

**Data Quality Objectives Summary Report To Support the Model
Toxics Control Act Remedial Investigation/Feasibility Study for the
Low-Level Radioactive Waste Disposal Site**

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Compiled by Environmental Quality Management, Inc.

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ACRONYMS

AA	alternative action
ALARA	as low as reasonably achievable
CLARC	Cleanup Levels and Risk Calculations
COPC	contaminants of potential concern
CPC	conditional point of compliance
CSM	conceptual site model
DOE	U.S. Department of Energy
DNAPL	dense, non-aqueous phase liquids
DQO	Data Quality Objective
DR	Decision Rule
DS	Decision Statement
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EQM	Environmental Quality Management, Inc.
GPR	ground penetrating radar
HQ	hazard quotient
ICP	inductively coupled plasma
LLRW	Low-Level Radioactive Waste
LLW	Low-Level Waste
MCL	maximum contaminant level
MDL	minimum detection limit
MSL	mean sea level
MTCA	Model Toxics Control Act
NARM	Accelerator-Produced Radioactive Material
NOAEL	No Adverse Effects Level
NORM	Naturally Occurring Radioactive Material
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PLP	Potentially Liable Party
PQL	practical quantitation limit
PSQ	Principal Study Question
QA	quality assurance
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RI	remedial investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
SAP	sampling and analysis plan
SVOC	semi-volatile organic compounds
TOX	total organic halogens
USE	US Ecology Inc.
VOA	volatile organic analysis
VOC	volatile organic compound
WAC	Washington Administrative Code

WDOE Washington State Department of Ecology
WDOH Washington State Department of Health

1.0 STEP 1- STATE THE PROBLEM

The purpose of this Data Quality Objectives (DQO) Process is to identify the data required to support the Remedial Investigation/Feasibility Study (RI/FS) process for the Low-Level Radioactive Waste (LLRW) Disposal Site. The LLRW Site is operated by US Ecology Inc. (USE) under the terms of a sublease with the Washington State Department of Ecology (WDOE). The WDOE has determined that only the non-radioactive constituents at the LLRW Site may be dealt with via the Model Toxics Control Act of (MTCA). The WDOE has determined that any non-radioactive remediation will be performed under MTCA regulations; therefore, the radiochemical constituents present at the Site are not part of this DQO.

The Washington State Department of Health (WDOH) laws and regulations and conditions of WDOH radioactive materials license govern the management of the radiochemical constituents, including monitoring and corrective action involving radioactive constituents.

1.1 PROJECT OBJECTIVES

The following regulatory background is discussed in order to provide an understanding of the regulatory requirements and thus the project objectives.

A Closure Account was established to fund activities for closure of the disposal facility. This account is managed by WDOE and expenditures from the account require legislative appropriation. In 1997, the legislature appropriated \$7.4 million for investigation and closure of older, filled trenches at the LLRW site. Approximately \$925,000 was spent conducting the Phase I and II investigations. In 2003 the legislature reappropriated the remaining funds to complete the MTCA investigation and construct an interim cap. It is intended that the interim cap will function as an interim action under both the MTCA and applicable radiation control law. The Scope of Work will be limited to \$900,000, which covers the work plan, sampling plan with optimized design, implementation of the work plan, and writing the Remedial Investigation/Feasibility Study (RI/FS). Implementation of the remedial action is not included in these funds.

Although the WDOE has determined through Phase I and II Site investigations that contamination is present at the LLRW, the WDOE has not issued a Potentially Liable Party (PLP) letter to USE or any other party. Determination of PLP status for USE and potentially other parties will be made at a later date. The WDOE intends that a RI/FS will be conducted under a MTCA Agreed Order. The Agreed Order will incorporate the Scope of Work to be performed during the RI/FS. The Scope of Work will be used to generate a work plan to complete the site characterization required by an RI/FS. Previous site characterization was performed in Phase I and II investigations. Results from these efforts were considered in the DQO Process and summaries of these results are presented in the background and historical data sections of this document. The objective of this DQO is to identify the data needs required to complete the RI/FS. Figure 1-1 depicts the relationship between the DQO Process and the Scope of Work.

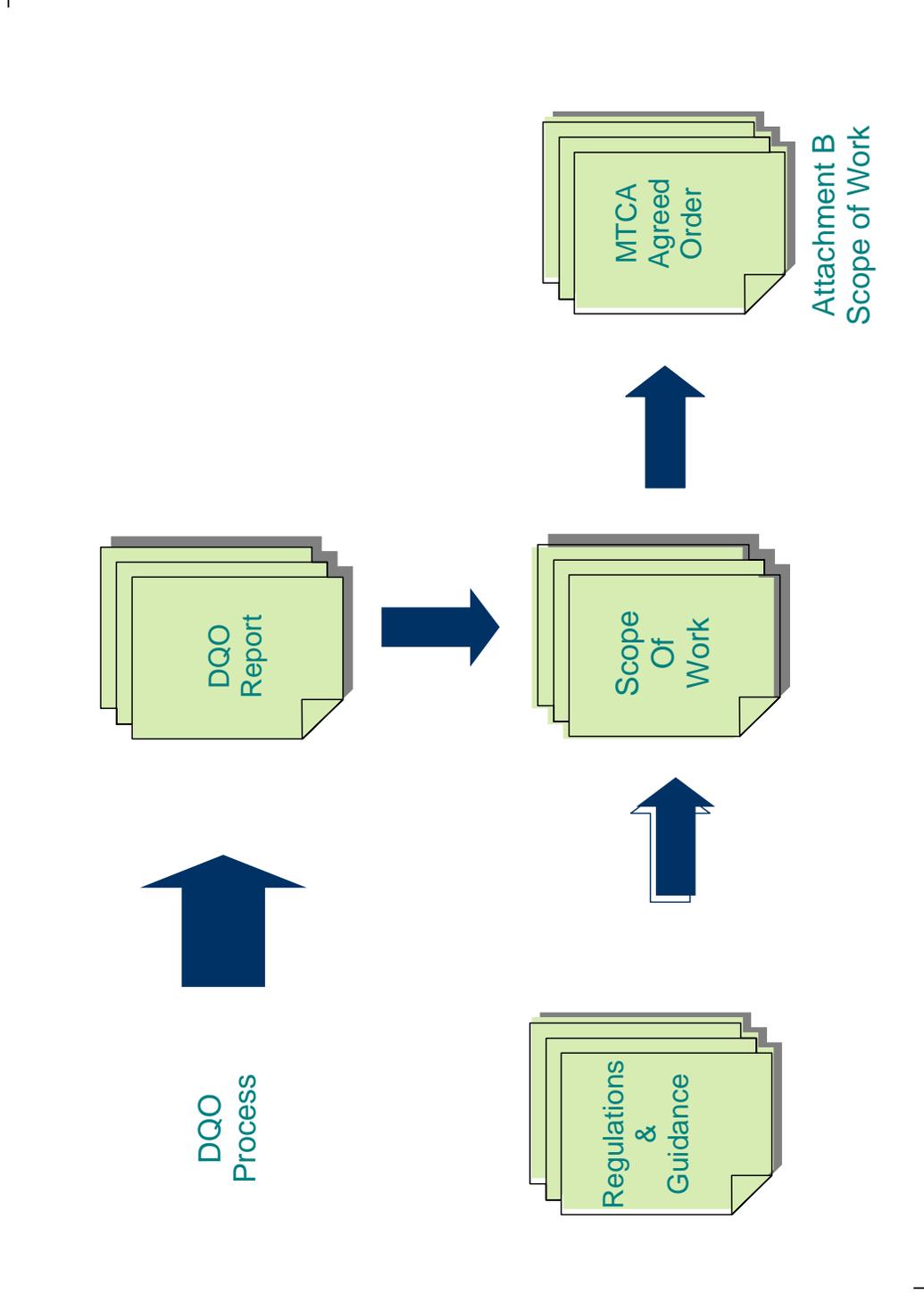
The final contractual vehicle has not yet been formalized; however, the WDOE has responsibility for disbursement of appropriated funds. Based on the Agreed Order and related RI/FS Scope of Work, USE will develop a field work plan which will be submitted to the WDOE for review and approval. Once the work plan has been approved, USE will begin scheduled field activities. USE will provide oversight of the field work, with direct technical assistance from the WDOE. As work is completed, invoices will be submitted by USE to the WDOE for approval and payment.

The Final DQO report will be issued in November 2003. The WDOE anticipates issuing an Agreed Order and RI/FS Scope of Work in early December. The WDOE anticipates review and approval of a detailed field work plan, based on the Scope of Work, by April 2004, so that field work can begin during the Spring/Summer of 2004. It is intended that the Scope of Work for the remedial investigation (RI) will be consistent with the approximately simultaneous installation of an interim cap as an interim action for both non-radiological and radiological constituents.

The DQO process was initiated because of the different regulatory requirements of the WDOH and WDOE. The WDOH was in the process of completing the Environmental Impact Statement (EIS) and planning for the interim closure cap; the WDOE was planning additional site investigation for hazardous constituents. The best approach was to hire a contractor to assist the WDOE with the DQO process in order to help identify data needs for the RI/FS. In early 2002, the WDOE sent out invitations to stakeholders, USE, the U.S. Department of Energy (DOE), and other state agencies, inviting them to participate in DQO meetings. The broad participation that resulted allowed the stakeholders to have input into RI planning from the beginning.

Environmental Quality Management, Inc. (EQM) was hired by the WDOE to facilitate the DQO process. The WDOE took the lead in compiling site information for the development of each DQO step. After each step was completed, a meeting was held to present the information to the stakeholders and discuss any concerns and issues. After each meeting, minutes were distributed to participants for comments. Meetings were scheduled through 2002 and early 2003. EQM was responsible for drafting the DQO report. The WDOE reviewed the draft DQO report, added new information that had become available since completion of the DQO meetings, and returned the draft DQO report to EQM. EQM revised the draft DQO report accordingly and prepared it for distribution to all DQO participants for comment. After the review process was completed, the final DQO report was issued by the WDOE. The DQO process has been utilized to involve stakeholders and receive their input on the content of the RI/FS for the LLRW Site. Stakeholder input gathered during the DQO process will be considered during the development of the Scope of Work for the MTCA Agreed Order. This DQO report does not set forth regulatory requirements. The Scope of Work in the MTCA Agreed Order will establish requirements and will be a regulatorily enforceable document. Stakeholders will have an additional opportunity for comment on the RI/FS for the LLRW Site during the MTCA public comment period.

Figure 1-1. Relationship Between the MTCA Order and the DQO Process and Scope of Work



1.2 SITE LOCATION AND DESCRIPTION

Since the early 1960s, commercial LLRW generated by hospitals, laboratories, universities, private industries, and nuclear power facilities have been disposed of at shallow-land disposal facilities across the United States. These facilities are located in Barnwell, South Carolina; Beatty, Nevada; Maxey Flats, Kentucky; Sheffield, Illinois; West Valley, New York; and Richland, Washington. Presently, only Nevada, South Carolina, and Washington are accepting wastes for disposal.

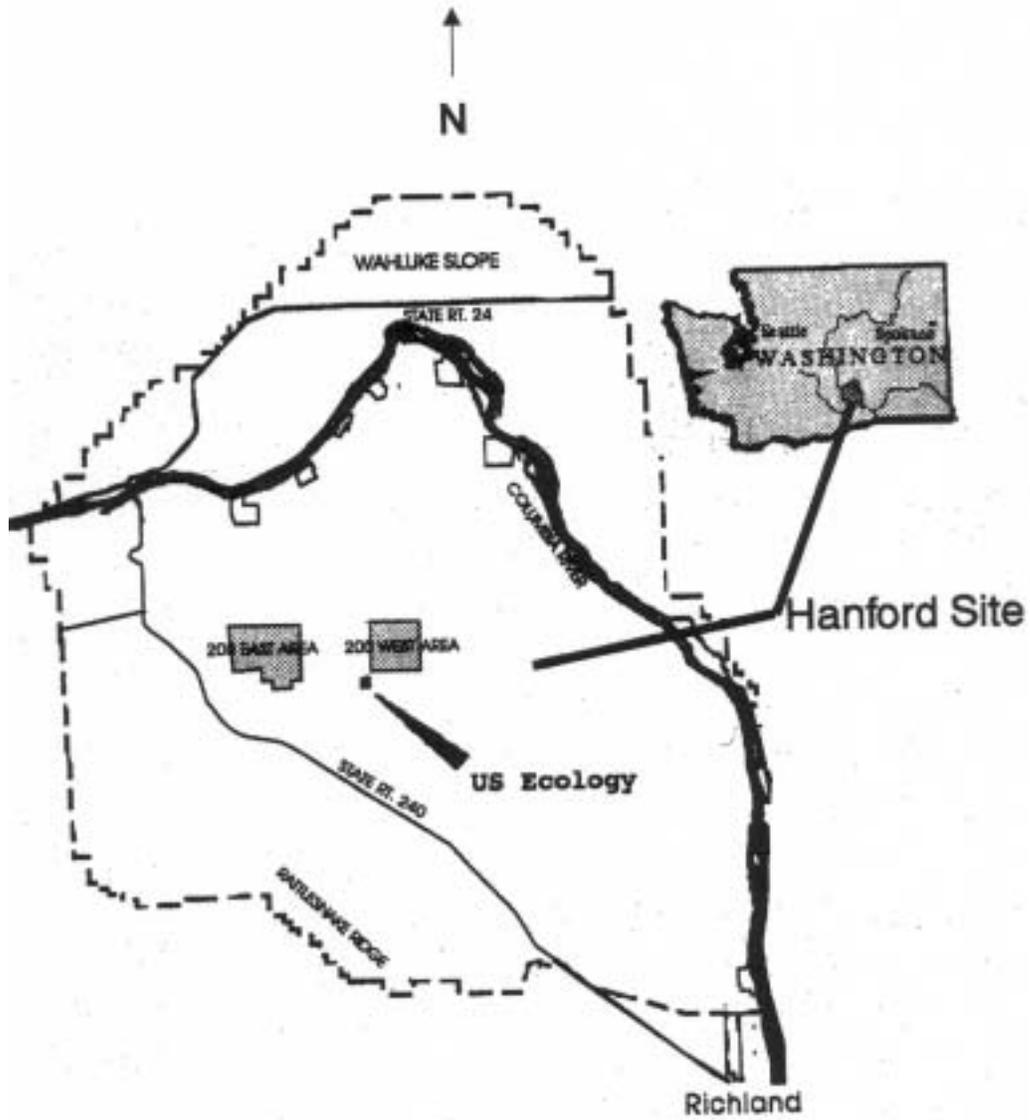
The LLRW Site is located in Benton County and is approximately 23 miles northwest of Richland, Washington. It is situated near the center of the 560 square mile DOE Hanford Facility (Hanford) on approximately 100 acres of federal land leased to the State of Washington and sublet to USE (see Figure 1-2). The commercial LLRW Site has been in operation since 1965 and is currently operated by USE. Access to the site is restricted and there are no permanent residences on or adjacent to the site. The Columbia River, located approximately six miles east, is the nearest significant surface water body. Groundwater depth is over 300 feet and the average precipitation is approximately 6 inches per year (Neitzel et al. 1996). There are no domestic or municipal wells onsite or within several miles of the Site.

The commercial LLRW 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.

The commercial LLRW Site practices conventional shallow-land burial of packaged waste into unlined trenches. The trenches range from 300-700 feet long, 50-80 feet wide and 30-50 feet deep. In addition to the trenches, five underground storage tanks were installed for treatment of liquid low-level radioactive resin wastes. Two of these tanks were removed and the remaining three tanks were emptied in 1986. There are currently three open operating trenches (Trench 14-W, Trench 11-B, and Trench 18) and 20 filled trenches whose contents include one nuclear reactor vessel, three emptied underground tanks, large quantities of scintillation fluids, absorbed liquids, and vast quantities of metal drums, fiber-board drums, and cardboard, wood, and metal boxes. Figure 1-3 shows the trench locations. The filled trenches have been covered with at least five feet of site soils.

Several types of waste have been disposed at the LLRW Site since 1965. Waste types include low-level radioactive, naturally occurring radioactive material (NORM) and accelerator-produced material (NARM), non-radioactive hazardous, and mixed waste (radioactive waste having a hazardous component). Since 1985, only LLRW and NARM have been allowed for disposal. LLRW is waste such as trash, clothing, tools, hardware, and equipment that has been contaminated by radioactive substances. The LLRW at the LLRW 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. NARM waste includes, but is not limited to, pipe scale from oil and gas pipelines, soils from cleanup of mineral processing sites, and measuring devices and gauges.

Figure 1-2. Map from EIS



1.3 SITE HISTORY

The following discussion provides a brief LLRW Site history. In 1965, the commercial LLRW Site was licensed to California Nuclear, Inc. and began accepting LLRW and chemical waste. In 1968, Nuclear Engineering Company acquired California Nuclear, Inc. and took over as site operator. Around 1970, the chemical trench, holding approximately 17,000 cubic feet of waste, was closed. After this date, purely chemical waste was banned from disposal unless it was mixed waste. In October 1979, the LLRW Site was temporarily closed due to transportation-related noncompliance events and was reopened in November of the same year.

In 1980, Congress passed the LLRW Policy. Therefore, packaging requirements became more stringent and cardboard packaging was no longer accepted; metal drums and boxes were required. In 1985, all disposal of *Resource Conservation and Recovery Act of 1976 (RCRA)* mixed waste ceased at the LLRW Site, including hazardous scintillation fluids. In 1985, Congress passed the LLRW Amendments Act of 1985.

In 1985 through 1986, five resin tanks were pumped to remove their contents. Liquids from the tanks were solidified with Aquaset/Petroset and disposed in Trench 11-A. Two tanks were removed, and three tanks were left in place. The remaining tank liquids were sampled and characterized as extremely hazardous waste by the WDOE. In 1986, oils and chelators were required to be solidified. By 1993, the Northwest Compact restricted disposal of LLRW to member states and Rocky Mountain Compact states (11 states total). Since 1993, rates have been regulated by the Washington Utilities and Transportation Commission, and the preferred packaging type changed from drums to wood or metal boxes. In 1997 the Draft EIS was started and the LLRW Site Investigation began. In 1999 the Trojan reactor vessel was disposed at the LLRW Site in Trench 12, and absorbed liquids were no longer accepted for disposal.

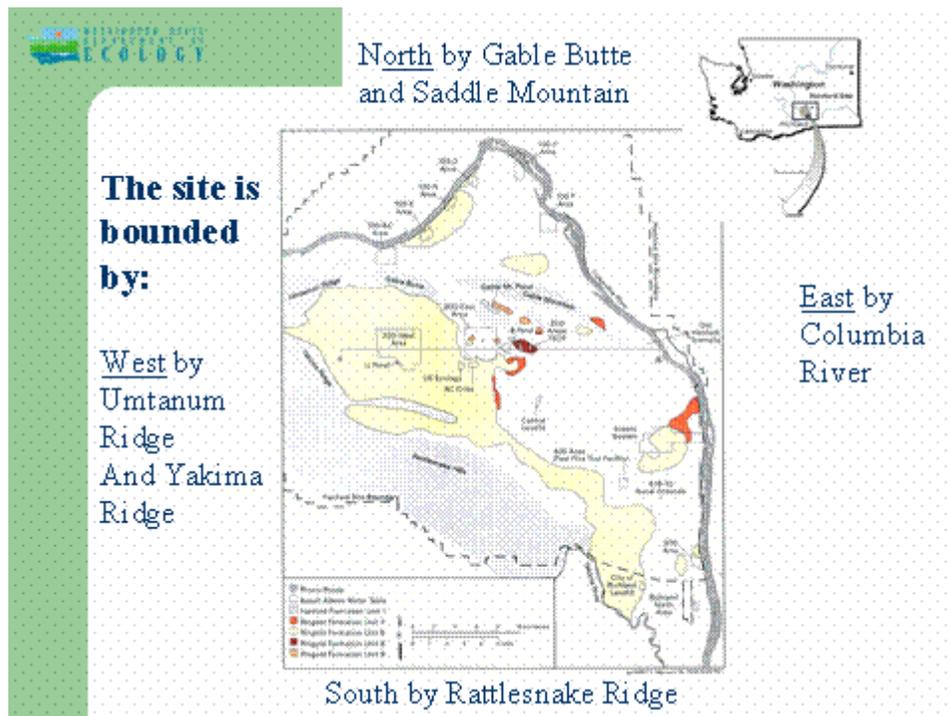
Vadose zone and groundwater contamination from past DOE activities on the central plateau has been well documented (PNNL 2002). Radionuclides and hazardous constituents contaminating the groundwater include tritium, chromium, cobalt 60, trichloroethene, strontium 90, carbon tetrachloride, technetium 99, nitrate, iodine 129, cesium 137, and plutonium and uranium isotopes. Several of these plumes have passed or are still expanding and moving towards the LLRW Site (PNNL 2002). The DOE, under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) with the WDOE and the EPA, is in the process of remediating many of these contaminated sites (WDOE, EPA, and DOE 1994). Although the LLRW Site is operated by USE, the DOE owns the land on which it is located. When the EPA issued the Hazardous and Solid Waste Act portion of the Hanford Facility Dangerous Waste RCRA Permit, the LLRW Site was included for corrective action, Condition II.Y.3.a.

The following sections provide a description of the regional and physiographic setting and major stratigraphic units of the USE Site.

1.3.1 Physiography

The LLRW Site is located in south-central portion of Washington State within the Columbia River Plateau, which is generally defined by a thick accumulation of basaltic lava flows that extend laterally from Central Washington eastward into Idaho and southward into Oregon (Tallman et al. 1979). Figure 1-4 shows the physiographic boundaries surrounding the LLRW Site. Deformation of these lava flows formed structural and topographic basins. The LLRW Site is located in the Hanford 200 Area, which lies in the Pasco Basin. Laterally, basalt ridges bound the site.

Figure 1-4. LLRW Physiographic Boundaries



These structures are Saddle Mountain and Gable Butte to the north; the Umtanum Ridge and Yakima Ridge to the west; the Rattlesnake Hills to the south, and the Columbia River to the east. During the Pleistocene era, the Pasco Basin was repeatedly affected by catastrophic flooding, resulting in flood channels, plains, bars, and current ripples. The LLRW Site is located on the 200 Area Pleistocene glaciofluvial flood bar in the Central Hanford Site. Holocene eolian deposits of loess and sand dunes mantle the surface areas.

1.3.2 Stratigraphy

Figure 1-5 shows the geological setting of the LLRW Site. The Miocene basaltic lava flows of the Columbia River Basalt Group and intercalated sediment of the Ellensburg Formation form the bedrock of the Pasco Basin. Late Miocene to mid-Pliocene fluvial and lacustrine sediments of the Ringold Formation overlies the basalt. The Hanford formation overlies the Ringold formation. These catastrophic flood sediments were deposited when ice dams in Western

Montana and Northern Idaho were breached and massive volumes of water spilled across eastern and central Washington (Bretz 1923). The flood scoured the land surface, locally eroding the Ringold Formation and the basalts and sedimentary interbeds, leaving a network of buried channels crossing the Pasco Basin (Tallman et al. 1979). Flood waters entering the Pasco Basin impounded behind the Wallula Gap, forming Lake Lewis. Thick sequences of sediments were deposited by multiple episodes of flooding (Baker 1973). Most of these sediments are late Pleistocene and are divided into two main facies: the Pasco gravel facies and the Touchet beds facies (Myers, Caggiano, and Price 1979). Recent alluvium, colluvium, landslide debris, and active and inactive sand dunes make up the surficial deposits.

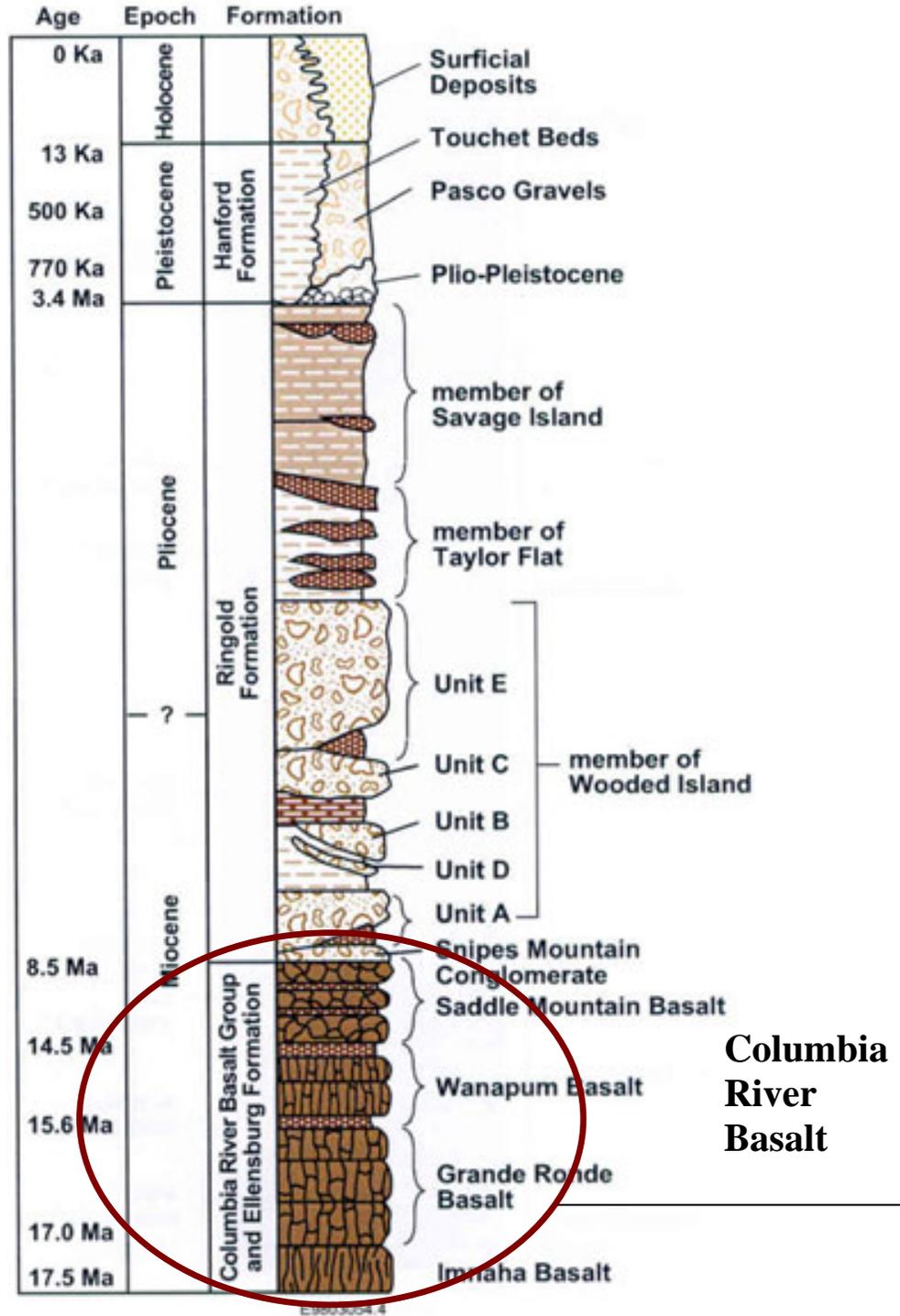
The unlined trenches at the LLRW Site were constructed in the Hanford Formation. The upper sand and silt unit is the host material for the LLRW Site's waste. Excavation of waste disposal trenches has extended to depths of up to 45 feet. Sediments exposed in the trench walls display a variety of bedding types related to their depositional and post-depositional environments. The general structure of the bedding surfaces appears to be rather wavy and nonparallel. Materials within the beds are generally uniform or gradational in particle size. Internal structure of the beds varies, with several types of bedding forms. These include massive bedding where no stratification was apparent, horizontal bedding consisting of fine lamination, cross bedding with fore set, and graded-bed sequences. These bedding types were observed in measured sections from the south wall of Trenches 13 and 14 (Bergeron, Last, Reisenauer 1987).

