Cleanup level
Dade Moeler	Dade Moeller and Associates
DOE	United States Department of Energy
DOT	United States Department of Transportation
DQO	Data Quality Objective
Ecology	Washington State Department of Ecology
EcoSSL	Ecology soil screening levels
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPC	Exposure point concentration
EQL	Estimated quantitation limit
EQM	Environmental Quality Management, Inc.
ER	Equipment rinsate
ES	EnergySolutions, L.L.C.
FD	Field duplicate
FS	Feasibility Study
GPR	Ground Penetrating Radar
HASP	Health and Safety Plan
Hanford Site	United States Department of Energy Hanford Facility
HEAST	Health Effects Assessment Summary Tables
HFUF	Hanford formation units fine
HHR	Hydraulic Hammer Rig
HMS	Hanford Meteorological Station
HQ	Hazard quotient
IRIS	Integrated Risk Information System
KM	Kaplan-Meier

LCS	Laboratory control sample
LLRW	Low-level radioactive waste
LVL	Lionville Laboratories Inc.
MCL	Maximum contaminant level
MS	Matrix spike
MSD	Matrix spike duplicate
MTCA	<i>Model Toxics Control Act</i>
NARM	naturally accelerator-produced material
NCEA	National Center for Environmental Assessment
NEPA	<i>National Environmental Policy Act</i>
NOAEL	No observed adverse effect levels
NORM	Naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
OD	Outside diameter
OSWER	Office of Solid waste and Emergency Response
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory
PPRTV	Provisional peer-reviewed toxicity values
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
QAPjP	Quality Assurance Project Plan
RCBRA	Hanford River Corridor Baseline Risk Assessment
RCW	<i>Revised Code of Washington</i>
RfD	Reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
ROS	Regression on order statistics
RPD	relative percent difference
SAP	Sampling and Analysis Plan
Shaw	Shaw Environmental Inc.
SOW	Scope of Work
SVOCs	Semi-volatile organic compounds
SwRI	Southwest Research Institute
TB	Trip blank
TOX	Total organic Halides
UCL	Upper confidence limit
USE Site	LLRW Disposal Site in Benton County
USE	US Ecology, Inc.

VI	Chromium
Vista Engineering	Vista Engineering Technologies, L.L.C.
VOA	Volatile organics analysis
VOC	Volatile organic compounds
WAC	<i>Washington Administrative Code</i>
WCH	Washington Closure Hanford
WDOH	Washington State Department of Health
Work Plan	USE Site Remedial Investigation Work Plan
WRS	Wilcoxon Rank Sum

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11.0 Appendices: A-J

The appendices are located on the enclosed CD.

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