1.3.3 Hydrologic Setting

The LLRW Site is located within the Pasco Basin of the Columbia River Plateau, which is drained by the Columbia River and smaller tributary streams. Other streams close to the site include the Yakima River and ephemeral streams of Cold and Dry Creeks.

Groundwater within the basin is found under both confined and unconfined conditions. The unconfined aquifer is contained in the unconsolidated glaciofluvial sands and gravels of the Hanford formation and silts and gravels of the Ringold formation. At the site, the water table is positioned in the upper part of the Middle Ringold formation, making the saturated thickness of the unconfined aquifer between 90 to 100 feet. The bottom of the unconfined aquifer is assumed to be the low-permeable silty sand of the Lower Ringold formation.

Figure 1-5. Geologic Setting: Late Cenozoic Stratigraphy of the Pasco Basin



1.3.4 Unsaturated Zone

Understanding the potential for infiltration and rate of deep percolation of precipitation is essential for evaluating the geohydrology of the LLRW Site. The major stratigraphic units that lie above the water table and beneath the site, in ascending order, are the Middle Ringold, the Hanford formation, and recent eolian sands and backfill.

Underneath the LLRW Site, the oldest stratigraphic unit exposed above the water table is the Middle Ringold Formation. Tallman et al. (1979) described the Middle Ringold in the Hanford 200 Area as silty, sandy gravel consisting of well-rounded pebbles and small cobbles with interstitial spaces filled with coarse to fine sand and silt. There are seven groundwater monitoring wells at the LLRW Site; all penetrate the Middle Ringold. Measurements of the geologic contacts from these wells indicate that the unsaturated portion of this unit averages 17 feet, ranging from 13 feet in MW13 to 21 feet in MW5. The top of the Middle Ringold appears to be relatively flat; however, other slight undulations may also be present in the eroded surface of the formation (Bergeron, Last, Reisenauer 1987).

Overlying the Middle Ringold is a thick unit of unconsolidated sands. These sands are considered part of the glaciofluvial sediments of the Hanford formation described by Tallman et al. (1979). In a report by CH2M Hill (1986), these sands are referred to as “fluvial deposits” and “sand and silty sand,” and are described as poorly graded fine to medium sand with 0 to 25% intermixed and interlayered silt containing less than 5% pebbly gravel and some calcium carbonate. The sands were further described as being light brown in color and loose.

The upper 20 feet were described as damp to moist with the rest being dry. The lowermost sand and silt unit lies non-conformably on the eroded surface of the Ringold formation. This unit consists of poorly graded coarse black sands and fine brown sands and silts, with some areas of cobbles. The sands are generally coarse to medium and contain mica. Compaction of the materials varies from loose to partially compacted. The silts in this unit are concentrated in seams, alternating with the coarser sand layers. Minor gravelly lenses were noted near the top of the Ringold in MW5 and MW13. Overlying the lowermost sand and silt unit is a thin, discontinuous gravelly sand unit. This unit has been identified in all wells except MW5. Sediments of this unit are described as moderately graded brown sand and small gravel, with silt. The gravels consist of subangular to angular basalt and quartz-rich clasts. The sands are very medium to coarse. The uppermost sand and silt unit consists of alternating layers of coarse black sands, fine brown sands, and silts. The sediments are generally loose and poorly graded (Bergeron, Last, Reisenauer, 1987).

A 3 to 5 foot thick veneer of eolian sand originally covered the LLRW Site. Operational activities at the site have removed or covered up these sands. Bioturbation by vegetation, burrowing animals and small nesting birds in the upper 12 feet of fill material in opened trenches has been observed, as shown in Figure 1-6.

Figure 1-6. Open Trench at LLRW Site

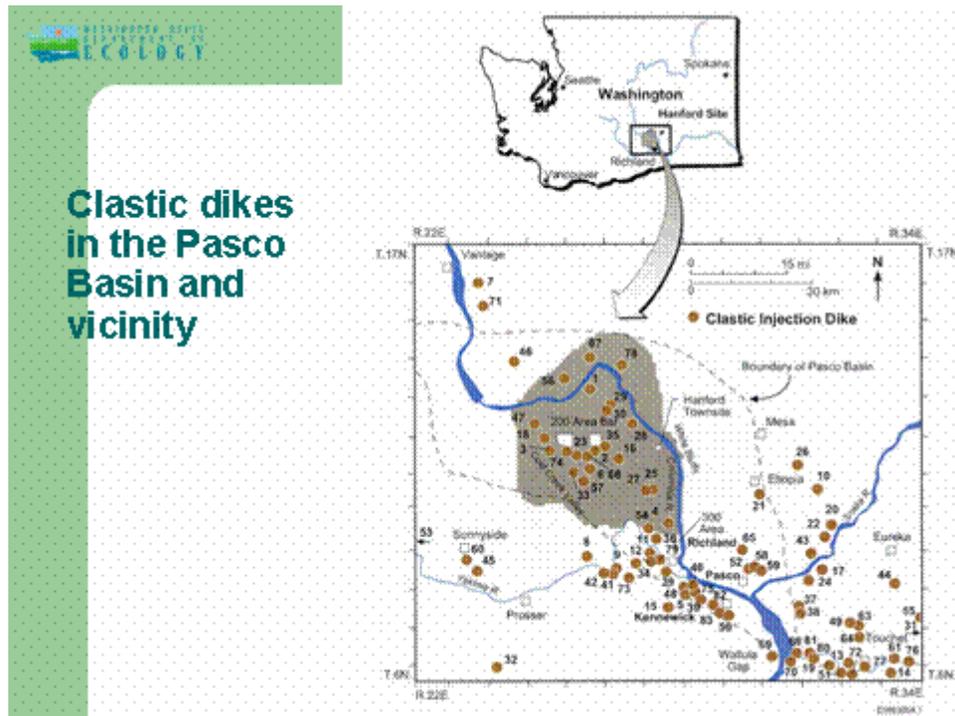
1.3.5 Clastic Dikes

Clastic dikes are common structures that occur in many geologic units in the Pasco Basin and vicinity.

Figure 1-7 indicates field identified locations of clastic dikes; location 66 is the LLRW Site. Clastic dikes are fissures filled with sand, silt, clay, and minor coarser debris. Many dikes occur as near vertical tabular and tapered bodies filled with multiple layers of unconsolidated sediments. The margin of most dikes, and internal layers within the dikes, are separated by thin clay/silt linings. Clastic dikes occur in geologic units ranging from Miocene to Pleistocene in age and are associated with hydraulic injection during cataclysmic flooding, mass wasting, earthquakes, and other geologic processes (Fecht et al. 1999).

Clastic dikes have been observed in all of the trenches. These dikes are thought to represent dewatering structures that developed during compaction of the loosely deposited sediments and draining of glacial Lake Lewis. Clastic dikes are generally near-vertical planar structures composed of several small “dikelets” of well-sorted sands separated by clay.

Figure 1-7. Clastic Dikes in the Pasco Basin and Vicinity



These dikes vary from simple dikes a few inches wide, to complex dike systems, as shown in Figure 1-8, that run both vertically and horizontally, intersecting with other dikes. Some of the more complex dikes are up to 3 feet wide. The dikes have been observed at depths of 45 feet near the bottom of the excavated trenches (Bergeron, Last, Reisenauer 1987).

Clastic dikes are widespread in the Pasco Basin. At the LLRW Site, clastic dikes are multiple at the location, occur in a variety of rock types, and represent multiple ages of emplacement. The significant clastic dikes at the site represent some of the most extensive exposures of clastic dike networks in South-Central Washington. Clastic dikes may serve as a preferential pathway for transport of waste constituents through the vadose zone to groundwater and are major dispositional features throughout the LLRW Site.

Figure 1-8. Clastic Dike near LLRW Trenches



1.4 DATA FROM PREVIOUS INVESTIGATIONS

Table 1-1 presents general trench numbers and general information. The previous phases of site characterization included data collection from slanted borings to assess soil and soil gas contamination under the trenches, borings to evaluate soil contamination around the resin tank area, and groundwater samples to evaluate groundwater contamination. Regional groundwater flows into the Pasco Basin in an easterly to northeasterly direction across the Hanford Site and easterly to northeasterly beneath the LLRW Site flowing toward the Columbia River.

Table 1-1. Trench Numbers and General Trench Information. (2 sheets)

Area	Trench Information
Trenches 16* & 18*	Trench 18 active now. Clastic Dike was observed in 2002 photograph.
Trenches 13 & 14	West portion of Trench 14A active now. Confirm no hazardous substances are present.
Trench 12	Trojan reactor disposed August 1999, 8,490 ft ³ w/1.54 million curies.
Trench 11A	Contains mixed waste stabilized with Aquaset/Petroset, including drums from close out of resin tank area.
Trench 11B	Active, now in use. Contains caissons (vertically placed corrugated steel culverts) as described in trenches 4A & B.
10	Likely to contain scintillation fluids.
9	Likely to contain scintillation fluids.
8	Likely to contain scintillation fluids.
7	Likely to contain scintillation fluids.
6	Likely to contain scintillation fluids.
7A	Need to confirm if hazardous substances are present or not.
RXT	Head and Reactor Vessel Trench.
5	Known to have containerized/absorbed liquids disposed in the trench. Contains scintillation fluids. Contains mixed waste.
4A & B	Trench 4A, which was open from 4/30/82-6/18/82, was designed for dewatered, feedwater heaters from J.A. Fitzpatrick power plant. 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.

Table 1-1. Trench Numbers and General Trench Information. (2 sheets)

Area	Trench Information
1-4	Contain waste in metal drums, fiber-board drums, and cardboard boxes. Likely to contain scintillation fluids.
Chemical	Known to have 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 sequence is out of order; trenches 15 and 17 have not been constructed at this time.

1.4.1 Trench area soil gas and soil data

The LLRW, with technical assistance from the WDOE and WDOH, conducted Phase I and Phase II of a site investigation at the LLRW Site in 1998 and 1999 (USE 1999). The purpose of the LLRW Site investigation was to determine if any release has occurred at the site.

The LLRW Site investigation included a total of eight vadose zone slant borings, four under the Chemical Trench and four under Trench 5. The slant borings were located at a distance from the trench edges to minimize the risk of drilling into waste materials. Figure 1-9 shows the orientation of the slant borings beneath the trench.

Trench 5 was selected for placement of slant borings because it is reported to contain high volumes of tritium-containing waste and volatile organic compounds, such as toluene, xylene, and benzene. These compounds were components of scintillation fluids used in research. The Chemical Trench was selected for evaluation because it may contain unique chemical contaminants when compared with the other trenches. Two borings were completed at each of the four locations as shown in Figures 1-10 and 1-11. Figure 1-12 shows a surface view of the borehole casings.

Table 1-2 provides further information regarding the sampling design of the Phase I investigation. While both radioactive and non-radioactive hazardous constituents were evaluated, this DQO only addresses the non-radioactive constituents; therefore, only non-radioactive constituent data have been provided.

Table 1-2. LLRW 1998 Site Investigation Summary.

Media	Sample Site and Locations	Sample Method	Constituents Sampled
Vadose Zone	Boring A1 - North Boundary Chemical Trench Boring B1 - South Boundary Chemical Trench Boring C1 - East Boundary Trench 5 Boring D1 -West Boundary Trench 5	30-degree drilling angle; 10 feet from bottom corner of trench to 70 feet below bottom of trench	Volatile organic compounds (VOCs); semi-volatile organic compounds (SVOCs), metals, anions, cyanide, nitrate/nitrite, sulfide, organic content
Vadose Zone Gas	8 well installations; 4 inches soil boring wells, 4 \approx 10 feet from geophysical wells	30-degree drilling angle; 10 feet from bottom corner of trench to 25 and 45 feet below bottom of trench	VOCs, SVOCs, methane
Groundwater	6 wells inside the fence and 1 well outside the fence 1 W Trench 15, 2 S Trench 14A, 1 E Trench 6, 1 E Trench 1, 1 NE Chemical Trench, 1 E Trench 10; Mean depth of wells 358 feet below grade		Temperature, conductivity, anions, total dissolved solids, nitrate, nitrite, sulfide, total organic content, VOCs, SVOCs, total metals, hexavalent chromium, total organic halides (TOX), cyanide phenols

Results of the LLRW Site investigation indicate the presence of non-radioactive hazardous constituents in the vadose zone and in the vadose zone gases below the Chemical Trench and Trench 5. Data indicates metals in the vadose zone including arsenic, beryllium, cadmium, and chromium that exceed screening levels.

Graphs of select organic data have been prepared which plot the highest values detected in the soil samples above the practical quantitation limits (PQLs). Locations where data were collected are shown on the figures. Volatile and semivolatile organic chemicals detected in the soil include acetone (see Figure 1-13), 1,2,4-trimethyl-benzene (see Figure 1-14), and (total) xylene (see Figure 1-15).

Many VOCs were detected in vadose zone gas samples (USE 1998). In Figures 1-16 through 1-23, the graphs indicate the highest value for the detected volatiles in the soil gas. There are no 'action or clean up' thresholds for soil gas.

The detection of metals at elevated concentrations and organic chemicals in the vadose zone beneath the trenches indicates a release and a continual threat of release of non-radioactive hazardous substances to the environment from the commercial LLRW Site (WDOE 2000a). A potential future risk from contaminants in the vadose zone gas exists (WDOE 2000a).

1.4.2 Resin Tank Area Data

Five steel tanks were buried in the ground at the LLRW Site in the 1960s. Three large tanks held up to 23,000 gallons of LLRW liquid, and two smaller tanks had a capacity of 1,000 gallons each; the location is shown in Figure 1-24. The tanks provided storage for liquid LLRW to be treated by solar evaporation. The LLRW was from laundering activities and ion exchange resins from the U.S. Navy nuclear power plants. During the 1985 snow runoff (shown in Figure 1-25), pooled water entered one of the tanks and filled it to the riser. Changing liquid levels in the tanks indicated liquid release from the tanks, estimated at 100-120 gallons.

In 1985-86, tank liquids were drained, stabilized, and disposed of in Trench 11-A. The remaining tank bottom liquids were sampled and characterized as an extremely hazardous waste. The two smaller tanks were removed and the larger three tanks left in place after filling with concrete. The tank area was covered with soil on August 12, 1988.

In May 1988, eight soil borings (#1-8), as shown in Figure 1-26 were installed adjacent to the underground tanks. Ninety-four samples were collected for analysis. One background sample was collected from a boring about 50 feet from the underground tanks; no compounds were detected above the background sample. Composite samples were analyzed from two of the boring locations (#4 and #5) and one background location. One organic compound, Di-n-octylphthalate, was detected in both composite samples at concentrations of 300 ug/kg and 750 ug/kg. Direct radiation level readings on each sample were collected along with a visual inspection for discoloration. Good agreement between radiation levels and extent of discoloration was observed. Five additional boreholes (A-E) yielded another 33 samples; however, these were not submitted for laboratory analyses, and no confirmed quality assurance (QA)/quality control (QC) was in place during any of the sample collection or analysis. A composite sample from borehole #4 was considered representative of Tanks 2 and 3. A composite sample from borehole #5 had the highest radioactivity readings. Figure 1-27 shows the angle boring approach and depths of individual samples collected for the composite sample. However, composite samples are not appropriate for cleanup verification, and are not defensible for regulatory purposes

1.4.3 Groundwater Wells

The water table is positioned in the upper part of the Middle Ringold Formation, making the saturated thickness of the unconfined aquifer between 90 to 100 feet. The bottom of the unconfined aquifer is assumed to be the low-permeable silty-sand of the Lower Ringold Formation.

In 1986, four down gradient wells MW3, MW5, MW8 and MW10, and one upgradient well, MW13, were constructed. Quarterly sampling and monitoring was conducted for specific conductivity, total organic carbon, TOX, pH, nitrates and volatile organics analysis (VOA) (DOE 1993, Appendix 4C). In 1996, two additional upgradient monitoring 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 of the unconfined aquifer. This data was intended to be used to validate the values of transmissivity used in scenario modeling in the closure plan (WDOH Letter dated 2/19/97, Maxine Dunkelman).

During the DQO meeting, the following four questions were identified and needed to be addressed by the WDOH:

- Has the groundwater flow direction changed under LLRW Site since the initial start-up operation?
- Has there been a well deviation survey to measure how far off the groundwater reading could be? What are the errors in interpretation of ground water level data?
- How were the well locations chosen? What is upgradient and downgradient at the LLRW Site?
- Are the groundwater monitoring well screen levels appropriate for present groundwater flow regime conditions?

In December 2002, John Riley and Dorothy Stoffel (WDOH) addressed the above questions. John discussed the location of previous Ground Penetrating Radar (GPR) test sites (Trenches 5E & W and the Chemical Trench). He presented graphs of the well water height above Mean Sea Level (MSL) for MW3, MW5, MW8, MW9, MW9A, MW10, and MW13 (USE 2001). Declining water levels, top of screen and well total depth were calculated for each well. John presented a table listing the well casing elevation, total depth, screen length, total depth elevation, screen top elevation, water elevation, depth of water in well, useful life (years) and rate of water level decline (feet/year) for all the groundwater monitoring wells. The calculations and table are presented in Appendix B.

Monitoring wells MW3, MW5, MW8, MW9, and MW13 had a projected useful life from 71-86 years. Wells MW9A and MW10 have a projected useful life of 32 and 49 years, respectively. The WDOE asked for clarification why MW9A, a groundwater monitoring well drilled in 1996, would only have a projected useful life of 32 years and MW 10, drilled in 1986, only has 17 years of useful life remaining. In addition, the scheduled site closure is planned for December 2056, the closure period will last two years (January 2057 through December 2058), the stabilization period will last five years (January 2059 through 2063), and the institutional control period will last one-hundred years (January 2064 through the end of 2163) (USE 2003). No new well construction or maintenance has been planned or budgeted after 2056.

Next, the WDOH uses an illustration to address whether screens are exposed. The illustrations show that MW13, MW8, MW5, and MW3 well screens are currently above the water table. However, water level may be impacted by changes in pump-and-treat operations in the Hanford 200 Areas. Two contour maps were presented which provided a comparison of groundwater gradients from MW13 (upgradient) to MW3 (downgradient) for the first quarter of 1993 and fourth quarter of 2001. The Oregon Office of Energy stated that water level data used to develop a water table map should be gathered in a fairly short time period. During the water level evaluation, it is important to note any differences in well screening depths, which may intersect different portions of the aquifer, and to note lithology changes.

1.4.4 Groundwater Data

In addition to the borings described above, two rounds of ground water samples were collected from six existing onsite wells and one well located outside the LLRW Site fence. The two sampling events occurred between September/October and December 1998.

Figure 1-28 shows the upgradient and downgradient well locations for the LLRW Site. The highest detected analytical results from the groundwater samples that are above the PQL for trichloroethylene, chloroform, chromium VI, and nitrate are plotted in Figures 1-29 through 1-32. The dark lines on the plots are the reported PQLs, and if a maximum contaminant level (MCL) is applicable, it is shown on the charts. For groundwater, trichloroethylene concentrations in one well exceeded the MTCA Method B and MCL limits in successive quarters, chloroform has exceeded MTCA Method B in two wells, and for hexavalent chromium results in six wells have exceeded the MTCA Method B level.

Figure 1-33 depicts the declining water level in comparison to MSL in all groundwater-monitoring wells on site. It is an accumulative analysis of groundwater levels from CY1993 to CY2000. Water levels may be impacted by changes in pump-and-treat operations on the Hanford 200 Areas. Figure 1-34 identifies additional groundwater monitoring wells near the LLRW Site. No data is available for the area south and southeast of the LLRW Site, because Hanford does not have any groundwater monitoring wells in that area. Groundwater from the west flows beneath the site and then flows to the southeast.

1.4.5 Additional documents

In addition to the data from the previous investigations, the WDOE reviewed a report titled "Document Review Regarding Hazardous Chemical Characteristics of Low-Level Waste," NUREG/CR-4433, March 1986. This document was an initial evaluation of LLRW in terms of RCRA constituents. The report was a result of a comprehensive literature research and survey of commercial radioactive shipment and disposal records. The report evaluates both fuel cycle sources and non-fuel cycle sources. The fuel cycle wastes include organic resins, cleaning solvents, waste oil, evaporator concentrates, spent solvents, and filter demineralizer sludge. The non-fuel cycle waste includes pharmaceutical and laboratory wastes. Appendix A includes copies of the chemical constituent lists for each waste group from the report.

Table 2.3 of the NUREG/CR-4433 report indicates that records of shipments to the LLRW Site from December 1982 included the following constituents:

☒ Chelates	☒ Methanol
☒ Chromates	☒ Oil
☒ Citrate	☒ Phenols
☒ Cyano Compounds	☒ Toluene
☒ Detergents	☒ Xylene

In addition the NUREG/CR-4433 report states:

Four of the chemical constituents listed in Table 2.3, chelates, detergents, citrates and oil, are not of themselves hazardous as defined in 40 CFR Part 261. These were included to obtain an estimate of the amount of wastes containing constituents that have the potential to enhance radionuclide migration. The cyano compounds listed are organic cyano compounds cyanocobalamine and cyanopindolol.

Other LLW may contain substances, which, while not necessarily hazardous under Part 261, can enhance radionuclide migration at waste disposal facilities (i.e., chelating agents).

1.5 CONCEPTUAL SITE MODEL

Two conceptual site models (CSMs) were prepared, one for various human scenarios (Figure 1-35) and one for various terrestrial and aquatic ecological receptors (Figure 1-36). These figures show interrelationships among sources, release mechanisms, transport and exposure media, exposure pathways, and receptors. Sources, release mechanisms, and transport media are similar for both human and ecological CSMs, in line with the recommendation that CSMs for human and ecological risks should be consistent (Suter et al, 2000). CSMs indicate three possibilities for the various sources to receptor pathway combinations shown. Some are considered complete and significant and will be addressed quantitatively in the risk assessment, others are considered complete, but less significant and will be addressed only qualitatively, while other pathways are considered incomplete and will not be evaluated. This latter case demonstrates that no exposure results in no risk.

Additional details of how risk assessment will be performed are found in Step 3 of this document.

1.6 CONSTITUENTS OF POTENTIAL CONCERN

At the LLRW Site, there are impacts to the environment from releases of organics from aging barrels and packaging. Transport of contaminants from the waste can occur in the gas, dense non-aqueous phase liquids (DNAPLs), and liquid phases. The greatest impact to the environment is from the chronic release of gases and DNAPLs from the bottom of the trenches, not acute releases of “large quantities” of liquids. DNAPL in the vadose zone exists as droplets

and coatings in unsaturated conditions. When DNAPLs and gases encounter low permeable strata, they spread laterally along the path of least resistance. This movement can be affected by hazardous substances in the LLRW that enhance migration through the vadose zone to groundwater.

The DQO Working Group examined the analytical results from previous investigations, specifically looking for detections above the minimum detection limit (MDL) and PQL to determine which constituents merit additional evaluation. During this RI/FS, the WDOE will require the analysis of all the constituents included in any test method. For example, for volatile organics, the SW-846 Method is 8260B. Rather than specify only one analyte such as acetone or toluene, the WDOE will specify the full list of compounds listed for the analytical methodology. Tables 1-3, 1-4, 1-5, 1-6, 1-7, 1-8, and 1-9 list the constituents of potential concern (COPCs) and any chemical detected during the Phase I and/or Phase II investigation which would be of interest for soil and groundwater. Table 1-10 lists the volatiles for analysis in the master list of soil gas by Method TO-14.

Table 1-3. Anions and Metals for Soil and Groundwater.
(2 sheets)

Constituent	CAS #	Method (SW-846 Except as Noted Otherwise)
Anions		
Chloride	7782-50-5	9056
Fluoride	16984-48-8	9056
Nitrate	14797-55-8	9056
Nitrite	14797-65-0	9056
o-Phosphate	14265-44-2	9056
Sulfate	14808-79-8	9056
Sulfide		9030B
Metals		
Aluminum	7429-90-5	6010B
Antimony	7440-36-0	6010B
Arsenic	7440-38-2	6010B
Barium	7440-39-3	6010B
Beryllium	7440-41-7	6010B
Boron	7440-42-8	6010B
Cadmium	7440-43-9	6010B
Calcium	7440-70-2	6010B
Chromium	7440-47-3	6010B
Cobalt	7440-48-4	6010B
Copper	7440-50-8	6010B
Iron	7439-89-6	6010B
Lead	7439-92-1	6010B
Magnesium	7439-95-4	6010B
Manganese	7439-96-5	6010B
Molybdenum	7439-98-7	6010B
Nickel	7440-02-0	6010B
Potassium	7440-09-7	6010B

**Table 1-3. Anions and Metals for Soil and Groundwater.
(2 sheets)**

Constituent	CAS #	Method (SW-846 Except as Noted Otherwise)
Selenium	7782-49-2	6010B
Silicon	7440-21-3	6010B
Silver	7440-22-4	6010B
Sodium	7440-23-5	6010B
Strontium	7440-24-6	6010B
Thallium	7440-28-0	6010B
Tin	7440-31-5a	6010B
Titanium	7440-32-6	6010B
Vanadium	7440-62-2	6010B
Zinc	7440-66-6	6010B
Uranium	7440-61-1	ASTM D5174 or 6010B
Chromium VI	18540-29-9	7195 or 7196A or 7197 or 7198
Mercury	7439-97-6	7470A/7471A

**Table 1-4. Volatile Organic Analysis Compounds by
Method 8260B. (2 sheets)**

Acetone	1,4-Difluorobenzene
Acrylonitrile ³	Ethylbenzene
Allyl Chloride ³	Ethyl Ether
Benzene	Ethylmethacrylate ³
Bromobenzene	Freon 11
Bromochloromethane	Freon 12
Bromodichloromethane	Freon 113
Bromoform	Hexachlorobutadiene
Bromomethane	Hexachloroethane
2-Butanone	2-Hexanone
n-Butylbenzene	Isopropylbenzene
sec-Butylbenzene	p-Isopropyltoluene
tert-Butylbenzene	Methacrylonitrile ³
Carbon Disulfide	Methyl Acrylate ³
Carbon tetrachloride	Methyl Iodide
Chlorobenzene	Methyl Methacrylate ³
1-Chlorobutane ³	4-Methyl-2-Pentanone
Chloroethane	Methylene Chloride
Chloroform	2-Methoxy-2-Methylpropane
Chloromethane	Naphthalene ²
2-Chlorotoluene	2-Nitropropane ³
4-Chlorotoluene	Pentachloroethane
1,2-Dibromo-3-Chloropropane	n-Propylbenzene
Dibromochloromethane	Styrene
1,2-Dibromoethane (EDB)	1,1,1,2-Tetrachloroethane
Dibromomethane	1,1,2,2-Tetrachloroethane
1,2-Dichlorobenzene ²	Tetrachloroethene ¹

Table 1-4. Volatile Organic Analysis Compounds by Method 8260B. (2 sheets)

1,3-Dichlorobenzene ²	Tetrahydrofuran
1,4-Dichlorobenzene ²	Toluene
<i>trans</i> -1,4-Dichloro-2-butene	1,2,3-Trichlorobenzene
Dichlorodifluoromethane	1,2,4-Trichlorobenzene
1,1-Dichloroethane	1,1,1-Trichloroethane Xylene, o-
1,2-Dichloroethane	1,1,2-Trichloroethane
1,1-Dichloroethene	1,1,2-Trichloroethene
<i>cis</i> -1,2-Dichloroethene	Trichloroethane
<i>trans</i> -1,2-Dichloroethene	Trichlorotrifluoroethane
1,2-Dichloropropane	1,1,2-Trichlorotrifluoroethane
2,2-Dichloropropane	1,2,3-Trichloropropane
1,3-Dichloropropane	1,2,4-Trimethylbenzene
1,1-Dichloropropanone ³	1,3,5-Trimethylbenzene
1,1-Dichloropropene	Vinyl Chloride
<i>cis</i> -1,3-Dichloropropene	Xylene, m & p-Surrogate
<i>trans</i> -1,3-Dichloropropene	Xylene, total

1. Compounds with the suffix -ethene are sometimes written with the suffix -ethylene (e.g., trichloroethene is also written trichloroethylene).
2. Compounds found on the semi-volatiles list of target compounds may be reported as semi-volatiles if both tests are performed on the sample.
3. These compounds are typically poor performers and will not be reported unless specifically requested in advance.

Table 1-5. Semi-Volatiles-Base/Neutrals/Acids by Method 8270C. (3 Sheets)

Compounds
Acenaphthene
Acenaphthylene
Aniline
Anthracene
Benzidine
Benzo (a) anthracene
Benzo (a) pyrene
Benzo (b) fluoranthene
Benzo (k) fluoranthene
Benzo (g,h,i) perylene
Benzoic Acid
Benzyl Alcohol
Butylbenzylphthalate
4-Bromophenyl-Phenylether
Di-N-Butylphthalate
Carbazole
4-Chloro-3-Methylphenol
4-Chloroaniline
Bis(2-Chloroethoxy) Methane
Bis(2-Chloroethyl) Ether

**Table 1-5. Semi-Volatiles-Base/Neutrals/Acids by
Method 8270C. (3 Sheets)**

Bis(2-Chloroisopropyl) Ether
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl-Phenylether
Chrysene
Dibenzo (a,h) anthracene
Dibenzofuran
3,3'-Dichlorobenzidine
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2,4-Dichlorophenol
2,4-Dimethylphenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
1,2-Diphenylhydrazine
Fluoranthene
Fluorene
2-Fluorophenol
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno (1,2,3-cd) pyrene
Isophorone
4,6-Dinitro-2-Methylphenol
1-Methylnaphthalene
2-Methylnaphthalene
2-Methylphenol
4-Methylphenol
Naphthalene
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
Nitrobenzene
2-Nitrophenol
4-Nitrophenol
N-Nitroso-Di-N-Propylamine
N-Nitrosodiphenylamine
2,2'-Oxybis[1-chloropropane]
Pentachlorophenol
Bis (2-Ethylhexyl) Phthalate
Diethylphthalate
Dimethylphthalate
Di-N-Octyl Phthalate

Table 1-5. Semi-Volatiles-Base/Neutrals/Acids by Method 8270C. (3 Sheets)

Phenanthrene
Phenol
Pyridine
Pyrene
1,2,4-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

Table 1-6. Polynuclear Aromatic Hydrocarbon by Method 8270C.

Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene
1,1-Biphenyl
2-Chloronaphthalene
2,6-Dimethylnaphthalene
Acenaphthylene
Acenaphthene
Dibenzofuran
1,6,7-Trimethylnaphthalene
Fluorene
9H-Fluorene, 1-methyl-
Dibenzothiophene
Phenanthrene
Anthracene
Carbazole
2-Methylphenanthrene
1-Methylphenanthrene
4,6-Dimethyldibenzothiophene
Phenanthrene, 3,6-dimethyl-
Fluoranthene
Pyrene
2-Methylfluoranthene
Retene
Benzo(a)anthracene
Chrysene
Chrysene, 5-methyl-
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo[e]pyrene
Benzo(a)pyrene
Perylene
Indeno(1,2,3-cd)pyrene
Dibenzo(a,h)anthracene
Benzo(ghi)perylene

**Table 1-7. Polychlorinated Biphenyls (Aroclors)
by Method 8082**

Aroclor 1016	Aroclor 1248
Aroclor 1221	Aroclor 1254
Aroclor 1232	Aroclor 1260
Aroclor 1242	

Table 1-8. Phenols by Method 9065.

Total Phenols

Table 1-9. Cyanide by Method 9010A.

Cyanide

**Table 1-10. Soil Gas Volatiles
by Method TO-14. (2 sheets)**

Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)
Trichloroethene (TCE)
1,1,1-Trichloroethane
Choroform
Tetrachloroethene (PCE)
Freon 11 (Trichlorofluoromethane)
1,1-Dichloroethane
1,1-Dichloroethene
Methylene Chloride
1,2,-Dichloroethane
Chloroethane
Benzene
Cis-1,2-Dichloroethene
1,2-Dichloropropane
Toluene
Styrene
Ethylbenzene
Chlorobenzene
Freon 12 (Dichlorodifluoromethane)
Chloromethane
Freon 114 (1,2-Dichlorotetrafluoroethane)
Vinyl chloride
Bromomethane
cis-1,2-Dichloroethene
Carbon tetrachloride
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
1,1,2-Trichloroethane
Ethylene dibromide
m-Xylene

**Table 1-10. Soil Gas Volatiles
by Method TO-14. (2 sheets)**

p-Xylene
o-Xylene
Tetrachloroethane
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
m-Dichlorobenzene
p-Dichlorobenzene
o-Dichlorobenzene
1,2,4-Trichlorobenzene
Hexachloro-1,3-butadiene
Benzyl chloride
Acetaldehyde
Acetone
Trimethylene oxide
Isopropyl alcohol
Butanol
2-Butanone
2-Pentanone
3-Methylbutanal
2-Hexanone
2-Heptanone
6-Methyl-2-heptanone
Benzaldehyde
Octanone
Decane
Octanal
3-Methylbenzaldehyde

1.7 PROBLEM STATEMENT

Additional data are needed to enhance the current understanding of the nature and extent of non-radiological hazardous substance contamination at the site. Collection of these data shall comply with MTCA requirements. The DQO will result in a Scope of Work for the Agreed Order and a Sampling and Analysis Plan (SAP) for the MTCA RI/FS.

While radiological contamination at the site is not the primary focus of this MTCA RI/FS, the WDOH intends to gather radiological data at sampling locations established by the DQO process, to supplement the WDOH's understanding of the LLRW Site. The WDOH will evaluate the locations for inclusion into its existing environmental monitoring program for periodic sampling.

Figure 1-9. Slant Borings

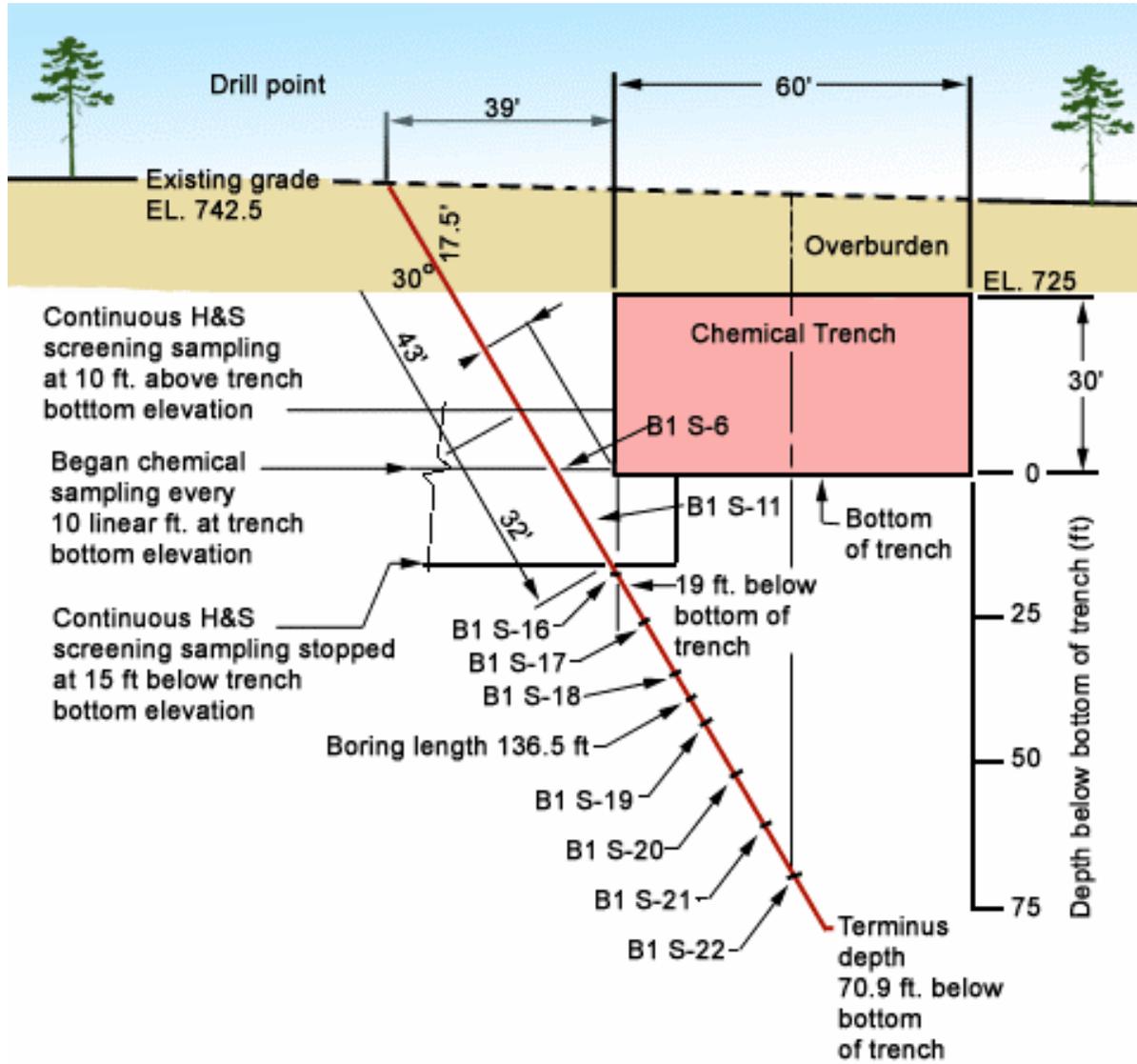


Figure 1-10. Two Borings at LLRW Location

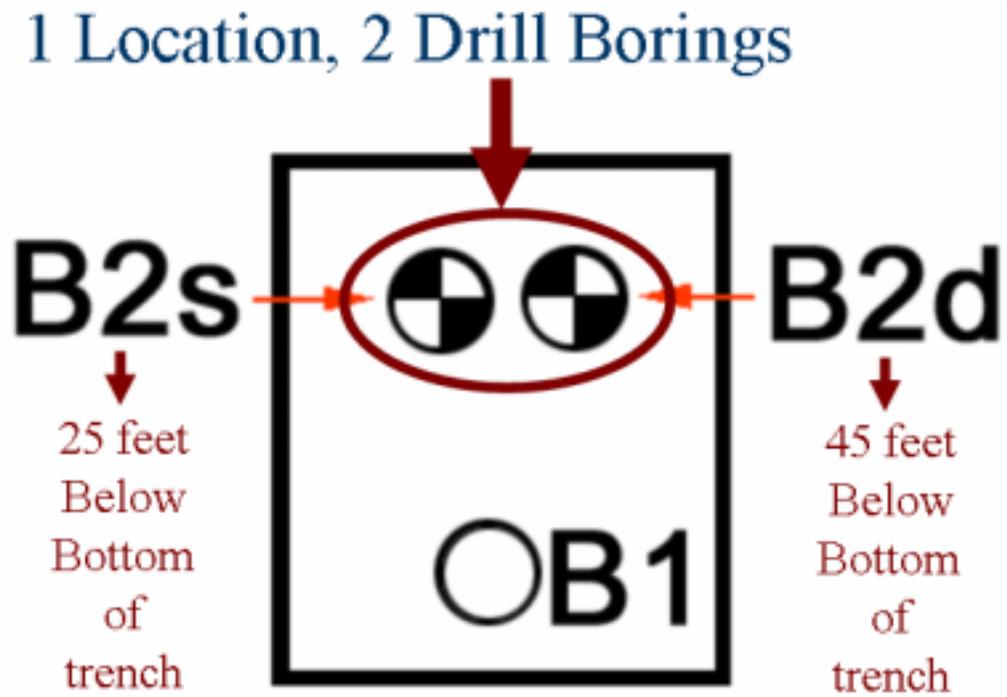


Figure 1-11. Two Borings B

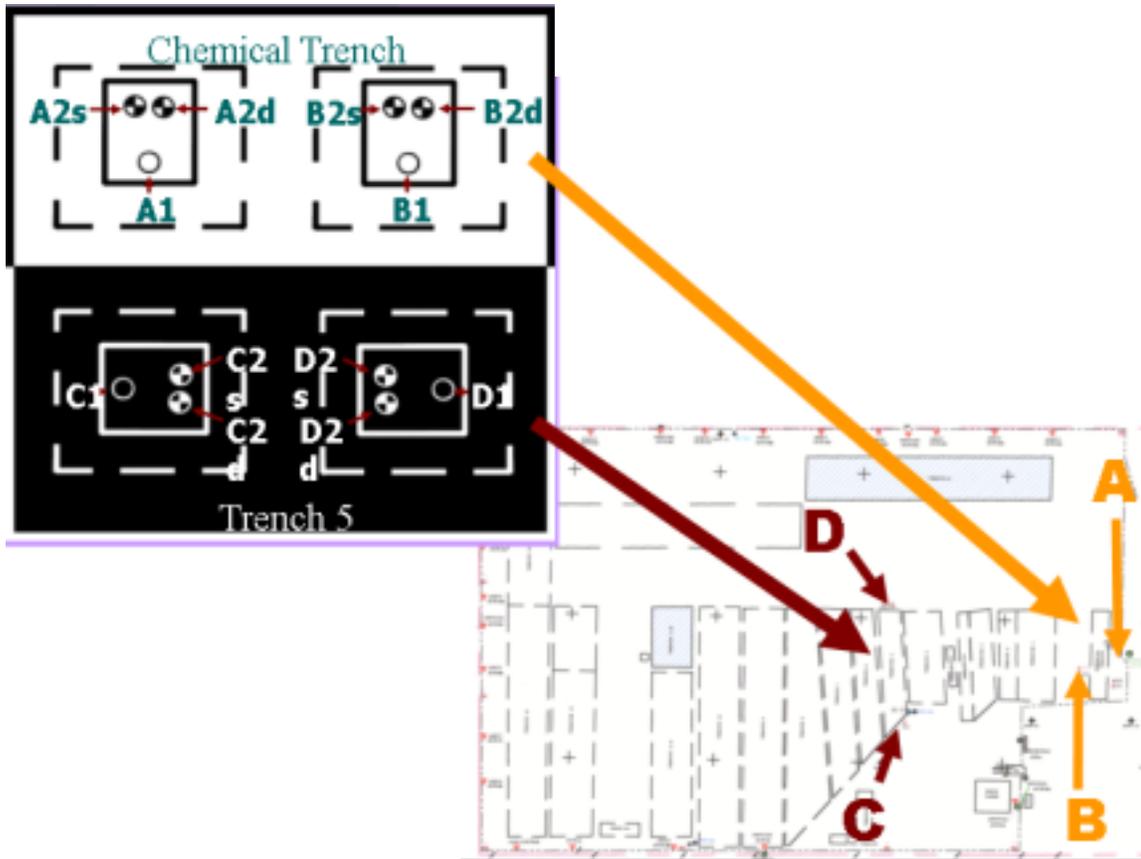


Figure 1-12. Surface View of Boring Casings



Figure 1-13. Acetone

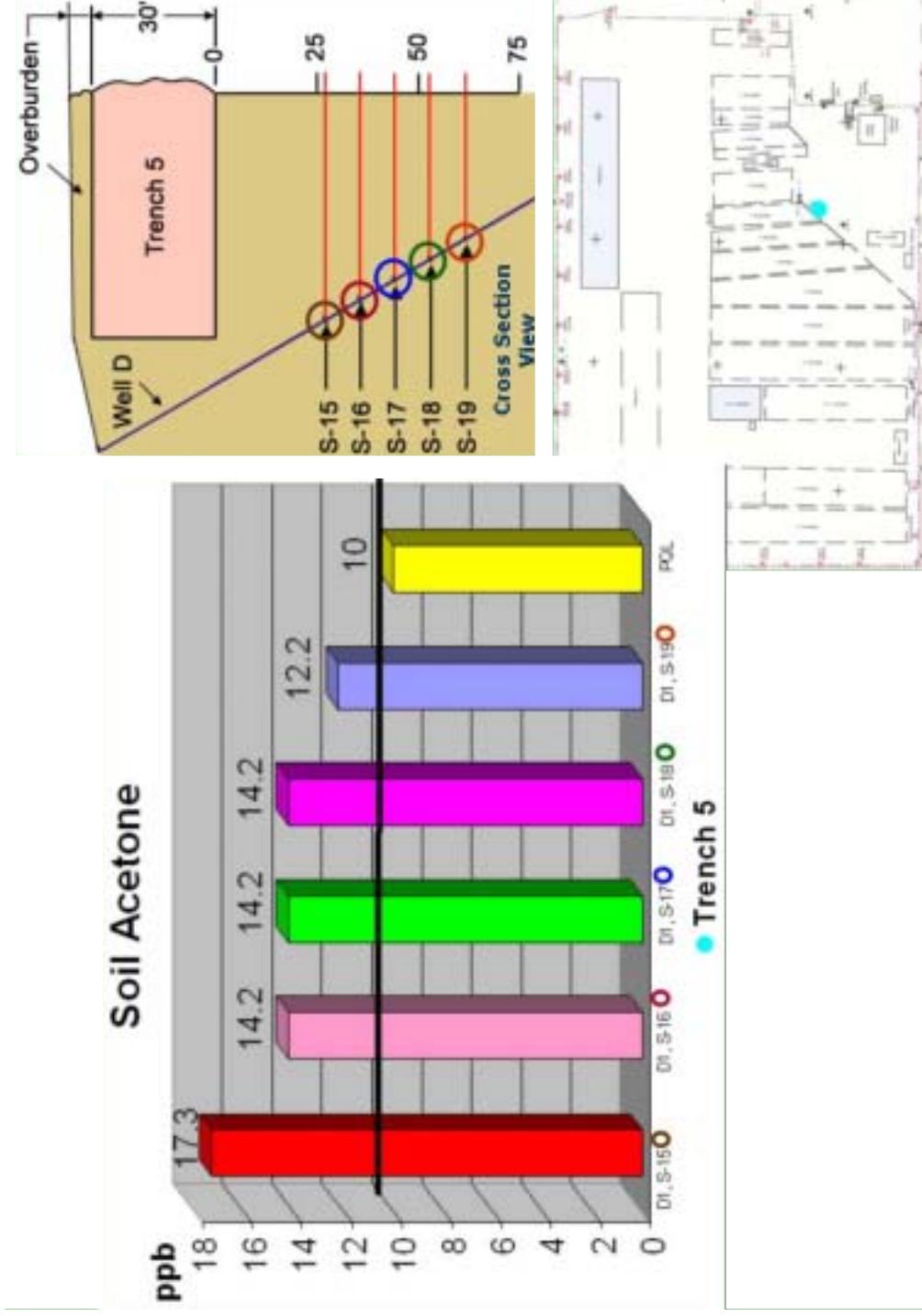


Figure 1-14. Trimethylbenzene

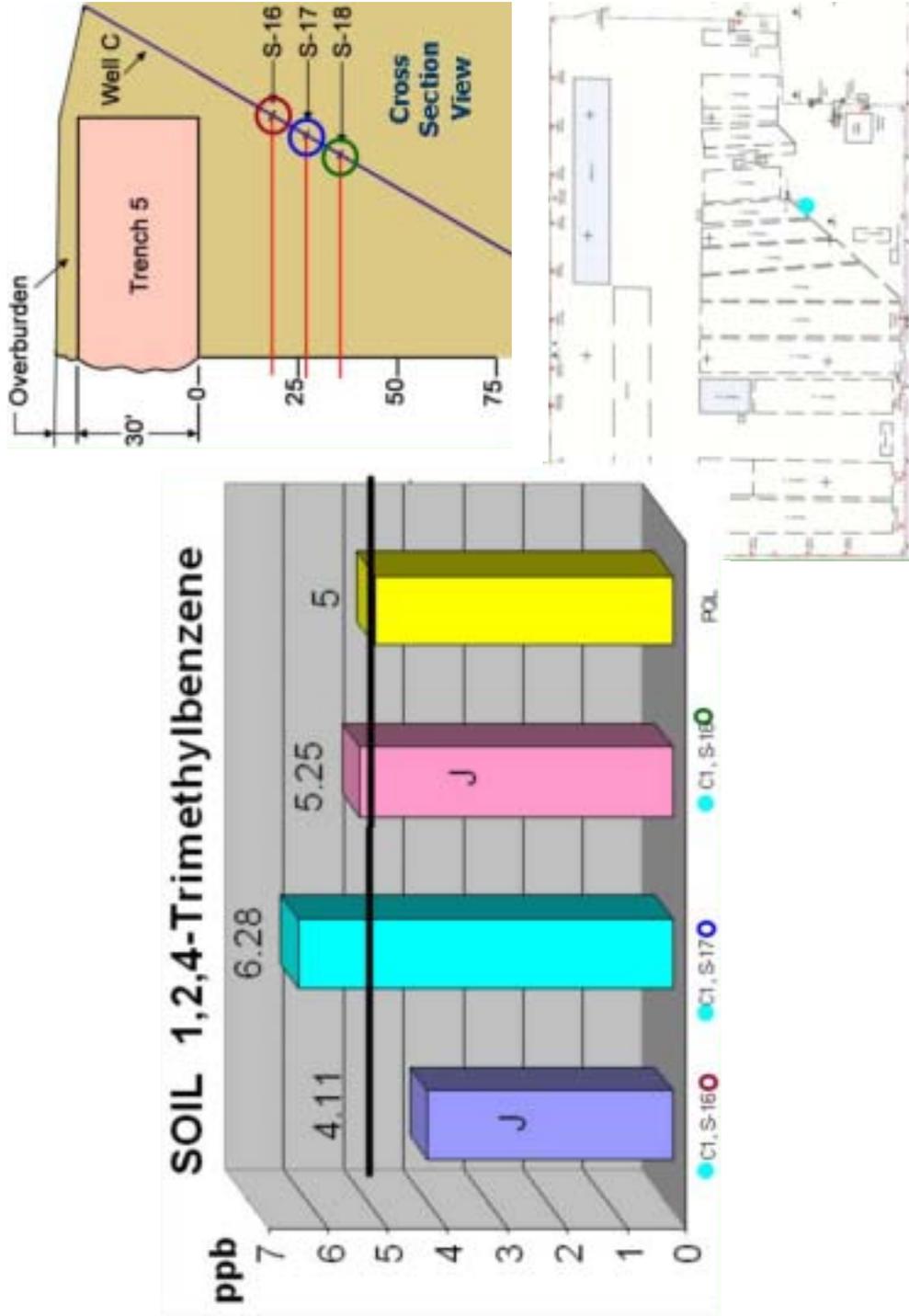


Figure 1-15. Xylenes, Total



Figure 1-16. Soil Gas - Freon 113

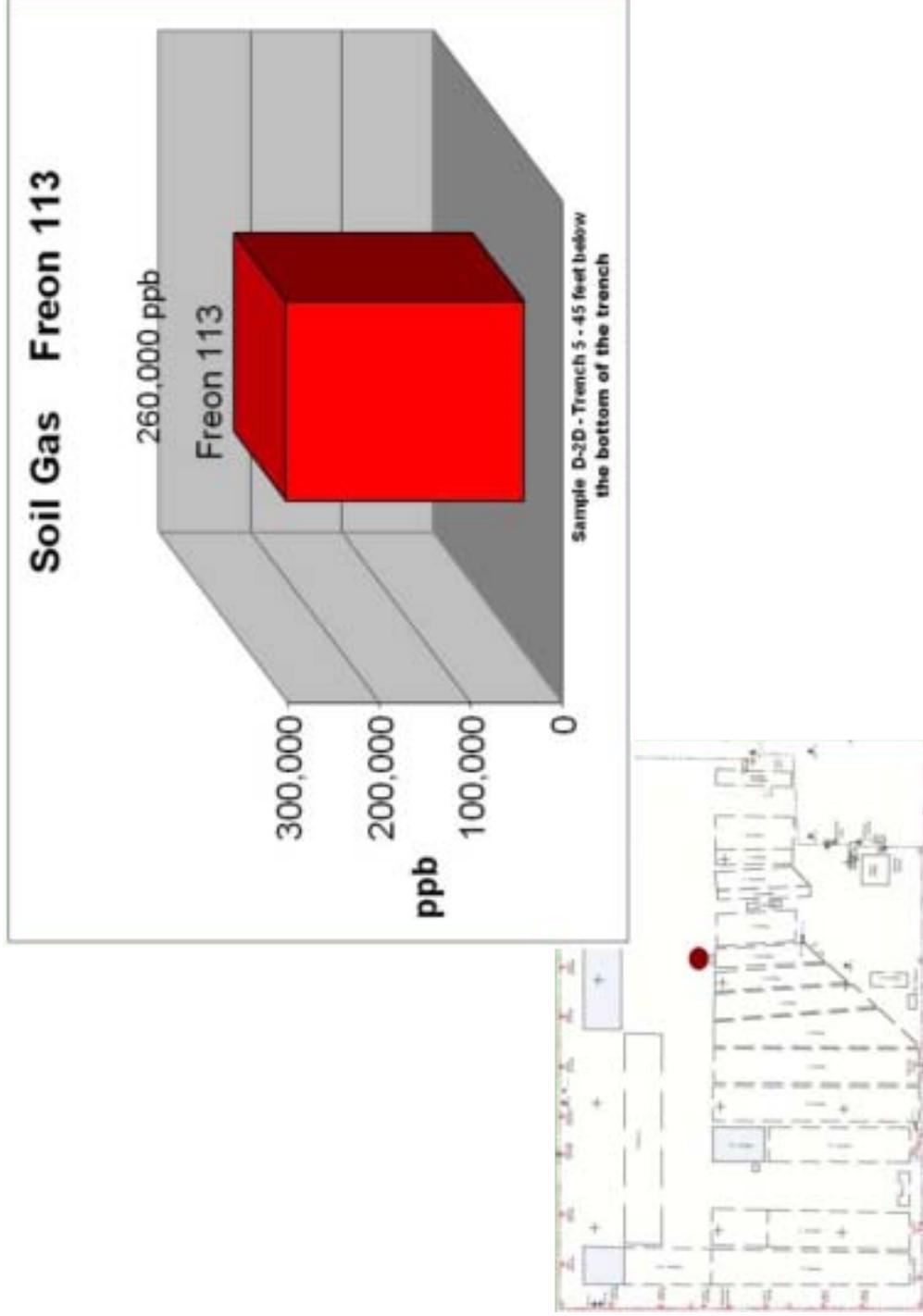


Figure 1-17. Soil Gas

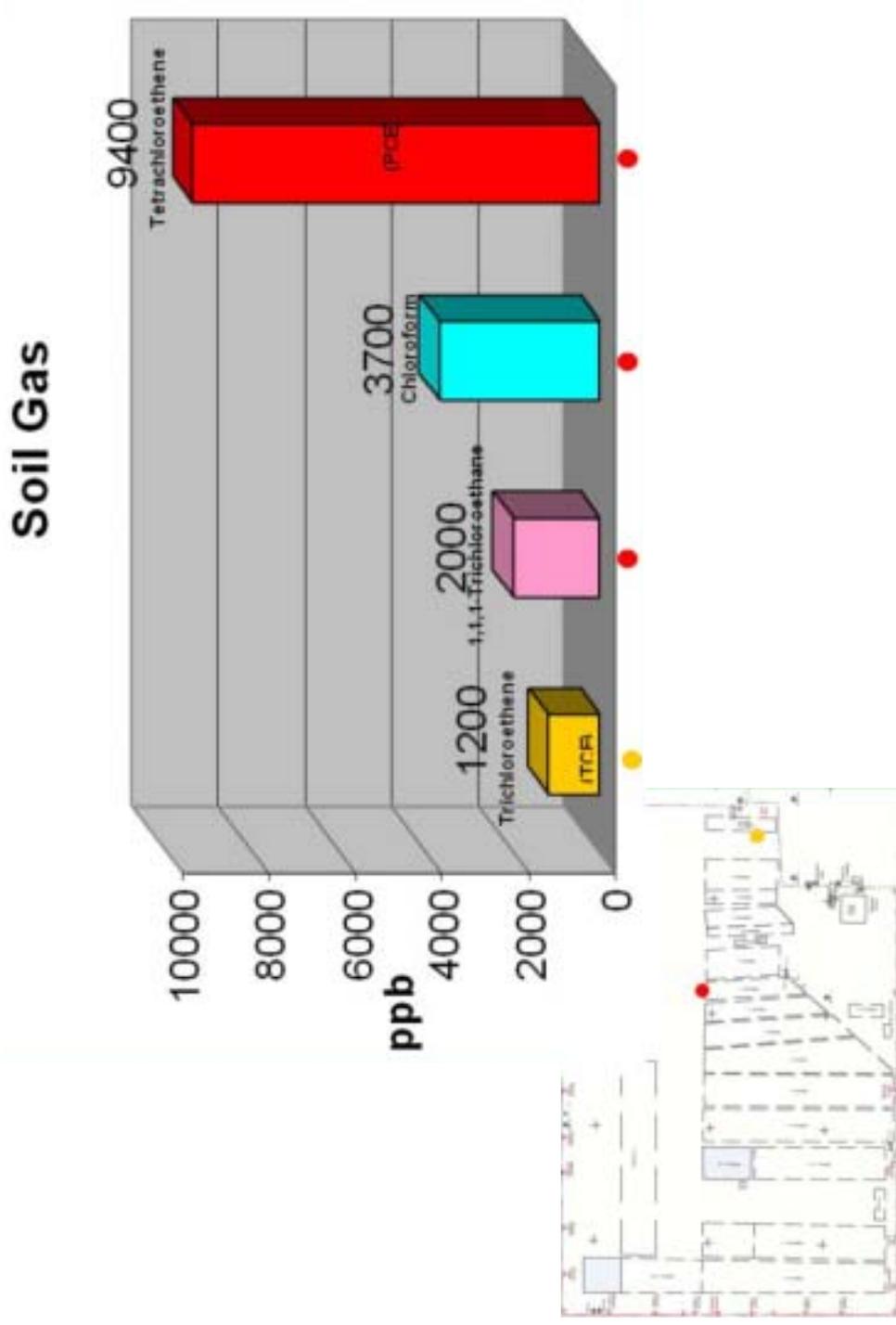


Figure 1-18. Soil Gas

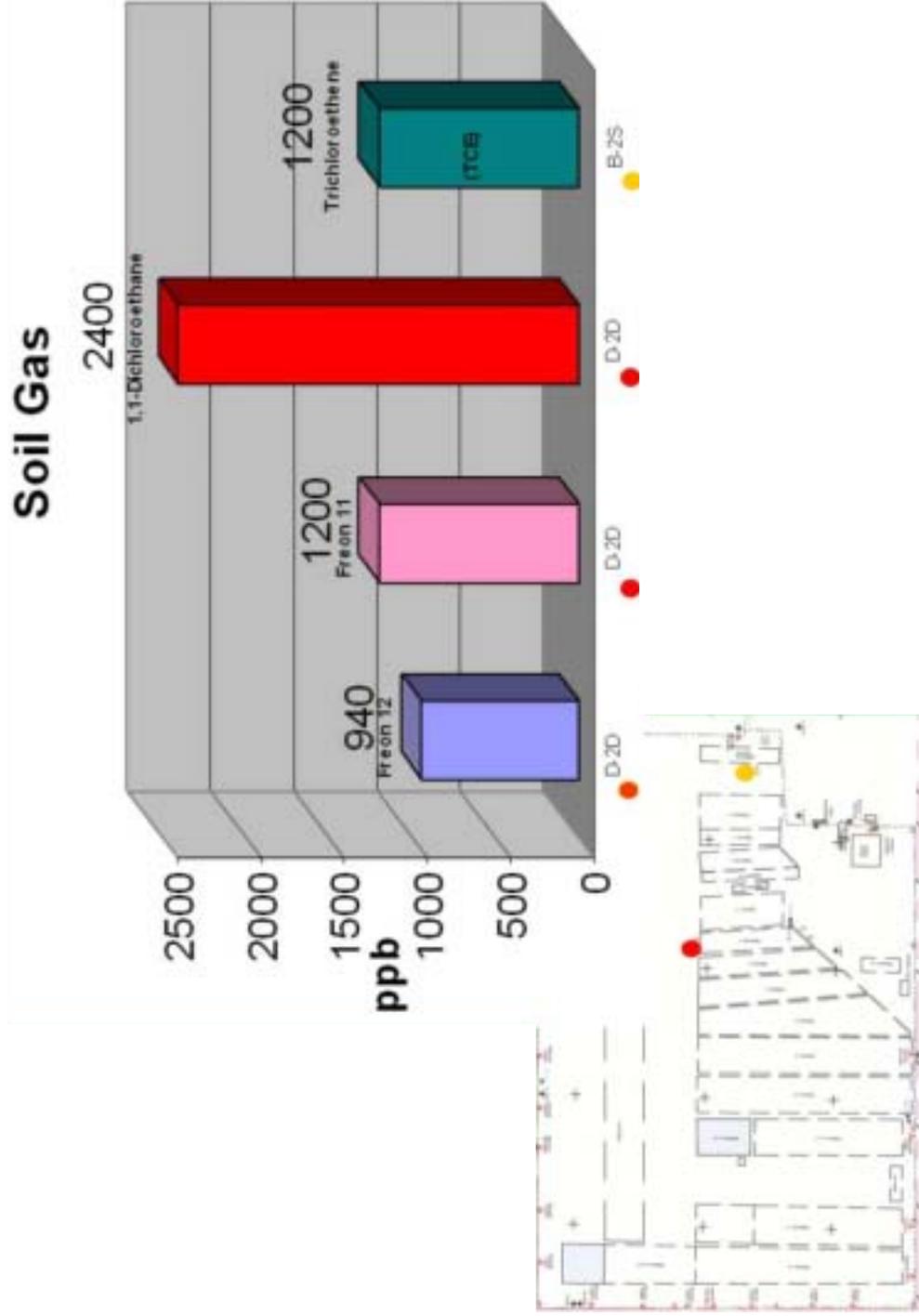


Figure 1-19. Soil Gas

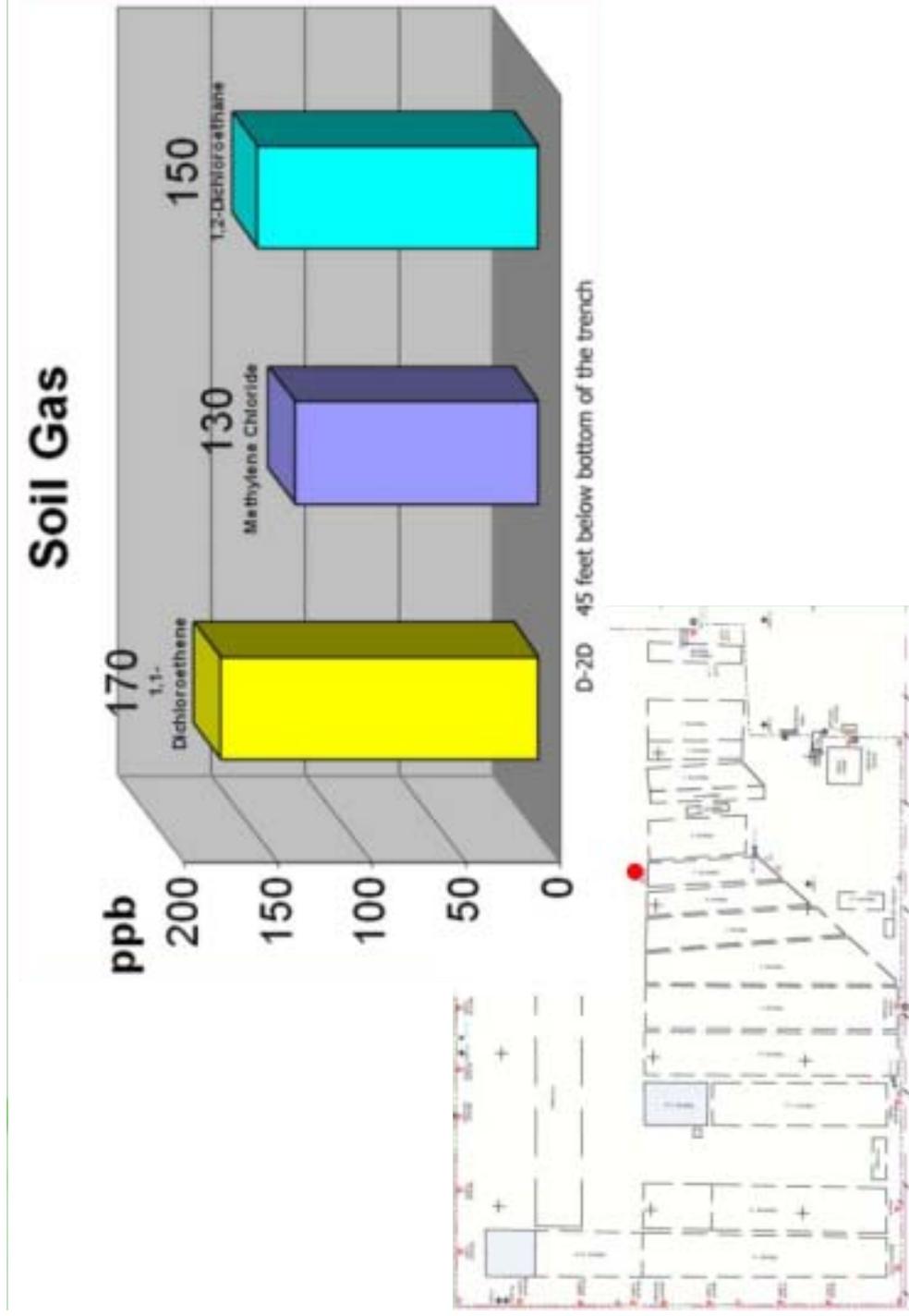


Figure 1-20. Soil Gas

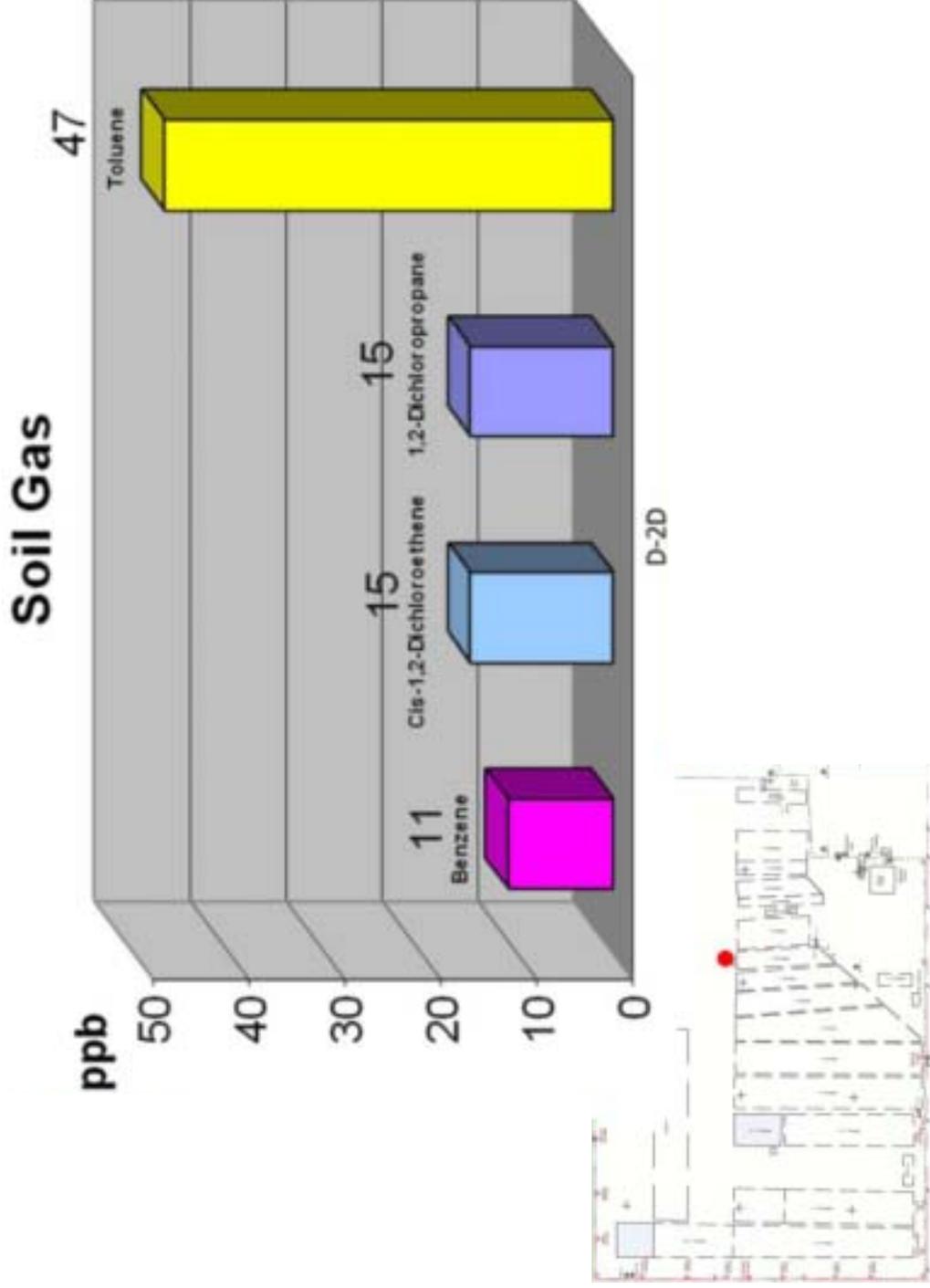


Figure 1-21. Soil Gas

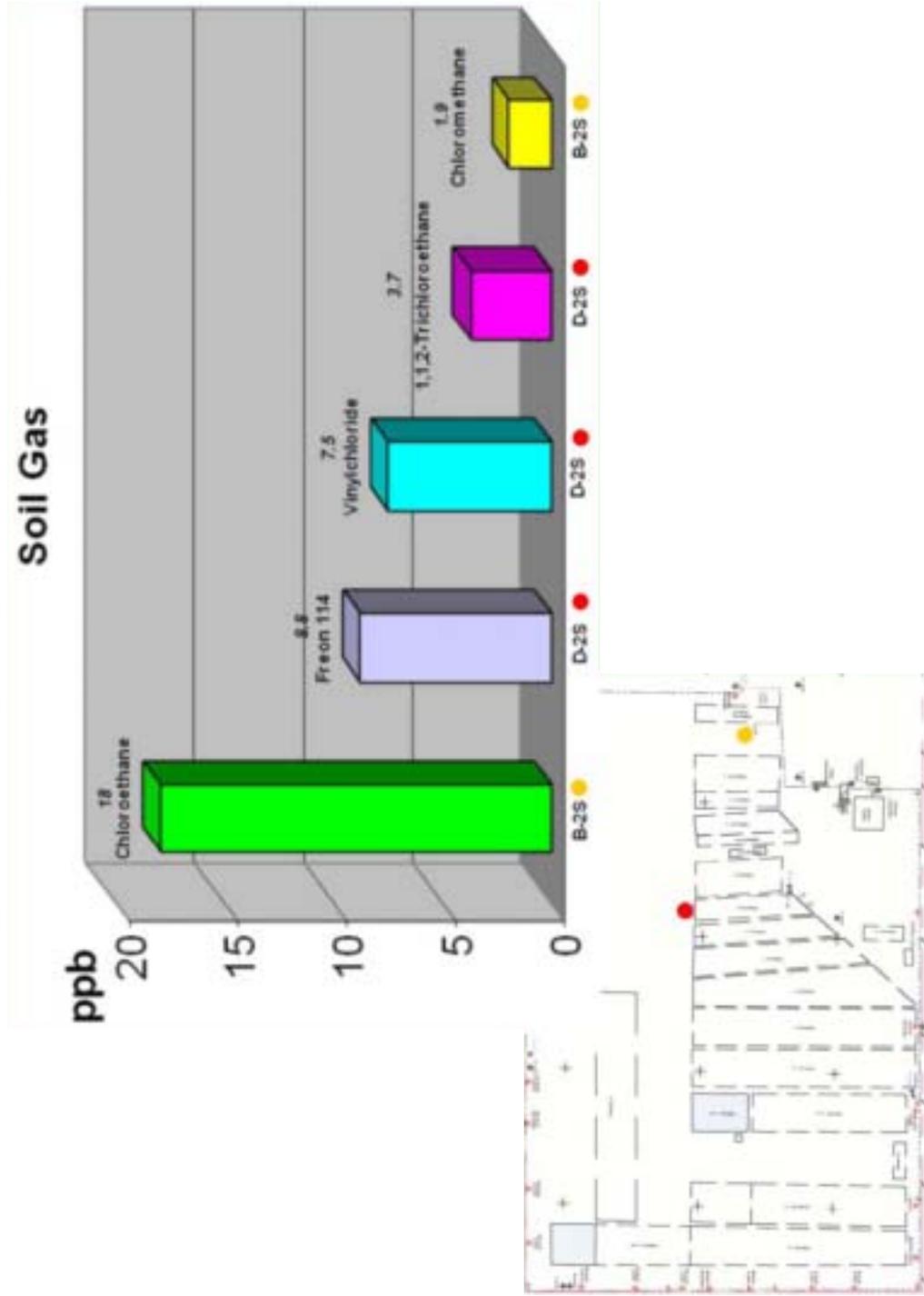


Figure 1-22. Soil Gas

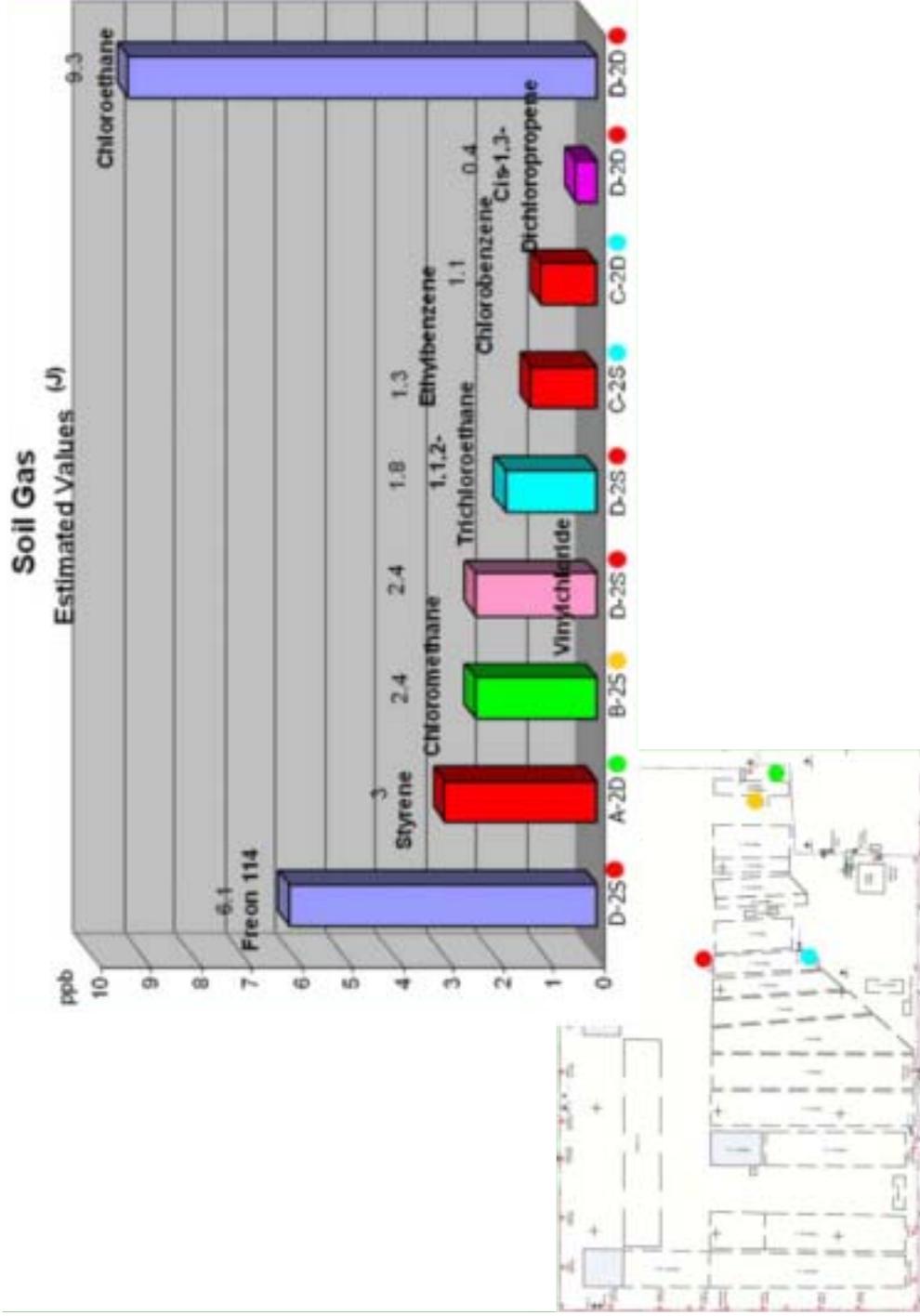


Figure 1-23. Soil Gas

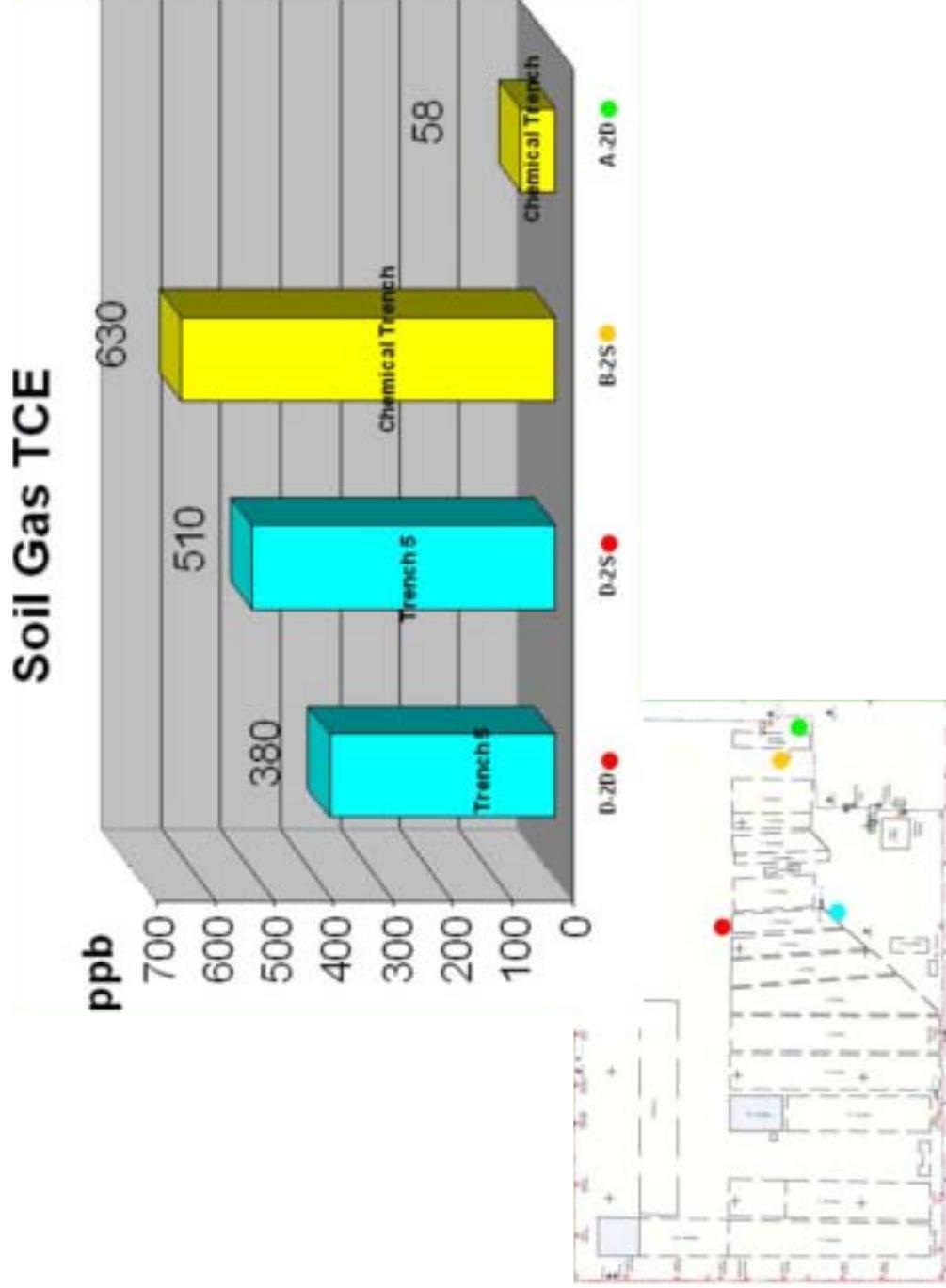


Figure 1-24. Location of Resin tanks with respect to Trench

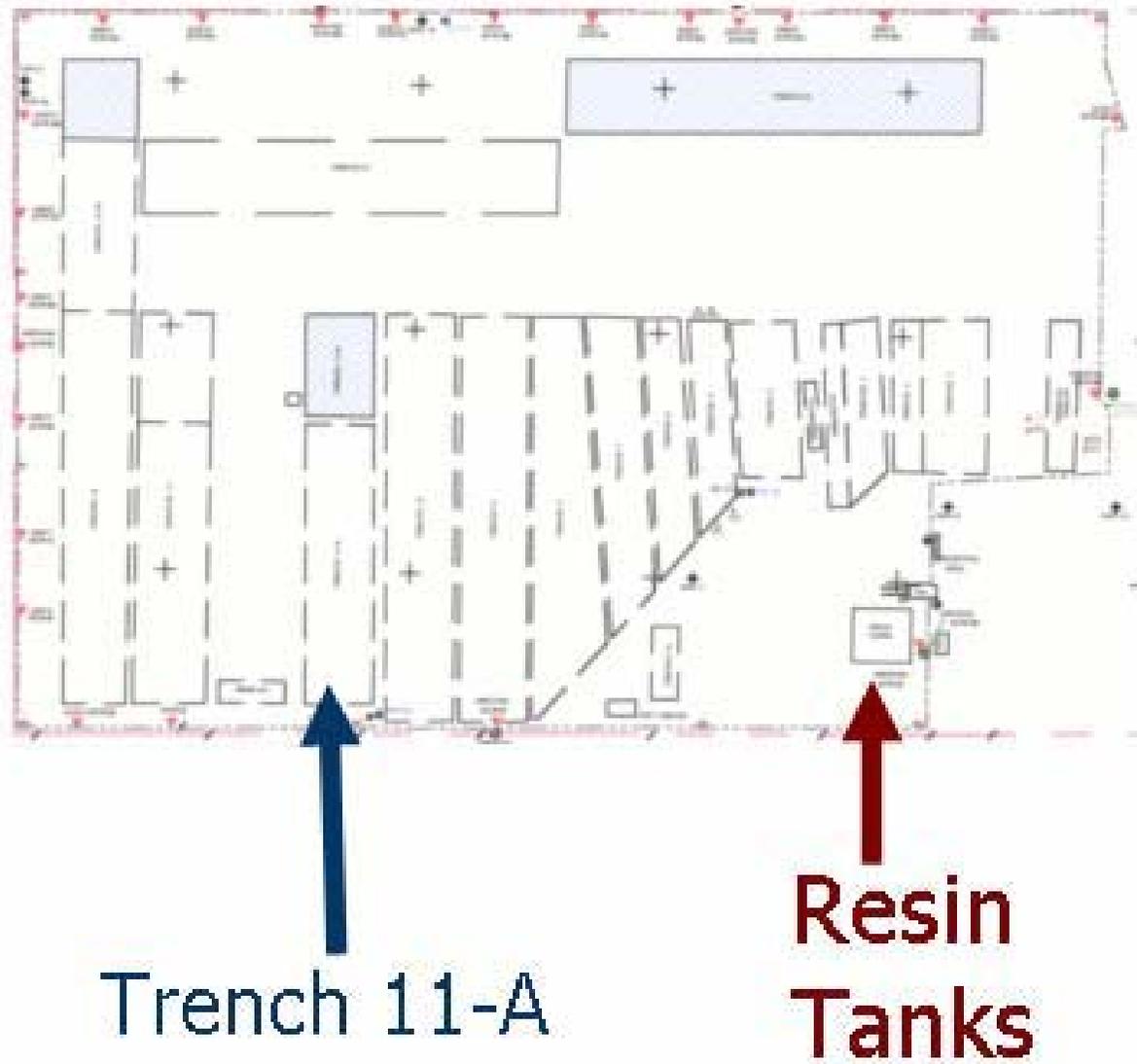


Figure 1-25. Flood waters over Resin tanks



Figure 1-26. Borehole Locations Around Underground Tanks

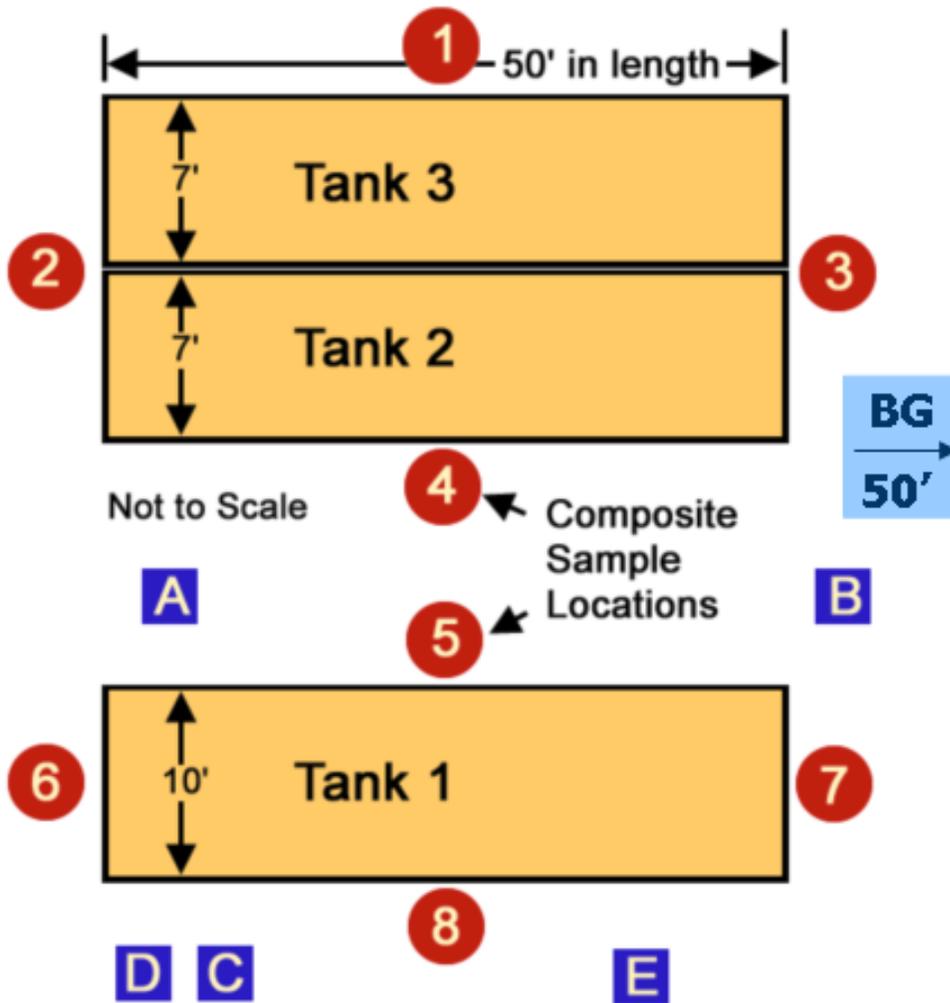
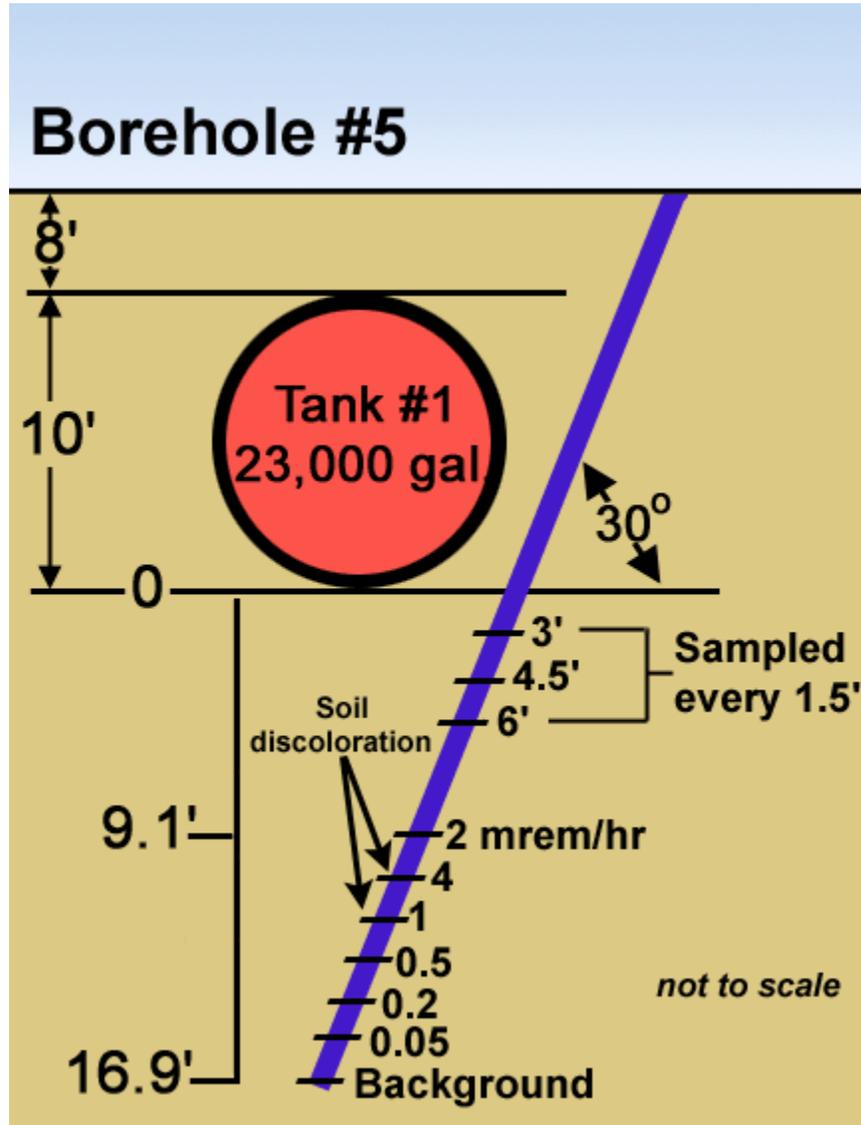


Figure 1-27. Angle Boring Approach and Depths of Sample Collection



*Background = measurement result equal to background

Figure 1-29. Highest Detected Groundwater Results for Trichloroethylene

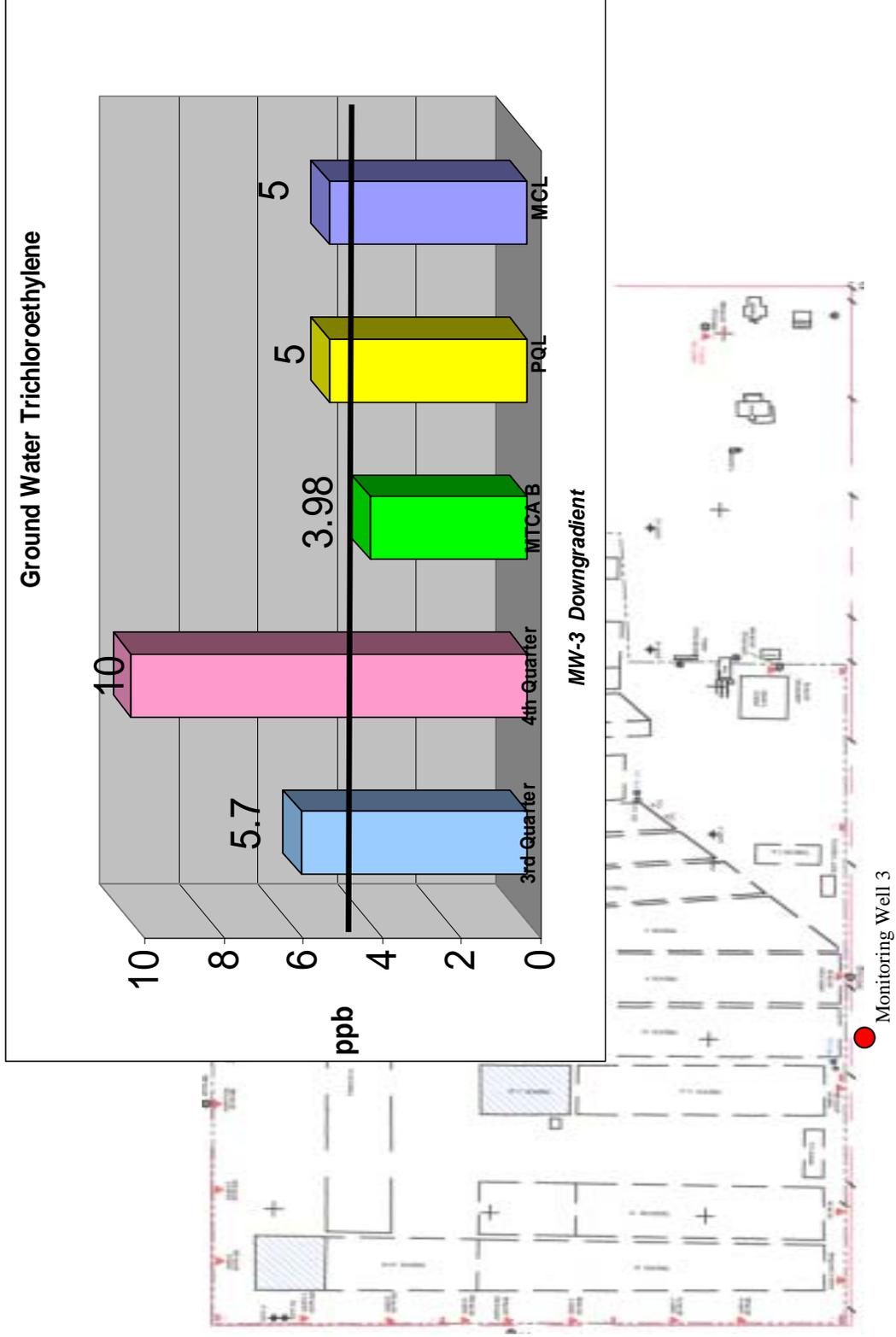


Figure 1-30. Highest Detected Groundwater Results for Chloroform

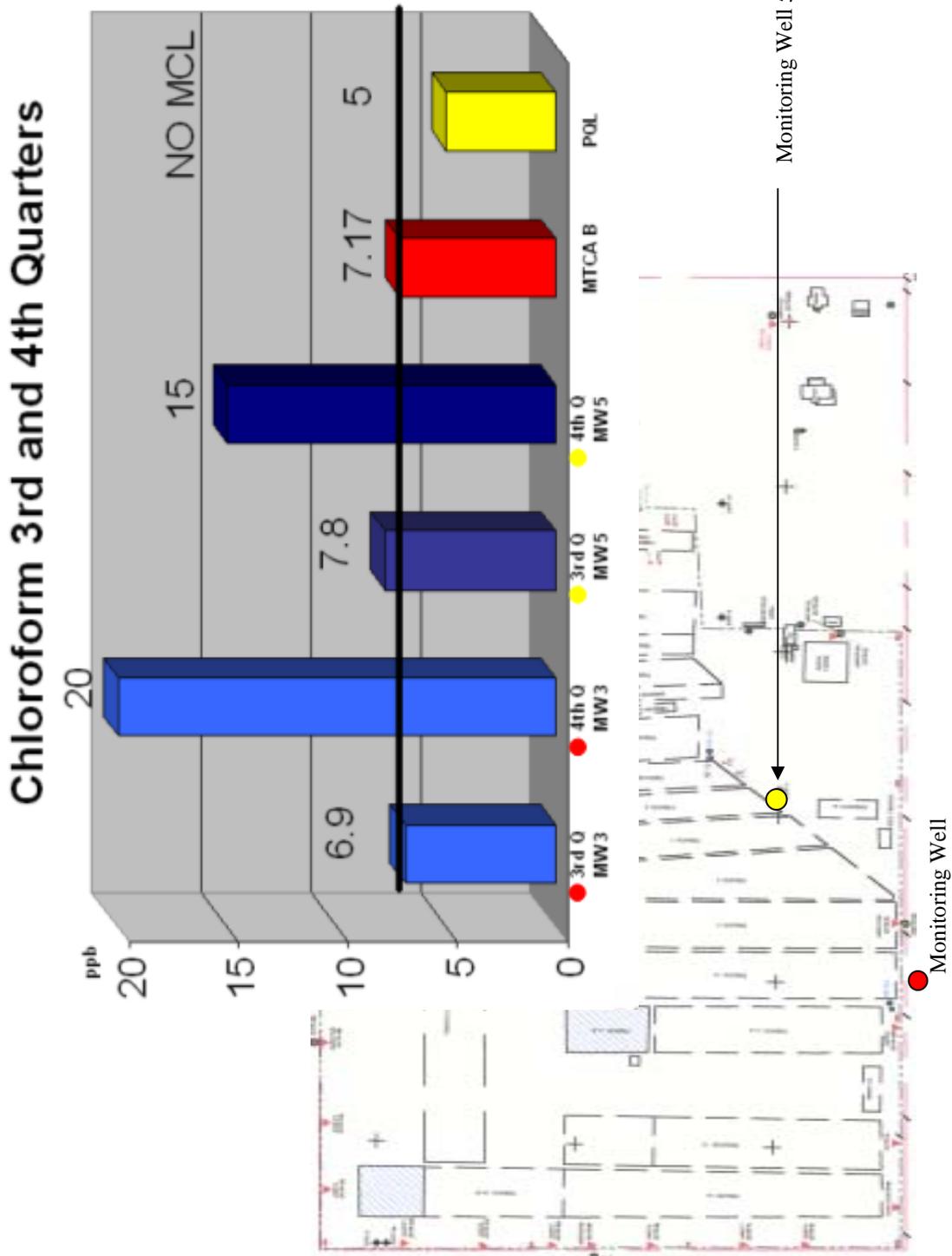


Figure 1-31. Highest Detected Groundwater Results for Nitrate

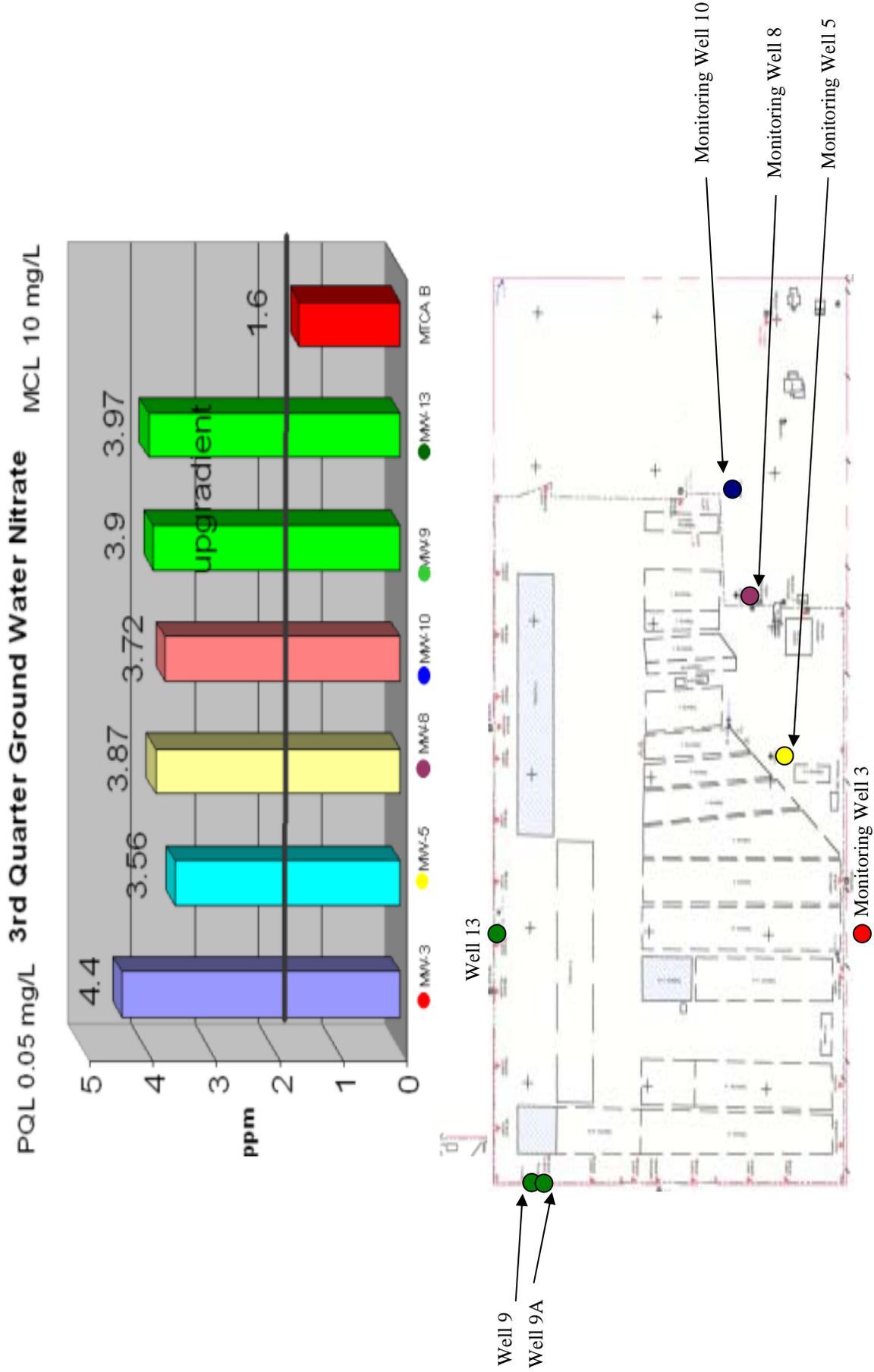


Figure 1-32. Highest Detected Groundwater Results for Chromium VI

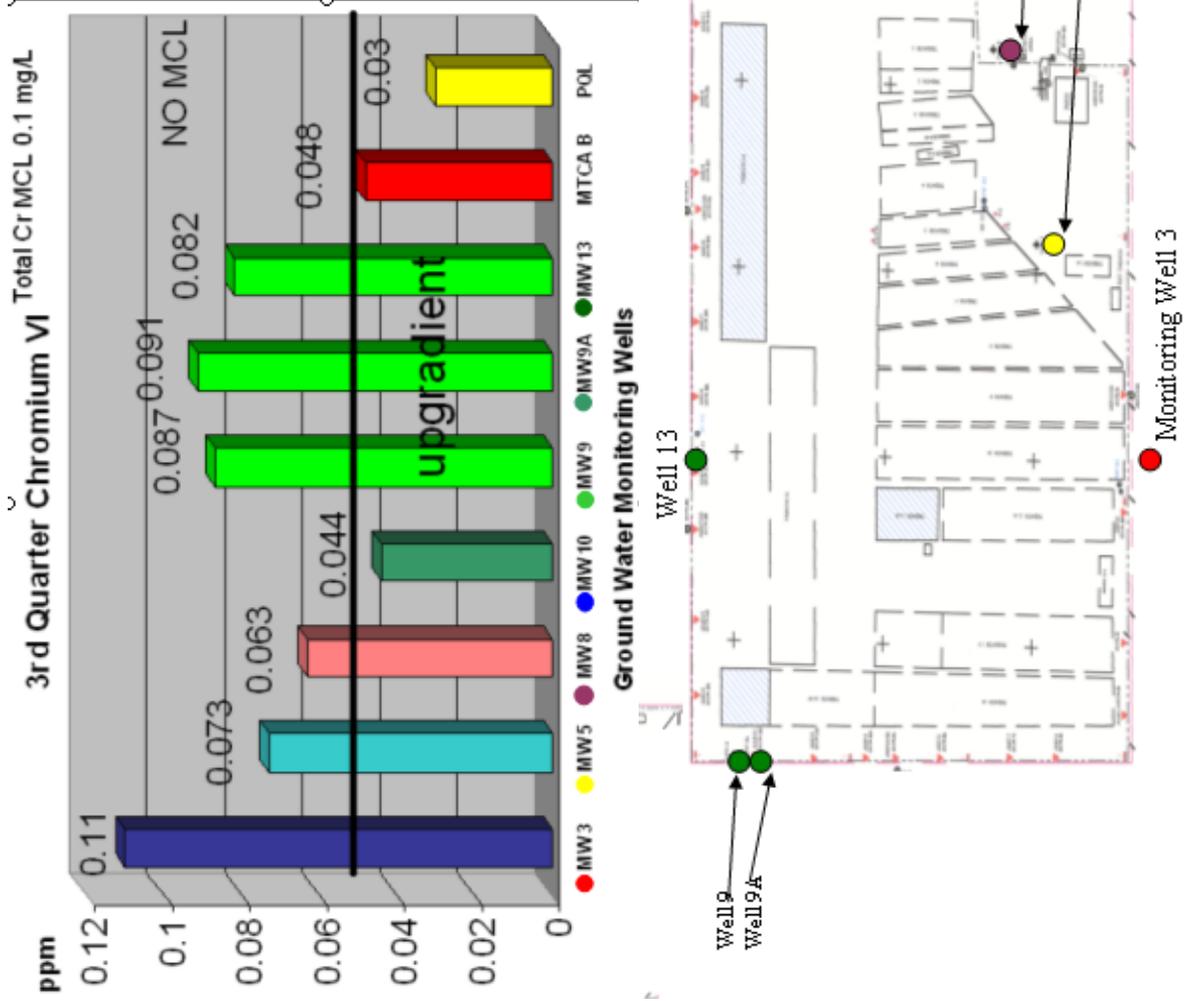


Figure 1-33. Water Level in All Wells Over Time

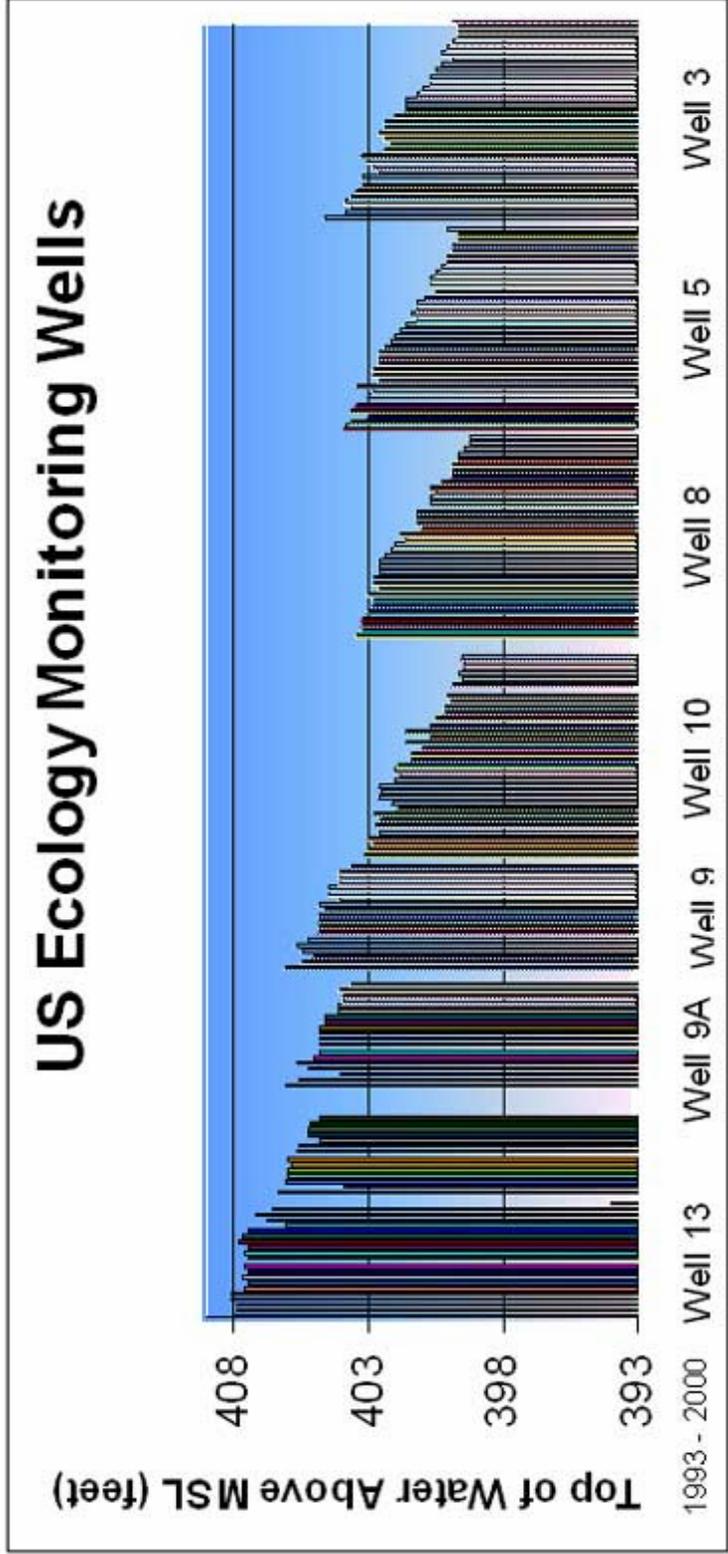


Figure 1-34. Groundwater Wells on the Hanford Site Near LLRW Site

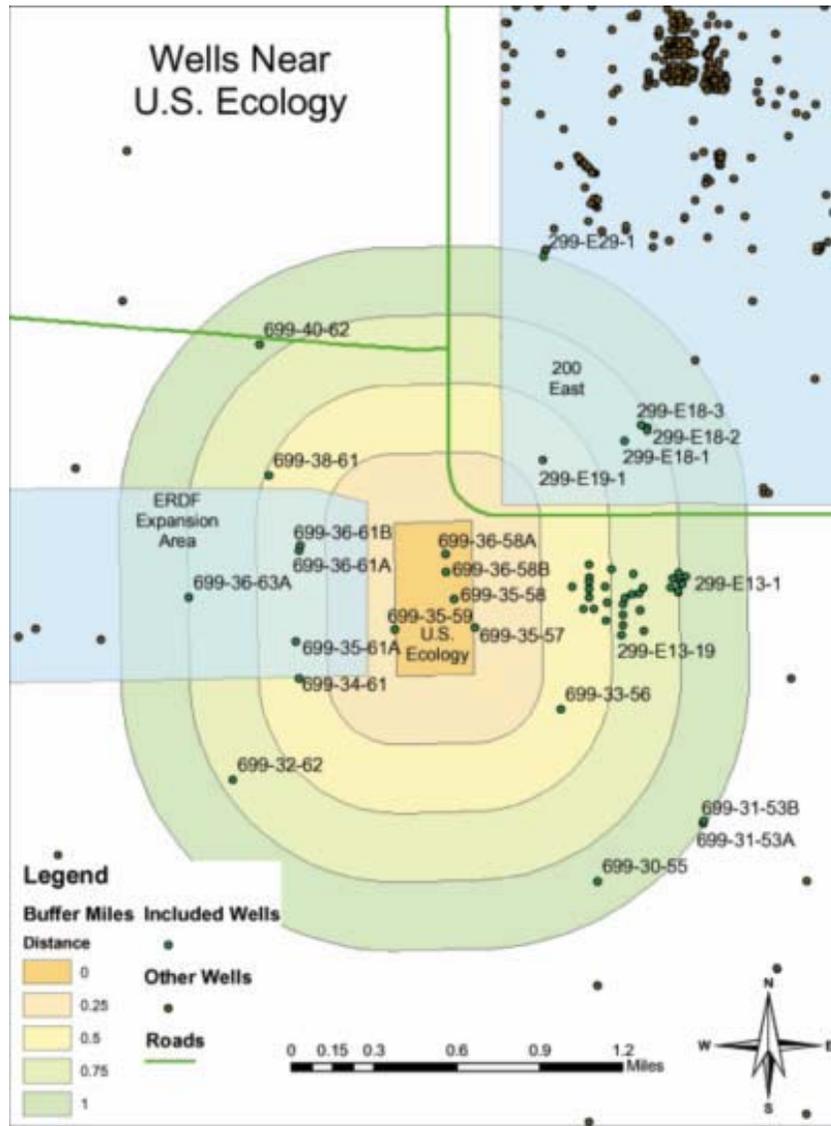
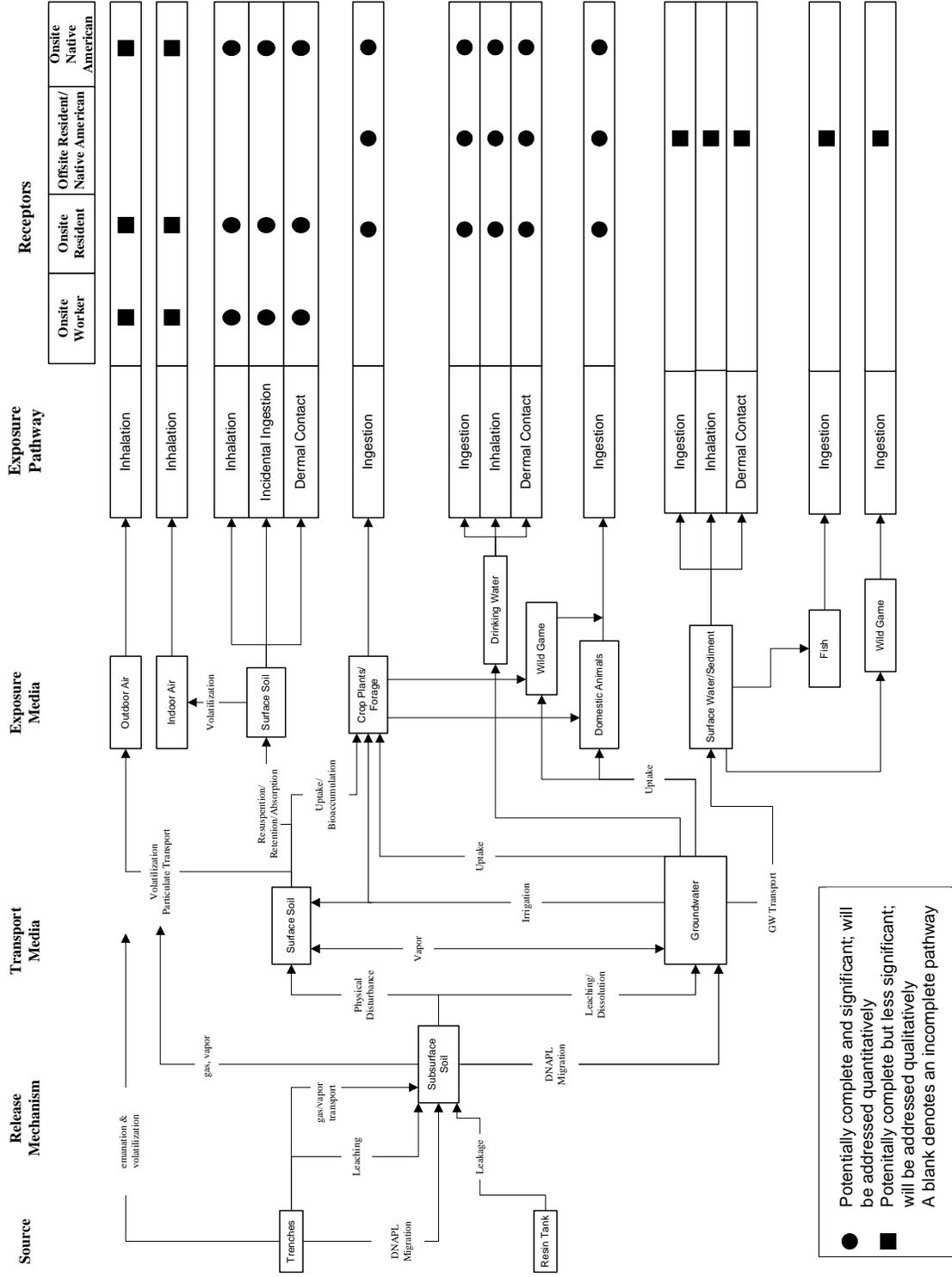
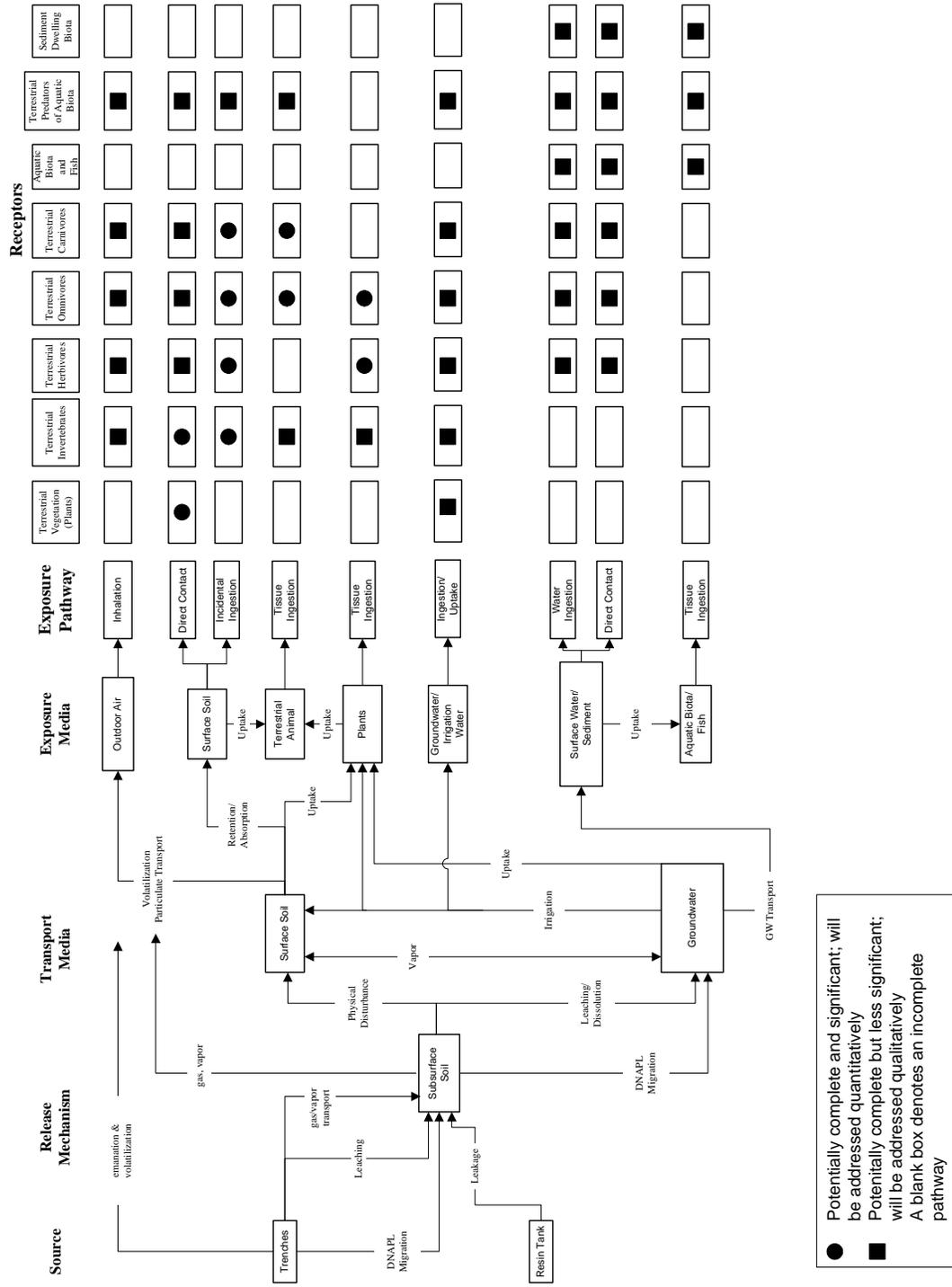


Figure 1-35. Human Health Conceptual Site Model for the LLRW Site for Non Radiological Constituents



Human Health Conceptual Site Model for the US Ecology Site for Non Radiological Constituents

Figure 1-36. Conceptual Site Model for Ecological Receptors for the LLRW Site for Non Radiological Constituents



Conceptual Site Model for Ecological Receptors for the US Ecology Site for Non-Radiological Contaminants

2.0 STEP 2 - IDENTIFY THE DECISIONS

A cleanup action means any remedial action (except interim actions) taken at a site to eliminate, render less toxic, stabilize, contain, immobilize, isolate, treat, destroy, or remove a hazardous substance. A site that has been listed on the State's Hazardous Site List is a MTCA cleanup site and a RI/FS and cleanup action must be performed at that site. The LLRW Site has been listed on the State Hazardous Site List. The cleanup action for the LLRW Site must meet the requirements of WAC 173-340, including the requirement that the cleanup action is protective of human health and the environment. Remedial actions commonly utilize monitoring as one cleanup alternative. When the term "remediation" is used in the Principal Study Questions (PSQs) and Decision Statements (DSs), remediation may include monitoring.

PSQs 1-3 specifically identify site soils and groundwater as environmental media to potentially remediate. Although naming these media may be logical from a remediation perspective, the situation may require clarification from a risk perspective. That is, not all "exposure media" are named in PSQs 1-3. For example, humans are exposed not only directly to soil (e.g., soil ingestion) and groundwater (e.g., drinking water ingestion) but perhaps also to surface water and sediment or indirectly via the food chain (e.g., crop ingestion, domestic animal ingestion, etc.). Similarly, ecological receptors may be exposed to surface water and sediment or via the food chain (e.g., plant and animal ingestion). By containing the source and remediating soils and groundwater (i.e., transport media nearer to the source term), other 'downstream' pathways should be eliminated over time.

The PSQs are presented by media for clarity. Table 2-1 presents the PSQs and DSs. The consequences of making an error in the selection of the alternative action are qualitatively evaluated in Table 2-2.

**Table 2-1. Principal Study Questions, Alternative Actions, and Decision Statements.
(3 sheets)**

#	PSQ	#	Alternative Action
1	Do LLRW Site soils contain non-radiological contaminants at concentrations that would result in exceedance of human health risk thresholds?	a	Yes, Remediate
		b	No, no further action, continue to other decisions
Determine whether LLRW Site soils contain non-radioactive contaminants at concentrations that would result in exceedance of human health risk thresholds, so that remedial action would or would not be needed.			
2	Does groundwater contain non-radiological contaminants at concentrations that would result in exceedance of human health risk thresholds? See PSQs 4a and 4b	a	Yes, Remediate
		b	No, no further action, continue to other decisions
Determine whether groundwater contains non-radioactive contaminants at concentrations that would result in exceedance of human health risk thresholds, so that remedial action would or would not be needed.			

Table 2-1. Principal Study Questions, Alternative Actions, and Decision Statements.
(3 sheets)

#	PSQ	#	Alternative Action
3	Do LLRW Site soils contain non-radiological contaminants at concentrations that would result in exceedance of ecological risk thresholds?	a	Yes, remediate
		b	No, no further action, continue to other decisions
Determine whether LLRW Site soils contain non-radioactive contaminants at concentrations that would result in exceedance of ecological risk thresholds, so that remedial action would or would not be needed.			
4a	Are the COPCs and contaminants from other Hanford plumes (e.g., Cr, nitrate, Tc-99) present in upgradient wells at the LLRW Site?	a	Yes, notify Hanford
		b	No, evaluate decision 4b
Determine whether additional groundwater contamination is from a source up-gradient from the LLRW Site and requires action by other Hanford/DOE Sites, otherwise, evaluate decision 4b.			
4b	Have the groundwater contaminants moved off the LLRW property?	a	Yes, LLRW takes remedial actions
		b	No, review other decisions
Determine whether the groundwater contamination has moved off the LLRW property and requires LLRW action or requires no further actions by LLRW.			
5	Do clastic dikes create preferential pathway(s) for contaminants at the LLRW Site?	a	Yes, evaluate the best location for groundwater wells
		b	No, does not contribute to the placement of groundwater wells.
Determine whether the clastic dikes create preferential pathways for contaminant migration at the LLRW Site resulting in modification of groundwater well placement or whether clastic dikes have no effect on the groundwater flow at the LLRW Site and thus do not affect well placement.			
6	Does the cap need a non-radiological contaminant soil gas collection system?	a	Yes, collect/treat/manage the soil gas with a gas collection system
		b	No, a gas collection system is not needed
Determine whether the cap needs a non-radiological contaminant soil gas collection system or not.			
7	Do the data indicate that the resin tank area requires new/different remedial actions than the rest of the LLRW Site?	a	Yes, determine the remedial action
		b	No, no different actions required, move to next question/decision
Determine whether the data indicate that the resin tank area requires new/different remedial actions than the rest of the LLRW Site.			
8	Has contaminated soil gas migrated off the LLRW property?	a	Yes, evaluate soil gas remedial action
		b	No, no further action, consider other decisions
Determine whether the contaminated soil gas has migrated off the LLRW property and requires remedial action.			

**Table 2-1. Principal Study Questions, Alternative Actions, and Decision Statements.
(3 sheets)**

#	PSQ	#	Alternative Action
9	What constituents in groundwater and soil gas need to be monitored?	a	Yes, set up non-rad monitoring program (set up monitoring plan as applicable)
		b	No, no further action, consider other decisions
Determine whether ongoing groundwater and soil gas monitoring is required.			
10	At the culmination of the RI/FS process, are additional soil vapor and groundwater monitoring-well locations needed to monitor any releases from the LLRW Site? If yes, where should the wells be located? MTCA requires a five-year review of groundwater monitoring data.	a	Yes, install wells/soil gas monitoring.
		b	No, do not install additional wells.
Determine whether any additional soil vapor and groundwater monitoring locations are needed.			
11	Do we have sufficient physical properties data/information to design the cap?	a	Yes, do not collect added data
		b	No, need additional data
Determine whether sufficient data are available to allow cap design.			
12	Does interim cap design meet RCRA Subtitle C requirements for the final cap? Can interim cap be part of the final cap design?	a	Yes, approve the use of the interim cap for the final cap
		b	No, need additional data or different design
Determine whether the interim cap design meets RCRA Subtitle C and thus could be used for the final cap.			
13	Does the existing groundwater network reflect the gradient?	a	Yes, continue to use the existing well network
		b	No, identify where the new wells need to be located
Determine whether the existing groundwater network reflects the gradient; otherwise implement new groundwater network.			

Table 2-2. Consequences of Incorrectly Taking Each Alternative Action. (3 sheets)

PSQ #	AA #	Alternative Action	Error if AA Incorrectly Taken	Consequences of Error	Severity of Consequences
1	a	Remediate	Cleaning up clean dirt	Financial	Severe
	b	No further action, continue to other decisions	Leaving contamination in place, resulting in continuing vadose zone and groundwater contamination	Increased risk to human health and the environment	Moderate to Severe
2	a	Remediate	Cleaning up clean groundwater	Financial	Severe
	b	No further action, continue to other decisions	Leaving the groundwater contaminated.	Increased risk to human health and the environment via potable groundwater and the Columbia River	Severe
3	a	Remediate	Cleaning up clean dirt	Financial	Severe
	b	No further action, continue to other decisions	Leaving contamination in place, resulting in continuing vadose zone and groundwater contamination	Increased risk to ecological receptors	Moderate to Severe
4a	a	Notify Hanford	Erroneous notification to Hanford causing expansion of the groundwater monitoring network	Financial and politically sensitive issues	Moderate to Low
	b	Evaluate decision 4b	Not identifying Hanford contaminant at the LLRW Site.	Increased remediation costs and politically sensitive issues	Moderate
4b	a	LLRW takes remedial actions	Monitoring clean groundwater	Financial	Low
	b	Review other decisions	Contaminated groundwater moving off the LLRW Site.	Increased risk to human health and the environment via potable groundwater and the Columbia River	Severe
5	a	Evaluate the best location for groundwater wells	Unnecessary investigation	Financial	Moderate
	b	Does not contribute to the placement of groundwater well placement.	Conducting the investigation in the wrong locations as well as leaving contaminants in place	Increased risk to human health and the environment	Severe

Table 2-2. Consequences of Incorrectly Taking Each Alternative Action. (3 sheets)

PSQ #	AA #	Alternative Action	Error if AA Incorrectly Taken	Consequences of Error	Severity of Consequences
6	a	Collect/treat/manage the soil gas with a system	Installation of an unnecessary soil gas system	Financial and schedule impacts	Severe
	b	A collection system is not needed	No containment of soil gas vapors, noncompliance with regulatory requirements	Increased risk to human health and the environment	Severe
7	a	Determine the remedial action	Selection of an inadequate remedial action	Potential increased risk to human health and the environment and financial	Moderate to Severe
	b	No different actions required, move to next question/decision	Not selecting an appropriate remediation, leaving contamination in place	Increased risk to human health and the environment	Moderate to Severe
8	a	Evaluate soil gas remedial action	Unnecessary remediation	Financial	Moderate
	b	No further action, consider other decisions	Not selecting an appropriate remediation	Increased risk to human health and the environment	Severe
9	a	Set up non-rad monitoring program (set up monitoring plan as applicable)	Monitoring for constituents that are not present	Financial	Low
	b	No further action, consider other decisions	Allowing contaminants to be released from the LLRW Site through the vadose zone to the groundwater	Increased risk to human health and the environment and financial	Severe
10	a	Install wells/soil gas monitoring	Installation of unnecessary groundwater monitoring wells	Financial	Severe
	b	Do not install additional wells	Not detecting contaminants in the groundwater or their migration off site	Increased risk to human health and the environment and financial	Severe
11	a	Do not collect added data	Incorrect design of the cap	Financial	Severe
	b	Need additional data	Collecting unnecessary data	Financial	Severe

Table 2-2. Consequences of Incorrectly Taking Each Alternative Action. (3 sheets)

PSQ #	AA #	Alternative Action	Error if AA Incorrectly Taken	Consequences of Error	Severity of Consequences
12	a	Approve the use of the interim cap for the final cap	Over design of the interim cap	Financial and potential schedule impacts	Severe
	b	Need additional data or different design	Noncompliance with regulatory requirements, potential release of contaminants to the environment	Increased risk to human health and the environment and financial	Severe
13	a	Continue to use the existing well network	May have contamination leaving the site undetected	Increased risk to human health and the environment	Severe
	b	Identify where the new wells need to be located	May install unnecessary monitoring wells and soil gas monitoring	Financial	Severe

3.0 STEP 3 INPUTS

3.1 REGULATORY BASIS FOR CLEAN-UP LEVELS/ACTION LEVELS

The following is a summary from Appendix C, MTCA Cleanup Primer (WAC 173-340). To establish cleanup standards, MTCA requires the evaluation of the contaminants present, pathways of exposure, and the current and future land use of the site. The initial step is to examine the land use, and determining which of the three cleanup methods apply to the site. The most common cleanup method used at Hanford is MTCA Method B. For planning purposes, the DQO attendees agreed to use the MTCA Method B cleanup levels. MTCA Method B requires residential exposure risk calculations [173-340-740(3)] to determine the contaminant-specific cleanup level to be achieved. The WDOE has used the formulas in the regulations to pre-calculate concentrations of constituents at the 1×10^{-6} risk level or concentrations associated with a hazard quotient (HQ) of one. These levels are published in the Cleanup Levels and Risk Calculation (CLARC III) database, available at http://www.ecy.wa.gov/programs/tcp/tools/CLARC_v_3.1/clarc_v_3_1.htm. The cleanup levels are for environmental media such as groundwater, soil, and surface water.

For planning purposes, preliminary tables of the potential cleanup levels were generated for analytes that were detected at the LLRW Site during the Phase I and Phase II investigation. Tables 3-7 and 3-8 provide these preliminary lists of analytes and cleanup levels. These tables also provide the action limits that will be used in Decisions 1-3. The contaminants listed in these tables are a subset of those listed in the analytical methods called out in Step 1 of this document. DQO Team Members recognize that the MTCA cleanup levels will be established within the RI/FS process after the PLP is named.

It must be noted that there are no cleanup levels for the soil gas.

3.2 BACKGROUND

Background values are established per WAC 173-340-709 (1) to distinguish site related concentrations of hazardous substances from non-site related concentrations or to support development of MTCA Method C cleanup up levels under Section 706. There are two types of background values possible at a site, Natural and Area. Natural is not influenced by localized human activity unless it is a “global distribution.” Area Background has to be unrelated to releases at a MTCA site. When MTCA Method A or B cleanup up levels are below area background, cleanup levels may be established based on area background, but can never be above Method C cleanup levels.

3.2.1 Natural Background and Analytical Considerations

In some cases, cleanup levels calculated using the methods specified in MTCA are less than natural background levels or levels that can be reliably measured. In those situations, the cleanup level shall be established at a concentration equal to the PQL or natural background concentration, which ever is higher (173-340-700(6) (d)). See WAC 173-340-707 (Analytical Considerations) and -709 (Methods for Defining Background Concentrations) for additional information.

3.2.2 Groundwater

One potential scenario for background is that the groundwater flowing under the LLRW Site is contaminated by the upgradient Hanford Facility, unrelated to releases at the LLRW Site. Background groundwater data from the Hanford Facility is presented in Table 3-7. However, the LLRW Site disposal history and past practices can not be ruled out as contributors to vadose and groundwater contamination. Regardless of the sources of contamination, area background cannot exceed Method C for groundwater, MCLs for drinking water, and criteria in WAC 173-340-706(1).

3.2.3 Approach for LLRW Site

Table 3-1 shows the background soil levels from Hanford Guidance (USDOE 1995) and the San Juan (1994) publications. No background values exist for organics because typically they are not naturally occurring. It is up to the PLP to justify site-specific criteria for background in accordance with WAC 173-340.

Table 3-1. Background Soil Values. (2 sheets)

Chemical Name	Background	Background	Background	Background
	San Juan (1994)	San Juan (1994)	San Juan (1994)	USDOE (1995)
	East, WA	Yakima Basin	Group "E"	Hanford
	(90 th %, mg/kg)	(90 th %, mg/kg)	(90 th %, mg/kg)	(90 th % LN, mg/kg)
Xylene total	ND	ND	ND	ND
m-Xylene	ND	ND	ND	ND
o-Xylene	ND	ND	ND	ND
p-Xylene	ND	ND	ND	ND
Acetone	ND	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND	ND
Tetrachloroethene	ND	ND	ND	ND
Toluene	ND	ND	ND	ND
Beryllium	1.30E+00	1.60E+00	6.00E-01	1.51E+00
Cadmium	8.00E-01	9.00E-01	ND	ND
Chromium	3.19E+01	3.83E+01	3.78E+01	1.85E+01
Copper	2.84E+01	2.65E+01	2.84E+01	2.20E+01
Lead	1.31E+01	1.10E+01	9.90E+00	1.02E+01
Mercury	4.00E-02	5.00E-02	2.00E-02	3.30E-01
Nickel	2.45E+01	4.59E+01	2.24E+01	1.91E+01
Selenium	ND	ND	ND	ND
Silver	ND	ND	ND	7.30E-01
Thallium	ND	ND	ND	ND
Uranium	ND	ND	ND	ND
Zinc	8.09E+01	7.87E+01	6.75E+01	6.78E+01
Fluoride	ND	ND	ND	2.81E+00
Nitrate	ND	ND	ND	5.20E+01
Nitrite	ND	ND	ND	ND
Cyanide	ND	ND	ND	ND
Hydrogen Sulfide	ND	ND	ND	ND
PCB's	ND	ND	ND	ND

Table 3-1. Background Soil Values. (2 sheets)

Chemical Name	Background	Background	Background	Background
	San Juan (1994)	San Juan (1994)	San Juan (1994)	USDOE (1995)
	East, WA	Yakima Basin	Group "E"	Hanford
	(90 th %, mg/kg)	(90 th %, mg/kg)	(90 th %, mg/kg)	(90 th % LN, mg/kg)

Note: USDOE (1995), "Hanford Site Background: Part 1, Soil Background for Non-radioactive Analytes," DOE/RL-92-24, Rev. 3, Richland, WA.

San Juan (1994), "Natural Background Soil Metals Concentrations in Washington State," WDOE, Pub. No. 94-115, Olympia, WA.

ND = no data

3.3 COPCS

The COPCs are listed in Tables 1-3 through 1-10 of Step 1 of this DQO and are related to Decisions 1-3, 4a, 4b, and 9. The soil gas COPCs are related to Decisions 6, 8, 9, and 10. The COPC List was developed by reviewing analytical results from the Phase I and Phase II investigation results. Any analyte detected above the PQL was identified as a COPC. Several analytes were detected above the MDL but below the PQL, these were not included in the COPC list. This DQO recommends that all samples collected during the remedial investigation be analyzed by EPA SW-846 method analysis. Method analysis will allow for the detection of any contaminant, which is included in the analytical method. If, during the remedial investigation, additional contaminants are detected above the MDL they will be taken into consideration when making remedial action decisions at the LLRW, this approach is consistent with the requirements of WAC 173-340-740(7).

WAC 173-340-830 lists the analytical and sampling methods allowed under MTCA. For the COPCs listed in Step 1, Tables 3-2 through 3-4 lists the reporting limits, accuracy, and precision. If a method substitution is required, it must comply with WAC 173-340-830. The recommended methods are from Physical\Chemical Methods, US EPA, SW-846. The accuracy and precision are based on typical SW-846 methodology.

WAC 173-340-820 lists the contents of a sampling and analysis plan (SAP). A SAP will be developed for this project in accordance with regulatory requirements. The SAP should include a detailed description of how sampling will be conducted, in accordance with "Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies, WDOE Publication #01-03-003."

Soils will be sampled and the fraction sampled should be < 2 mm in particle size and the data presented in dry weight. For groundwater, unfiltered samples will be analyzed unless it can be demonstrated to the WDOE that a filtered sample provides a more representative measure of groundwater quality, per WAC 173-340-720(9).

The reporting limits from the analytical laboratory should be compared to Tables 3-7 and 3-8 (which summarize potential groundwater and soil cleanup levels, respectively). The goal is to have the PQL lower than the cleanup levels. The reporting limits are listed by analytical method along with accuracy and precision from the SW-846 methods. If a PQL below the action limit cannot be achieved, the PQL becomes the action limit per MTCA regulations.

Table 3-2. Analytical Performance Requirements For COPC Analysis.

Type of COPC	COPCs	Survey or Analytical Method	Reporting Limit - water, soil	Precision Required	Accuracy Required
VOC	Table 1-4	SW-846, Method 8260B	1-5 ug/L 5-20 ug/kg	^a	^a
SVOC or BNA	Table 1-5	SW-846, Method 8270C	1-5 ug/L 100-200 ug/kg	^a	^a
polynuclear aromatic hydrocarbons (PAHs)	Table 1-6	SW-846, Method 8270C	.01-.2 ug/L .5-2 ug/kg	^a	^a
Polychlorinated biphenyls (PCB)	Table 1-7	SW-846 Method 8082	.03-1 ug/L 50-5000 ug/kg	^a	^a
Metal, Inductively Coupled Plasma (ICP)	Table 1-3 and 3-3	SW-846 Method 6010B	See Table 3-3	<20%	±25%
Metal	Hg	7470A Water 7471 Soil	.05 ug/L 5 ug/kg	<20%	±25%
Anions	Nitrite	Method 300.0 or 9056	0.01 mg/L	<20%	±25%
Anions	Ortho Phosphate	Method 300.0 or 9056	0.3 mg/L	<20%	±25%
Anions	Fluoride Chloride	Method 300.0 or 9056	0.1 mg/L	<20%	±25%
Anions	Nitrate	Method 300.0 or 9056	75 mg/L	<20%	±25%
Anions	Sulfate	Method 300.0 or 9056	0.5 mg/L	<20%	±25%

^a Precision and accuracy will be calculated by the laboratory and vary depending on the analyte.

Table 3-3. Metals by Inductively Coupled Plasma (ICP) Detection Limits. (2 sheets)

Element	Water, dissolved or Water, total	Sediment
	µg/L	mg/kg
Aluminum	50	2.5
Antimony	40	2
Arsenic	50	2.5
Barium	5	0.25
Beryllium	5	0.25
Boron	50	2.5
Cadmium	5	0.25

Table 3-3. Metals by Inductively Coupled Plasma (ICP) Detection Limits. (2 sheets)

Element	Water, dissolved or Water, total	Sediment
	µg/L	mg/kg
Calcium	50	2.5
Chromium	5	0.25
Cobalt	5	0.25
Copper	5	0.25
Iron	50	2.5
Lead	50	2.5
Magnesium	50	2.5
Manganese	10	0.5
Molybdenum	5	0.25
Nickel	10	0.5
Potassium	500	25
Selenium	50	2.5
Silicon	50	2.5
Silver	10	0.5
Sodium	50	2.5
Strontium	5	0.25
Thallium	50	2.5
Tin	50	2.5
Titanium	10	0.5
Uranium	5	0.25
Vanadium	5	0.25
Zinc	10	5

Table 3-4. Typical Estimated Reporting limits for Select Soil Gas Volatiles by Method TO-14 Based on 1 µl Sample Volume, Reporting Limits. (2 sheets)

Analyte	Reporting Limit ^a ppb
Freon 113	
Trichloroethene	
1,1,1-Trichloroethane	450
Choroform	450
Tetrachloroethene PCE	14
Freon 112	
Freon 11	
1,1-Dichloroethane	
Trichloroethene	14
1,1-Dichloroethene	
Methylene Chloride	
1,2,-Dichloroethane	14
Chloroethane	
Benzene	2

Table 3-4. Typical Estimated Reporting limits for Select Soil Gas Volatiles by Method TO-14 Based on 1 µl Sample Volume, Reporting Limits. (2 sheets)

Cis-1,2-Dichloroethene	
1,2-Dichloropropane	
Toluene	
Styrene	3
Ethylbenzene	4
Chlorobenzene	

^a Reporting limits vary based on the instrument, analyte, and volume of sample.

3.4 STATISTICAL ASSESSMENT

The purpose of the RI is to collect sufficient data to select a cleanup action in accordance with WAC 173-340-360 through 390. In addition, the quantity of data collected must ensure the cleanup action selected complies with requirements per WAC 173-340-740(6)(f) for containment as part of the cleanup action. A statistical evaluation will be used to determine when sufficient data has been collected to provide a 95% confidence level for the regulatory decisions. Evaluation of data collected from the RI will be analyzed in accordance with *Guidance on Sampling and Data Analysis Methods*, WDOE Publication No. 94-49 (WDOE 1995) and *Statistical Guidance for Ecology Site Managers*, WDOE Publication No. 92-54, (WDOE 1999). Guidance for soil sampling and groundwater monitoring is provided in Tables 1 and 7, respectively. A direct comparison must be made between field data collected for both soil and groundwater and cleanup levels. Statistics will be used, as applicable, to design an efficient and cost-effective sampling plan.

3.5 MODELING

Risk assessment is a tool used to estimate the severity and likelihood of harm to humans and ecological receptors from exposure to hazardous substances. It represents one input to environmental management decisions. Other inputs include stakeholder concerns, availability of technical solutions, costs/benefit analysis, legal mandates, and political issues. Risk assessment is a systematic and tiered approach to analyzing scientific knowledge and information for potentially hazardous substances or activities. Applications are numerous, including determining health and environmental problems associated with a variety of risk agents.

The paradigm for human health risk assessment was initially conceived by the National Research Council (NRC 1983). The four major steps include hazard identification, toxicity assessment, exposure assessment, and risk characterization. Hazard identification characterizes the source term (i.e., amount and concentration of contaminants). The toxicity assessment describes the relationship between contaminant dose and adverse biological effects (e.g., non-cancer reference dose, cancer slope factor). The exposure assessment describes contaminant pathways and exposure scenarios. Finally, risk characterization integrates toxicity and exposure assessments, along with attendant uncertainties.

The model for ecological risk assessment was first detailed by the EPA (1992). This model primarily parallels the human health risk assessment paradigm. Three major steps include problem formulation, exposure and effects analyses, and risk characterization. Problem formulation identifies source, pathways, and receptors. The analysis phase characterizes contaminant exposure (e.g., temporal and spatial patterns, exposure point concentrations) and biological effects (e.g., No Adverse Effect Level – [NOAEL]). Finally, risk characterization integrates exposure and effect analyses to estimate risk (e.g., $HQ = \text{exposure}/\text{effects}$). This final step typically includes an uncertainty analysis, as well.

Risk targets for the proposed risk assessment will conform to MTCA Method B criteria. Method B is referred to as the universal method, applicable to any site (WDOE 2001a). Individual contaminants will meet a cancer risk of $1E-6$ and a non-cancer HQ of 1. Site wide limits for multiple contaminants include a cancer risk of $1E-5$ and a non-cancer hazard index of 1. Note that the allowable risk levels for a given land use remain constant. The risk scenario defines many parameters such as variation in exposure times that alter the calculated risk of the site.

3.5.1 1999 Risk Assessment

Methodology in the 1999 non-radionuclide risk assessment for the LLRW Site (Kirner 1999) conformed to methods in the WDOH (2000) radiological risk assessment, where appropriate. In the Kirner (1999) assessment, there was a high degree of uncertainty associated with the source term, since it was constructed largely from incomplete inventory data and few field data. Human health results showed that only two chemicals exceeded risk thresholds (i.e., phenol in soil and vinyl chloride in groundwater). However, risks from these contaminants were considered negligible, due to potential degradation and volatilization. Ecological results showed that inhalation of VOCs was possible for burrowing animals but that population-level effects were unlikely. Overall, ecological risks were considered negligible. In addition to uncertainty in the source term, a large degree of uncertainty was related to problems with modeling inorganics in the vadose zone. Data collected during the Phase I and Phase II investigation did not entirely support the Kirner risk assessment model.

3.5.1.1 Risk Approach and Consistency with the Radiological risk assessment and Hanford Core Area

The scenarios used in the radiological risk assessment used scenarios that included more than the MTCA Method B scenarios. The DQO team discussed whether the RI/FS should be consistent with the radioactive scenarios. The agreed-upon plan for the LLRW Site is to use MTCA Method B screening levels, with additional levels derived as needed for groundwater protection.

In addition to the WDOH risk assessment, Hanford is undergoing discussions with stakeholders regarding the Central Plateau Core Zone. The Nez Perce Tribe proposed that an industrial scenario should set the cleanup levels with other scenarios considered in addition to the industrial.

A response letter to the HAB (Martin 2002) indicates that worker (i.e., industrial), Native American, and intruder scenarios should be evaluated in the Core Zone and that residential and recreational scenarios could be considered for comparison (Klein, Einan, and Wilson 2002). Because the LLRW Site is located near the perimeter of the 200 Area Core Zone, it makes sense to evaluate industrial, residential, and Native American scenarios.

The current thinking is that in addition to MTCA Method B, industrial (on-site worker), residential (on-site intruder), Native American (on-site intruder) scenarios, along with off-site residential and off-site Native American scenarios will be evaluated. Onsite and off-site refer to the LLRW property boundary.

In terms of ecological risk, it was suggested that only a terrestrial scenario (i.e., not aquatic) be evaluated. This approach is consistent with the 7/11/02 Tri-Party response letter for the Core Zone, as well as the WDOH radiological risk assessment for the LLRW Site.

It must be noted that the LLRW Site is currently not zoned. Land use at the Hanford Facility has been determined in the Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement, and includes the LLRW Site as industrial exclusive. However, until the RI/FS is performed and a remedial action is selected, the cleanup levels are not final. An evaluation of soil cleanup levels must consider not only direct exposure issues for the top 15 feet of soil, but also levels that could contribute to groundwater contamination and all conditions for using Method C for soil and groundwater must be met. This DQO has assumed the use of MTCA Method B screening levels for soil and protection of groundwater. In accordance with WAC 173-340-702(14), the burden of proof for establishing cleanup levels under Method C falls on the PLP.

3.5.2 Transport modeling

There are two models that are frequently used for cap modeling; they are UNSAT and HELP. The question on modeling is whether a three-dimensional model or a one-dimensional model is needed. All models have limitations and uncertainty. It is the responsibility of the contractor performing the work to present to the PLP the uncertainties and provide an appropriately evaluated strategy for numerical modeling. The WDOE prefers the three dimensional model. Remediation design is an optimization problem and a 3D predictive model can handle the heterogeneous environment of the LLRW Site. The WDOE's preference for 3D modeling is based on making defensible predictions and dealing with data uncertainty. A recent data evaluation (8/2001) conducted by the WDOH focused on increasing the confidence in the Phase I and Phase II investigation radiological data. The evaluation developed a protocol for recalibration of the GWSCREEN groundwater model to determine if additional investigation data was necessary. The purpose was not to determine the source(s) of any detected environmental contaminants, nor intended to draw any conclusion regarding the spatial and/or temporal distribution of environmental contaminants. The LLRW data set used in the model did not include any vadose zone sample results. The model did not take into account the distribution of lithofacies, their sedimentary structure and other structural features that are very important to the analysis of contaminant transport behavior. To have a defensible prediction, the uncertainty must be minimized and confidence in the models is critical.

However, it was pointed out that the one-dimensional model requires the use of more conservative assumptions, and given the limited inventory data available for non-radioactive constituents, the one-dimensional model may provide a more cost effective and more conservative modeling approach. The final decision on the modeling will be made when the contractor is hired.

3.6 CAP DESIGN AND ASSOCIATED PHYSICAL PARAMETERS

While the cap design is being developed by the WDOH, it will not be completed before the RI data are gathered; therefore, some soil data may be gathered during the RI sampling. The goal is to make sure that the appropriate physical properties of the soil are either available from data already collected by other agencies, such as the WDOH for their cap design, or the data are gathered during the soil sampling for this sampling effort. The cap design data collected by this DQO will be used to augment the existing data already available from WDOH. The DQO team agreed on the following approach. The scope of work to be issued, after this DQO Process, will specify that the contractor must have expertise in cap design analysis. They will be required to look at the list of parameters in Table 3-5 and the existing WDOH data and determine whether any additional data should be collected to support hazardous waste cap design or for selection of a remedial alternative for the resin tank area.

Table 3-5. List of Physical Properties That May Influence Cap Design*

Porosity-total volume filled by pores (total soil porosity)
Bulk density-soil mass/whole soil volume
Dry soil bulk density
Grain size analysis
Plastic limits
Pore size distribution – pores may vary in size and may be indicative of volumes available for trapping soil gases
Moisture content (percent)
pH
Cation exchange capacity meq/100 grams
Fines, percent <200 mesh
Fraction soil organic carbon
Grain size, fines and percent <200 mesh
* Where ASTM methods are available, these will be used.

In addition to review of the physical properties, a draft list of performance criteria for cap design will need to be reviewed and refined by the qualified individuals performing the Statement of Work (see Table 3-6). The goal of this task is to assure sufficient information is available for determining if any modifications need to be made to the existing WDOH cap design, or that proper remedial alternatives can be selected for the resin tank area.

Table 3-6. Draft List of Performance Criteria Which Should be Considered When Reviewing Cap Design.

Hydraulic performance (infiltration through cover system/prime element of a cover strategy)
Stability and mechanical strength
Settlement (subsidence due to collapse of waste)
Erosion reduction
Drainage
Freeze/thaw
Desiccation and puncture resistance
Gas management (vertical and horizontal migration of gases)
Meet performance requirements of WAC 173-351 and 173-303
Meet performance requirements of 100, 500-year flood event
Animal and vegetation (plant roots) intrusion

Table 3-7. Primary Groundwater COPCs from LLRW Site and Potential Cleanup Limits. (2 sheets)

Chemical Name	CAS No.	MTCA-B-GW (Ingestion only)	MTCA/ Carcinogen	MTCA/VOC	MTCA-B-GW (Inh+Inh)	MTCA Comment	EPA MCL (mg/L) ND if blank	EPA MCL (σg/L)	MCL Comment	Background	Background Comment
(Groundwater)		(σg/L)			(σg/L)					USDOE (1992)	
Chloroform	67-66-3	7.17E+00	Yes	Yes			8.E-02	8.E+01	as Total Trihalomethanes (TTHMs)	ND	Hanford (Table 5-9)
Trichloroethylene	79-01-6	3.98E+00	Yes	Yes	3.98E+00		5.E-03	5.E+00		ND	
Chromium VI	18540-29-9	4.80E+1	Yes (inh only)	No						ND	
Chromium III	16065-83-1	2.40E+04		No							
Nitrate	14797-55-8	1.60E+03		No			1.E+01	1.E+04	as Nitrogen	1.24E+04	
Arsenic	7440-38-2	5.83E-02	Yes	No		MTCA Method A = 5E+0 σg/L, based on WA background	1.E-02	1.E+01	effective 2/22/02	1.00E+01	max
Barium	7440-39-3	1.12E+03		No		Error in CLARC	2.E+00	2.E+03		6.85E+01	max
Chromium	7440-47-3	ND	ND	No		MTCA Method A = 5E+1 σg/L	1.E-01	1.E+02		<30	non-detect, value is MDL
Lead	7439-92-1	ND	ND	No		MTCA Method A = 1.5E+1 σg/L		No MCL	1.5E+1 μg/L=Action Level	<5	non-detect, value is MDL

Table 3-7. Primary Groundwater COPCs from LLRW Site and Potential Cleanup Limits. (2 sheets)

Chemical Name	CAS No.	MTCA-B-GW	MTCA/Carcinogen	MTCA/VOC	MTCA-B-GW	MTCA Comment	EPA MCL	EPA MCL	MCL Comment	Background	Background Comment
Manganese	7439-96-5	2.24E+03		No			No MCL	No MCL	5E+1 σg/L=Secondary Level	24.5, 163.5	max, 2 concentration groups
Nickel	7440-02-0	3.20E+02		No			No MCL	No MCL	1E+2 μg/L remanded 2/9/95	<30	non-detect, value is MDL
Selenium	7782-49-2	8.00E+01		No			5.E-02	5.E+01		<5	non-detect, value is MDL
Uranium	7440-61-1	4.80E+01		No			3.E-02	3.E+01	effective 12/8/03	3.81E+00	max, 3.43 pCi/L (conversion factor=0.9 pCi/σg)
Fluoride	16984-48-8	ND	ND	No			4.E+00	4.E+03		775, 1340	max, +- outlier
Nitrite	14797-65-0	1.60E+03		No			1.E+00	1.E+03	as Nitrogen	ND	
Phenol	108-95-2	9.60E+03		No			No MCL	No MCL		ND	
Bis (2-ethylhexyl)phthalate	117-81-7	6.25E+00	Yes	No			6.E-03	6.E+00		ND	

Note: USDOE, 1992, "Hanford Site Groundwater Background," DOE/RL-92-93, Richland, WA.

GW = groundwater

VOC = volatile organic compound

MCL = maximum contaminant level

ND = no data

Table 3-8. Primary Soil COPCs and Potential Cleanup Levels. (2 sheets)

Chemical Name (Soil)	CAS No.	Protection of Potable GW Target Soil CUL (MITCA) (mg/kg)	MTCA-B-Soil (Ingestion) (mg/kg)	MTCA/ Carcinogen	MTCA/ VOC	Vapor P (mm Hg) (20-30°C)	MTCA-B-Soil (Ing+Dermal) (mg/kg)	MTCA/Eco Soil (Plants)	MTCA/Eco Soil (Soil Biota)	MTCA/Eco Soil (Wildlife)	Comment
Xylene total	1330-20-7	9.14E+00	1.60E+05		Yes	7.99	1.48+05	(mg/kg)	(mg/kg)	(mg/kg)	
m-Xylene	108-38-3		1.60E+05		Yes	8.29	1.48+05	ND	ND	ND	
o-Xylene	95-47-6		1.60E+05		Yes	6.61	1.48+05	ND	ND	ND	
p-Xylene	106-42-3		ND		ND	8.84	ND	ND	ND	ND	
Acetone	67-64-1	3.211E+00	8.00E+03		Yes	231	7.99E+03	ND	ND	ND	
1,2,4-Trimethylbenzene	95-63-6		ND	ND	ND	ND	ND	ND	ND	ND	1.3E+2 mg/kg, RAIS, ORNL, USDOE
Tetrachloroethene	127-18-4	5.30E-02	1.96E+01	Yes	Yes	18	18	ND	ND	ND	
Toluene	108-88-3	1.163E+01	1.60E+04		Yes	22	1.48E+04	2.00E+02	ND	ND	
Beryllium	7440-41-7	6.336E-01	1.60E+02	Yes (inh only)	No	<1E-8	1.44E+02	1.00E+01	ND	ND	
Cadmium	7440-43-9a	6.614E-02	8.00E+01		No	<1E-8	7.40E+01	4.00E+00	2.00E+01	1.40E+01	MTCA Method A (mg/kg): Cr+6=1.9E+1, Cr+3=2E+3
Chromium	7440-47-3		ND	ND	No	<1E-8	ND	4.20E+01	4.20E+01	6.70E+01	
Chromium III	16065-83-1		1.20E+05		No	<1E-8	1.08E+5	ND	ND	ND	
Chromium VI	18540-29-9	1.843E+01	2.4E+02		No	<1E-8	2.16E+2	ND	ND	ND	
Copper	7440-50-8	2.628E+02	2.96E+03		No	<1E-8	2.67E+03	1.00E+02	5.00E+01	2.17E+02	
Lead	7439-92-1		ND	ND	No	<1E-8	ND	5.00E+01	5.00E+02	1.18E+02	MTCA Method A=2.5E+2 mg/kg
Mercury	7439-97-6	5.015E+00	2.40E+01		No	1.85E-03	1.80E+01	3.00E-01	1.00E-01	5.50E+00	
Nickel	7440-02-0	4.173E+02	1.60E+03		No	<1E-8	1.44E+03	3.00E+01	2.00E+02	9.80E+02	
Selenium	7782-49-2	8.32E+00	4.00E+02		No	<1E-8	3.60E+02	1.00E+00	7.00E+01	3.00E-01	
Silver	7440-22-4	1.36E+01	4.00E+02		No	<1E-8	3.60E+02	2.00E+00	ND	ND	
Thallium	7440-28-0	1.595E+00	5.60E+00		No	<1E-8	5.05E+00	1.00E+00	ND	ND	
Uranium	7440-61-1	1.92E-01	2.40E+02		No	<1E-8	2.16E+02	5.00E+00	ND	ND	

Table 3-8. Primary Soil COPCs and Potential Cleanup Levels. (2 sheets)

Chemical Name (Soil)	CAS No.	Protection of Potable GW Target Soil CUL (MTCA) (mg/kg)	MTCA-B-Soil (Ingestion) (mg/kg)	MTCA/ Carcinogen	MTCA/ VOC	Vapor P (mm Hg) (20-30°C)	MTCA-B-Soil (Ing+Dermal) (mg/kg)	MTCA/Eco Soil (Plants)	MTCA/Eco Soil (Soil Biota)	MTCA/Eco Soil (Wildlife)	Comment
Zinc	7440-66-6	5.971E+01	2.40E+04	No	No	<1E-8	1.97E+04	(mg/kg) 8.60E+01	(mg/kg) 2.00E+02	(mg/kg) 3.60E+02	
Fluoride	16984-48-8		ND	No (inorganic)	No (inorganic)	ND	ND	ND	ND	ND	MTCA lists 200 mg/kg for plants for "Fluorine"
Nitrate	14797-55-8	6.4E+00	8.00E+03	No	No	ND	7.21E+03	ND	ND	ND	
Nitrite	14797-65-0	6.4E+00	8.00E+03	No	No	ND	7.21E+03	ND	ND	ND	
Cyanide	57-12-5	1.28E+00	1.60E+03	No	No	ND	1.44E+03	ND	ND	ND	
Hydrogen Sulfide	7783-06-4		2.40E+02	No (inorganic)	No (inorganic)	1.50E+04	2.16E+02	ND	ND	ND	
PCBs	1336-36-3		5.00E-01	Yes	No	<1E-2	3.60E-01	4.00E+01	ND	6.50E-01	

4.0 STEP 4 - DEFINE THE BOUNDARIES OF THE STUDY

The objective of DQO Step 4 is to define the spatial and temporal components of the population that are covered by each DS to ensure that the data collected are representative of the population. The scale of decision making for each DS is defined by combining the population of interest with the spatial and temporal boundaries. Practical constraints that could interfere with sampling are also identified. Table 4-1 presents the information needed to construct the scale of decision making for each DS.

Note that dividing a population into statistical strata and/or decision units may or may not increase sampling and analysis costs. A boundary unit containing a large area/volume may actually contain two or more smaller boundary units, each of which have some relatively homogeneous characteristic. Sampling within the larger unit will likely yield data that is not representative of these sub-populations, leading to decision errors. If the variability within each decision unit is substantially lower than that of the population as a whole, then sampling and analysis costs actually decrease.

After completing a 3-Day DQO Training “Managing Uncertainty and Systematic Planning for Environmental Decision Making” WDOE staff revised the boundary units for the LLRW Site RI/FS. When evaluating the homogeneity of the site, it was obvious that the trenches and resin tank area should be considered as separate decision units. The trenches were further divided based on the disposal history, into the ‘pre 1985 inclusive’ and the ‘post 1985’ units. The groundwater was segregated into a fourth temporal unit. The four units include:

- Resin Tank Area
- Pre 1985 inclusive – 1, 2, 3, 4, 4A, 4B, 5, 6, 7, 7A, 8, 9, 10, 11A, Chemical Trench
- Post 1985 – 11B, 12, 13, 14, 14A, 16, 18, RXT Trench
- Groundwater

This division of the site will allow for the sampling of four *relatively* homogeneous units, and the evaluation of the risk(s) posed by each.

Dividing the site into the four primary boundaries of trenches, resin tank areas, and groundwater allows consideration of separate remedial alternatives for each area. While capping is the primary remedial alternative for the trenches, this approach allows evaluation of alternative and/or additional remedial actions for the trench area.

Table 4-1. Spatial and Temporal Boundaries. (3 Sheets)

DS #	Population of Interest	Spatial - Geographic Unit Area or Volume	Spatial - Geographic Unit Homogeneous Statistical Strata	Spatial - Decision Unit Exposure	Temporal - Time-frame	Temporal - When to Collect Data	Practical Constraints
1,3	All soils within the property boundary (100 Acres)	All soils within property boundary to a depth of groundwater	Three units ≠ Resin Tank Area ≠ Pre 1985 inclusive ≠ Post 1985	Surface to: 15' depth for direct contact; surface to groundwater for protection of groundwater	Time frame is governed by project schedule, not technical time	Based on project schedule	Cannot sample through the trenches. Must sample under or around these As low as reasonably achievable (ALARA) Avoid buried tanks and waste
2, 4b, 9, 13	Groundwater	groundwater under and moving off property	Groundwater under and moving off property, screened interval in wells	groundwater under and moving off property	water level fluctuations, recharge rate, soil gas could contaminate groundwater, quarterly is typical frequency	Cannot place wells within trenches or tank area boundaries. ALARA Well screened interval	
4a	Groundwater entering the site	Groundwater entering the site	Groundwater entering the site	Wells upgradient	ditto	ditto	Need to notify USDOE prior to placing wells on USDOE property.

Table 4-1. Spatial and Temporal Boundaries. (3 Sheets)

DS #	Population of Interest	Spatial - Geographic Unit Area or Volume	Spatial - Geographic Unit Homogeneous Statistical Strata	Spatial - Decision Unit Exposure	Temporal - Time-frame	Temporal - When to Collect Data	Practical Constraints
5	All clastic dikes within the LLRW Site	All clastic dikes within the LLRW Site	Clastic dikes	Not applicable, cannot make decision based on clastic dike	Not applicable	Not applicable	Can examine clastic dikes unearthed during new trench construction, can also look at pictures and stratigraphy documents to get this information
12	Pre 1985 inclusive unit Post 1985 unit	Pre 1985 inclusive unit Post 1985 unit	Pre 1985 inclusive unit Post 1985 unit	Pre 1985 inclusive unit Post 1985 unit	Pre-closure cap design phase	Pre-closure cap design phase	Minimize holes punched in interim cap ALARA
6,8	Pre 1985 inclusive unit Post 1985 unit Resin Tank Area	Pre 1985 inclusive unit Post 1985 unit Resin Tank Area	Pre 1985 inclusive unit Post 1985 unit Resin Tank Area	Pre 1985 inclusive unit Post 1985 unit Resin Tank Area	Most soil gas sampling will be done when soil samples are collected, however soil gas sampling is periodical.	Most soil gas sampling will be done when soil samples are collected, however, soil gas sampling is periodical	ALARA
9,10	New groundwater and soil gas monitoring locations	On-property/ Off property	Evaluate after RI	Evaluate after RI	After RI sampling and RI data assessment		Waste site locations ALARA

Table 4-1. Spatial and Temporal Boundaries. (3 Sheets)

DS #	Population of Interest	Spatial - Geographic Unit Area or Volume	Spatial - Geographic Unit Homogeneous Statistical Strata	Spatial - Decision Unit Exposure	Temporal - Time-frame	Temporal - When to Collect Data	Practical Constraints
11	Soils on site	Soils on site	Not apply	Not apply	Collect with RI soil samples	Collect with RI soil samples	ALARA
7	Resin Tank Area	Resin Tank Area	Resin Tank Area	Surface to: 15' depth for direct contact; surface to Groundwater for protection of groundwater	During RI/FS	During RI/FS	Avoid buried tanks ALARA

5.0 STEP 5 - DEVELOP A DECISION RULE

The purpose of DQO Step 5 is to develop a decision rule (DR) for each DS in the form of an “IF...THEN...” statement that incorporates the parameter of interest, the scale of decision-making, the action level, and the alternative actions (AAs) that would result from resolution of the decision. Note that the scale of decision-making and AAs were identified earlier in DQO Steps 4 and 2, respectively.

Table 5-1 presents DRs that correspond to each of the PSQs/DSs identified in Table 2-1. Several of the DRs require professional judgment of data from widely differing sources and quality. The PSQs do not necessarily relate to a single sample statistic. In many cases, there is no sample statistic that relates directly to the question that must be answered; this is further discussed in Step 6.

Table 5-1. Decision Rules and PSQs from Table 2-1. (2 Sheets)

PSQ #1	Do LLRW Site soils contain non-radioactive contaminants at concentrations that would result in exceedance of human health risk thresholds?
DR#1	If LLRW Site soils contain non-radioactive contaminants at concentrations that exceed the MTCA Method B Concentrations for constituents listed in Table 3-8, then the LLRW Site soils will be remediated to achieve MTCA Method B cleanup levels. If additional constituents are detected that are not listed in Table 3-8, which exceed the MTCA Method B criteria, soil remediation will also be required for these constituents.
PSQ #2	Does groundwater contain non-radioactive contaminants at concentrations that would result in exceedance of human health risk thresholds? (also see PSQs 4a and 4b)
DR#2	If groundwater at the downgradient LLRW Site boundary contains non-radioactive contaminants listed in Table 3-7, at concentrations that exceed MTCA Method B cleanup levels (or MCLs as appropriate) then ground water remediation will be required consistent with remedy selection as established in WAC 173-340-350 through 390.
PSQ #3	Do LLRW Site soils contain non-radioactive contaminants at concentrations that would result in exceedance of ecological risk thresholds?
DR#3	If LLRW Site soils contain non-radioactive contaminants identified in Table 3-8 at concentrations that would result in exceedance of calculated MTCA ecological risk thresholds or values derived from other commonly accepted ecological screening databases, then soil remediation will be required consistent with remedy selection as established in WAC 173-340-350 through 390.
PSQ #4a	Are the COPCs and contaminants from other Hanford plumes (e.g., Cr, nitrate, Tc-99) present in upgradient wells at LLRW?
DR #4a	If Hanford plumes are present in LLRW upgradient wells at levels greater than or equal to MTCA Method B cleanup levels (or MCLs as appropriate), then remediation should be addressed with the Hanford Site.
PSQ #4b	Have the groundwater contaminants moved off the LLRW Site? (See DR #2)
PSQ #5	Do clastic dikes create preferential pathway(s) for contaminants at the LLRW Site?
DR#5	If clastic dikes are present and create a preferential pathway for contaminants to migrate through the vadose zone into the groundwater, then the location and influence of the clastic dikes will be considered when establishing the groundwater-monitoring program.
PSQ #6	Does the cap need a non-radioactive contaminant soil gas collection system?
DR #6	If soil gas monitoring indicates the presence of vapor-phase non-radioactive constituents, then the cap will require a soil-gas collection system.
PSQ #7	Do the data indicate that the resin tank area requires new/different remedial actions than the rest of the LLRW Site?
DR #7	If the data are above the MTCA Method B cleanup levels in the resin tank area, then soil remediation will be required consistent with remedy selection as established in WAC 173-340-350 through 390.
PSQ #8	Has contaminated soil gas migrated off the LLRW property?
DR#8	If contaminated soil gas has migrated off property, then go to DR 10.

Table 5-1. Decision Rules and PSQs from Table 2-1. (2 Sheets)

PSQ #9	What constituents in groundwater and soil gas need to be monitored?
DR #9	If soil gas and groundwater monitoring is needed, then COPCs listed on Table 3-7 should be monitored on a long term basis in accordance with WAC 173-340-410(3).
PSQ #10	At the culmination of the RI/FS process, are additional soil gas and groundwater monitoring-well locations needed to monitor any future releases from the LLRW Site? If yes, where should the wells be located?
DR #10	If groundwater or soil gas monitoring indicates that COPCs originating from the LLRW Site have migrated off property, then additional investigation of the nature and extent of the groundwater/soil gas plume will be needed to identify plume(s) boundary and future monitoring well locations.
PSQ #11	Do we have sufficient physical properties data/information to design the cap?
DR #11	If physical data for the LLRW Site soils are not available to support the engineering/design of the LLRW Site cap, then the missing information will be gathered, during the RI process.
PSQ #12	Does interim cap design meet the RCRA Subtitle C requirements for the final cap? Can the interim cap be part of the final cap design?
DR #12	If the interim cap design meets the requirements for the RCRA Subtitle C final cap, and is demonstrated to be protective of human health and the environment with containment as part of the cleanup action, then the interim cap may be incorporated into the final cap design. If the interim cap design does not meet the requirements for the RCRA Subtitle C final cap, an alternative cap design should be evaluated and the alternative cap is demonstrated to be protective of human health and the environment with containment as part of the cleanup action, then the interim cap can be incorporated into the final cap design.
PSQ#13	Does the existing groundwater-monitoring network reflect the gradient?
DR #13	If the current groundwater-monitoring network is determined to not accurately reflect the gradient beneath the LLRW Site, then an evaluation will be conducted to determine what modifications are necessary to correct the existing groundwater monitoring network.

6.0 STEP 6 – SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

The objective of DQO Step 6 is to define: the acceptable decision error for the sampling, the consequences of the errors, the null hypothesis, and the lower bound of the gray region. A statistician can be used to design an efficient and cost-effective sampling plan. However, any sampling plan must be designed to comply with the requirements provided in WAC 173-340-350(7) and the *Guidance on Sampling and Data Analysis Methods*, WDOE Publication No. 94-49 (WDOE 1995).

Because of the temporal and spatial division of the LLRW Site, three separate sampling strategies must be developed for:

- the resin tank area,
- the pre 1985 and inclusive trench areas,
- the post 1985 trench areas, and
- groundwater.

Each sampling strategy will be further defined in the following text.

6.1 RESIN TANK AREA

The existing data for the resin tank area is not regulatorily defensible and are based on radiological chemicals. Because of this, the resin tank area is considered an unknown for this investigation. The investigation of this area should be statistically designed based on the *Statistical Guidance for Ecology Site Managers* (WDOE 1999), and the *Guidance on Sampling and Data Analysis Methods* (WDOE 1995).

6.2 PRE 1985 AND INCLUSIVE TRENCH AREAS

The driver COPCs used for the statistical analysis will include all constituents listed in Table 3-8. Phase I and Phase II investigations field data, as well as historical depositional data compiled during the DQO process, should be used as background information for designing this focused sampling plan. However, not enough data are available to conduct a final statistical evaluation; therefore, field screening (e.g., GPR, high resistivity resolution, etc.) must be completed prior to determining any sampling locations for the collection of regulatorily defensible data to determine compliance with MTCA requirements. Data from the Phase I and Phase II investigations, in conjunction with the statistical concepts in the *Statistical Guidance for Ecology Site Managers* (WDOE 1999), should be used to calculate the standard deviation for any COPCs in the soil. This will provide an indication of the minimum number of statistical samples needed for regulatory compliance, but shall in no way limit the number of observation samples to be collected in the field.

6.3 POST 1985 TRENCH AREA

Based on process knowledge and historical depositional data compiled during the DQO process the post 1985 trench area should not contain mixed waste, and therefore does not need any sampling during the RI/FS.

6.4 GROUNDWATER

Groundwater sampling must be conducted in compliance with MTCA 173-340-720 and 173-340-350(7) requirements and the *Guidance on Sampling and Data Analysis Methods* (WDOE 1995). Sampling plans will be based on WAC 173-340-820.

7.0 STEP 7 - OPTIMIZE SAMPLE DESIGN

Step 7 uses the information generated from the previous stages of the DQO process to develop a broad sample design in response to the problem statement presented in Step 1. The sample design presented in Step 7 reflects consideration of AAs posed through the DSs, as well as the inputs and boundaries developed in previous steps. Step 7 also incorporates consideration of physical, and other constraints including logistical and fiscal resource constraints, that must be considered before a program can be implemented. Obtaining all the necessary data without rework is the goal of the DQO Process and the resulting work plan.

During the DQO Process initial sampling and analysis design options were discussed. However, the sampling designs were not optimized. The optimized design will be proposed by the contractor and agreed upon by the PLP and Ecology.

7.1 SAMPLING DESIGN

7.1.1 Initial Design Option

Appendix E presents the initial design option discussed during the DQO Process. It is included to allow the contractor to benefit from the previous discussions but it is not the optimized design. Section 7.1.2 presents the requirements for the optimization.

7.1.2 Criteria for Final Optimized Design

Since completion of the DQO meetings, new information has become available, causing the WDOE to refine the sampling strategy described in Section 7.1.1. The sampling strategies provided above might serve as guidance for the RI/FS which will be conducted at the LLRW Site. However, the Scope of Work developed for the MTCA Agreed Order will need to comply with the regulatory requirements in WAC 173-340, incorporate criteria from guidance documents as applicable, use existing data when possible, and take into account field considerations.

This DQO does not specify a sampling strategy for the RI/FS process. Rather this DQO is recommending the following documents be used in conjunction with information presented in this DQO report to develop a Scope of Work which incorporates conditions specific to each temporal and spatial division of the LLRW Site.

Resin Tank Area

The sampling and analysis plan must be based on requirements in WAC 173-340 and will reflect appropriate application of the *Guidance on Sampling and Data Analysis Methods*, WDOE Publication No. 94-49 (WDOE 1995).

Pre 1985 and Inclusive Trench Areas

The sampling and analysis plan for surface/near surface soils should be based on field screening (e.g., GPR, high resistivity resolution, etc.) prior to determining sampling locations for the collection of adequate data to determine compliance with MTCA requirements. The sampling and analysis plan must be based on requirements in WAC 173-340 and will reflect appropriate application of the *Guidance on Sampling and Data Analysis Methods*, WDOE Publication No. 94-49.

The sampling design should also include existing REMP vadose zone wells and slant boreholes for gases in accordance with TO-14 methodology. Sampling frequency should be determined to categorize seasonal variations and identify long-term trends.

Post 1985 Trench Areas

No sampling is required in this area.

Groundwater

The sampling and analysis plan for all existing wells must be based on requirements in WAC 173-340 and will reflect appropriate application of the *Guidance on Sampling and Data Analysis Methods*, WDOE Publication No. 94-49. The plan should also include performance of a dye test of existing wells to help determine groundwater flow and help evaluate groundwater analytical results.

Any data collected during the RI/FS should be evaluated using the analytical considerations called out in WAC 173-303-707. In addition, all data collected during the RI/FS should be used to validate the selected cleanup action, and ensure the compliance monitoring program is designed to ensure the long-term integrity of the containment system. Per MTCA, a health and safety plan will be required. This health and safety plan will also include applicable health physics and radiological monitoring.

7.2 ANALYTICAL APPROACH

Tables 1-3 through 1-8 list the analytes and analytical methods that will be used to evaluate samples from the various media. Tables 3-2, 3-3 and 3-4 provide the reporting limits, accuracy and precision. These are to be used for the appropriate matrix (e.g., soil, groundwater, and soil gas). Table 7-1 identifies the analytical priorities. This prioritization is needed because the volume or mass of sample collected during a sampling event may be much less than the quantity needed to run all the analyses desired. The prioritization will allow field staff to get the most desirable data. In addition, there is a different list of analytical priorities for the soil samples from the trench area versus those from the resin tank area. This is because the need for organic analyses is anticipated to be more critical in the resin tank area.

The data validation is performed by a qualified third party validator, not employed by the laboratory. The validation will be performed per Level C of *Data Validation Procedure for Chemical Analysis*; BNI-01435, which is, based on the EPA Functional Validation Guidelines. Level C provides review of the data review performed by the laboratory and summary QC. Should significant problems, such as method blanks with contamination well above allowable limits occur, more extensive validation such as levels D may be required. Ten percent of the data will be validated per Level C, unless more extensive validation is required.

Table 7-1. Analysis Priorities.

Priorities For Trench Area	Priorities For Resin Area
VOA	VOA
Hg	SVOC
Metals other than Hg	PAH
SVOC	PCB
PCB	Metals
PAH	Hg
Anions	Anions
Hexavalent Cr	TPH
TPH	Hexavalent Cr

7.3 PHYSICAL PROPERTIES

Data that will define the physical properties of site soils will be collected if sufficient sample volume is available to provide input for the design of the site cap. The physical properties to be evaluated by the contractor and agreed upon before collection are listed in Tables 3-5 and 3-6 if not already provided in the EIS (WDOE 2000a).

8.0 REFERENCES

- Baker, V.R., 1973, *Paleohydrology and Sedimentology of Lake Missoula Flooding in Eastern Washington*, Geological Society of America
- Bergeron, Last, Reisenauer, 1987
- Bretz, J.H., 1923, "Channeled Scablands of the Columbia Plateau"
- BHI, 2000, *Data Validation Procedure for Chemical Analysis*, BHI-01435, Bechtel Hanford, Inc., Richland, Washington.
- CH2M Hill, 1986
- DOE, 1993, *Hanford Federal Facility State of Washington Leased Land*, DOE/RL-93-76, Department of Energy, Richland Operations Office, Richland, Washington.
- EPA, 1992, *Framework For Ecological Risk Assessment*, Risk Assessment Forum, EPA/630/R-92/001, Washington, D.C.
- Fecht, K.R., B.N. Bjornstad, D.G. Horton, G.V. Last, K.A. Lindsey, S.P. Reidel, 1999, *Clastic Injection Dikes of the Pasco Basin and Vicinity*, Bechtel Hanford, Inc., Richland, Washington.
- Kirner, 1999, *Final Chemical Risk Assessment for The Commercial Low Level Radioactive Waste Disposal Facility, Richland, Washington*. Kirner Consulting, Inc., Tacoma, Washington.
- Klein, K.A., D.R. Einar, and M.A. Wilson, 2002, "Consensus Advice #132: Exposure Scenarios Task Force on the 200 Area," letter to T. Martin of the Hanford Advisory Board, dated July 11, 2002, 02-HAB-0006, Richland, Washington.
- Martin, T., 2002, "Exposure Scenarios Task Force on the 200 Area," letter to K. Klein (US Department of Energy, Richland Operations), H. Boston (US Department of Energy, Office of River Protection), J. Iani (US Environmental Protection Agency, Region 10), and T. Fitzsimmons (Washington State Department of Ecology), dated June 7, 2002, Richland, Washington.
- Myers, C.W., J.A. Caggiano, S.M. Price, 1979, *Geologic Studies of the Columbia Plateau: A Status Report*, Rockwell Hanford Company, Richland, Washington.
- Neitzel, D.A., et al, 1996, *Hanford Site National Environmental Policy Act (NEPA) Characterization*, PNL-6415, Rev. 9, Pacific Northwest National Laboratory, Richland, Washington.

- NRC, 1983, *Risk Assessment in the Federal Government: Managing the Process*, National Academy Press, Washington, D.C.
- PNNL, 2002, *Transient Effects of Hanford Waste Water Discharges on Unconfined Aquifer 1943 to 1996*, Pacific Northwest National Laboratory, Richland, Washington.
- San Juan, C., 1994, *National Background Soil Metals Concentrations in Washington State*, WDOE, Pub. No. 94-115, Olympia, Washington.
- Suter, G.W., R.A. Efrogmson, B.E. Sample, and D.S. Jones, 2000, *Ecological Risk Assessment for Contaminated Sites*, Lewis Pub., Boca Raton, FL
- Tallman, A.M., K.R. Fecht, M.C. Marratt, 1979, *Geology of the Separations Areas Hanford Site, South-Central Washington*, Rockwell Hanford Company, Richland, Washington.
- Tri-Party Agreement Letter, dated July 11, 2002 to Todd Martin, Hanford Advisory Board.
- US DOE, 1992, *Hanford Site Groundwater Background*, DOE/RL-92-93, Richland, Washington.
- US DOE, 1995, *Hanford Site Background, Part I, Soil Background for Non-Radiological Analytes*, DOE/RL-92-24, Rev. 3, Richland, Washington.
- USE, 1988, letter to C.E. Ingersoll of the Office of Radiation Protection Department of Social & Health Services and R. Stnaley of the Washington Department of Ecology, dated August 4 1988.
- USE, 1998, *US Ecology 1998 Site Investigation Design Summary*, US Ecology, Inc., Richland, Washington.
- USE, 1999, *Site Investigation Soil Chemistry Data Summary*, US Ecology, Inc., Richland, Washington.
- USE, 2003, *Annual Environmental Monitoring Report for Calendar Year 2002*, US Ecology, Richland Washington.
- USE, 2003, *Perpetual Care & Maintenance Surety Cost Analysis, Low-Level Radioactive Waste Facility US Ecology*, Richland, Washington, S. Jamil Ahmad, February 2003.
- WAC 173-303, "Dangerous Waste Characteristics," *Dangerous Waste Regulations*, Washington Administrative Code, as amended.
- WAC 173-340," Model Toxics Control Act – Cleanup", *Dangerous Waste Regulations*, Washington Administrative Code, as amended.
- WAC 173-351, "Criteria for Municipal Solid Waste Landfills," *Dangerous Waste Regulations*, Washington Administrative Code, as amended.

WDOE, 1995, *Washington State Department of Ecology Toxics Cleanup Program: Guidance on Sampling and Data Analysis Methods*, Pub. No. 94-49, Washington State Department of Ecology, Olympia, Washington.

WDOE, 1999, *Washington State Department of Ecology Toxics Cleanup Program: Statistical Guidance for Ecology Site Managers*, Washington State Department of Ecology, Olympia, Washington.

WDOE, 2000a, *Draft Environmental Impact Statement*, Washington State Department of Ecology, Richland, Washington.

WDOE, 2000b, *Model Toxics Control Act Cleanup Levels and Risk Calculations (CLARC III) Update*, Washington State Department of Ecology, Olympia, Washington.

WDOE, 2001a, *Model Toxics Control Act Cleanup Regulation*, Chapter WAC 173-340 WAC. Pub. No. 94-06, Olympia, W Washington.

WDOE, 2001b, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, Washington State Department of Ecology, Olympia, Washington.

WDOE, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

WDOH, Letter dated 2/19/97, Maxine Dunkelman

WDOH, 1997, *Hanford Guidance for Radiological Cleanup*, WDOH/320-015, Olympia, Washington.

WDOH, 2000, *Radiological Risk Assessment: Low Level Radioactive Waste Disposal Site*, Richland, Washington.

APPENDIX A

**DOCUMENT REVIEW REGARDING HAZARDOUS CHEMICAL
CHARACTERISTICS OF LOW-LEVEL WASTE**

Figure A-1

Table 4.3
Summary of Chemicals Present in Non-Fuel-Cycle Wastes(7)

Scintillation Vials	Other Liquids	Solid Waste	Biological Waste
toluene ^{a,b} xylene ^b sodium hydroxide methanol ^b (small amounts) aqueous POP	spent scintillation fluids (=50% of other liquids) alcohols benzene ^a ethyl acetate ^b RIA kit which may contain: ammonium sulfate sodium barbital sodium azide other ammonium salts sulfonic acids colloids stannous polyphosphate stannous glucoheptonate amino sugars amino acids nucleosides nucleotides protein hydrolysates pyruvic acid sodium bicarbonate anthracene compounds ^a phosphoric acid iodoacetic acid	cellulose PVC plastics rubber glass metal filings other trash	animal carcasses cultures disinfected with: bleach (sodium hypochlorite) phenol solutions ^a iodine based solution contaminated animal wastes
	Bolton-Hunter reagent iododeoxy uridine organic phosphates ortho phosphates methionine tritiated thymidine ethidium bromide (intercalating dye) paraformaldehyde (PMS) ethylene diamine tetraacetic acid (EDTA) other C-14 and H-3 labeled organic compounds		

^aLimited in Appendix VIII, 40 CFR Part 261 as hazardous constituents.
^bLimited in 40 CFR Section 261.31, Hazardous wastes from non-specific sources.

Figure A-2

Table 4.5

Chemical Constituents Identified in Fuel Cycle Low-Level Waste

<u>Organic Compounds</u>	<u>Elemental Species</u>
asphalt (solidification agents)	barium - 137m, 139, 140 ^b
urea-formaldehyde resin ^a (may contain alkali metal bisulfates)	bromine - 84
carboxylic acids (decontamination chemicals)	cerium - 144
chelating agents (NTA, EDTA, DTPA, TTHA)	cesium - 134, 136, 137, 138
ion-exchange resins (sulfonated and aminated organic polymers; modified polystyrenes, copolymers of divinyl benzene and styrene are typical substrates)	chloride (Cl ⁻)
phthalates (for filter testing)	chromium - 51 ^b
vinyl ester-styrene	oxide or hydrated oxide
	cobalt - 58, 60
	oxide or hydrated oxide
	copper
	fluoride (F ⁻), metallic fluorides
	iodine - 129, 131, 132, 133, 134, 135
	iron - 55, 59
	oxide or hydrated oxide
	lanthanum - 140
	magnesium
	manganese - 54
	oxide or hydrated oxide
	molybdenum - 99
	niobium - 95
	plutonium
	rubidium - 103, 106
	strontium - 89, 90, 91, 92
	uranium
	natural U and daughters
	tellurium - 132, 134
	thorium
	tritium
	yttrium - 90, 91
	zinc
	zirconium - 95
	oxide or hydrated oxide

^aAt this writing, urea-formaldehyde resins are not used as a solidification agent by the nuclear industry.

^bElement and compounds not otherwise specified are listed in Appendix VIII, 40 CFR Part 261 as hazardous constituents.

In conclusion, the GRC report gives limited information on the chemical characteristics of LLW. A wide variety of chemicals are listed but quantitative data regarding the amounts of these chemicals in particular waste streams

Figure A-3

Midwest Research Institute

Table 4.26
Solvents Present in MRI Radwaste Shipments⁽³²⁾

Listed in
Appendix VIII,
40 CFR, Part 261

Acetone	
Chloroform	X
Benzene	X
Toluene	X
Ethanol	
Methanol	
Acetonitrile	X
Acetic acid	
Trifluoroacetic acid	
Diethyl ether	
Methylene chloride	
Tetrahydrofuran	
Hexane and related solvents ^a	
N,N-Dimethylformamide	
Triethylamine	
2-Butanone	
DMSO	
Ethyl acetate	
Isooctane	
Water (other than THO) ^b	
Methyl t-butyl ether	
Dioxane	X
Pyridine	X

^aCyclohexane, petroleum ethers.
^bAcidic and basic pH.

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APPENDIX B
LLRW WATER LEVEL EXPLORATION

LLRW Water Level Exploration

WELL	Well Casing elev.	Well TD	Screen length	TD elev.	Screen top elev.	Water elev.	Depth of water in well	Useful life* (years)	Rate of Water level decline (ft/year)
3	725.73	354.40	40	371.33	411.33	399.7	45.3	37	0.47
5	721.70	353.00	40	368.70	408.70	399.9	46.8	42	0.43
8	724.48	353.30	40	371.18	411.18	399.9	46.4	37	0.47
9	722.10	352.33	29	369.77	398.77	403.4	51.2	47	0.40
9a	722.20	377.53	29	344.67	373.67	403.5	25.9	98	0.40
10	734.20	364.70	40	369.50	409.50	399.3	34.7	40	0.48
13	723.54	352.20	40	371.34	411.34	404.7	53.2	47	0.38

*Useful life calculated assuming:

Rate of water level decline = 0.5 feet/year

Need 10 feet of water left in well.

APPENDIX C
MTCA CLEANUP PRIMER

MTCA Cleanup Primer

MTCA requires the initial identification and assessment of a newly discovered site of contamination (WAC 173-340-300 & 310) and a site hazard assessment and hazard ranking (173-340-320 & 330). Once ranked, the remedial investigation and feasibility study (RI/FS) phase begins (WAC 173-340-350). This phase includes sampling and collecting data and a comparison of the contaminant levels to a set of exposure pathways designed to protect human health and the environment. The determination as to which cleanup method to apply at a waste site involves the evaluation of the contaminants present, pathways of exposure and the current and potential future use of the site.

The first step in determining current and potential future use of the Site is to determine the existing zoning. Once land-use or applicability has been established, further evaluation is necessary to determine which of the three Methods under MTCA is appropriate. However, **land-use zoning is not the only criterion that determines cleanup levels under MTCA**. MTCA contains three cleanup Methods: Method A - “ARARs and Tables”; Method B - “Universal Method” divided into two tiers the standard and modified; and Method C - “Conditional Method” divided into two tiers the standard and modified. Because Method A can only be used at sites with few hazardous substances which are undergoing “routine” cleanup (WAC 173-340-704(1), Method A is not used at Hanford. By default, most Hanford cleanups will implement Method B. However, if a site meets the definition of “industrial” captured in 173-340-200 (and by reference WAC 173-340-745), MTCA Method C cleanup levels may be used. Note: There are exceptions in MTCA for the use of Method C cleanup levels for soil if soil cleanup to Method B universal cleanup levels pose a greater risk to the environment. (See 173-340-706)

For those sites where Method A is not applicable, or appropriate, MTCA provides procedures for calculating universal (Method B) and conditional (Method C) exposure cleanup levels. Developing Method B and C cleanup levels involves several steps:

1. Determining reasonable maximum exposure according to WAC 173-340-708 (3);
2. Taking into account potential cross-media contamination; and
3. Determining what substances contribute to overall risks at a site (indicator hazardous substances) according to WAC 173-340-708 (2).

During any remediation the overall hazard index must not exceed one (1) and overall total excess cancer risk must not exceed one in one hundred thousand (1×10^{-5}) cumulative risk and 1×10^{-6} risk for individual constituents (WAC 173-340-705 (4) and -706 (4) and CLARC III) (WDOE 2000b). In some situations, cleanup levels for individual hazardous substances must be adjusted downward to take into account exposure to multiple hazardous substances and/or exposure resulting from more than one pathway, inclusive of radiation [WAC 173-340-740(5)].

Universal Method B must be used when:

1. The site does not meet the conditions for Method A;
2. The site does not meet the conditions for Method C;

3. A “residential” exposure scenario is chosen (WAC 173-340-740); and
4. Unrestricted land-use is preferred (i.e., no institutional controls or deed restrictions).

Method B requires residential exposure risk calculations [173-340-740 (3)] to determine the contaminant-specific cleanup level to be achieved. The WDOE has used these formulas to calculate the cleanup levels necessary for a wide range of constituents at the required 1×10^{-6} risk level. These cleanup levels are found in the CLARC III database (WDOE 2000b).

Conditional Method C may be used when:

Method C is only applicable to those sites that meet the criteria specified in WAC 173-340-706. However, special consideration is given to “industrial” soil cleanups under WAC 173-340-706(1)(b), as long as the property is designated an industrial property and meets the criteria for establishing industrial soil cleanup levels under 173-340-745. Method C cleanup levels are primarily used for industrial cleanups. Method C cleanup levels can be established by the WDOE if the PLP can demonstrate that:

- A. The levels comply with applicable state and federal laws
- B. All practicable methods of treatment will be utilized
- C. Institutional controls are implemented (as required by WAC 173-340-440), **AND**
- D. One or more of the following conditions exist:
 1. Method A or B cleanup levels are below background concentrations, then background concentrations can be used as a default, or
 2. Meeting Method A or B cleanup levels has potential to create a greater overall threat to the environment, or
 3. Method A or B cleanup levels are below technically possible concentrations.

Site cleanups establishing Method C cleanup levels must have restrictions placed on the property (institutional controls) to ensure future protection of human health and the environment. Once these conditions are met, Method C cleanup levels can be used.

Although Method C cleanup levels may be deemed applicable for one medium, they may not be applicable for all media. Therefore, when establishing cleanup levels under Method C, the requirements of WAC 173-340-708 must also be met. WAC 173-340-708 (6) delineates the evaluation of multiple pathways of exposure. The WDOE has provided Method C cleanup levels in the CLARC III database based on individual risk calculations of one in one hundred thousand.

While the approach for selecting cleanup standards under MTCA is fairly rigid, the approaches that may be used to meet/achieve cleanup standards are much more flexible. People conducting cleanups may use different methods for determining cleanup levels for different contaminants; however, there are limitations to method mixing. When using Method B, Method A cleanup levels may be used but not Method C cleanup levels. When using Method C, Method A or B cleanup levels may be used. No matter what Method or combination of Methods may be used, cleanup levels must be established so that the overall hazard index for a site does not exceed one (1) and overall total excess cancer risk for a site does not exceed one in one hundred thousand (1×10^{-5}). MTCA identifies that all pathways must be evaluated when selecting cleanup standards. The CLARC III database provides cleanup levels for soil, water, air and groundwater. Each medium must be evaluated separately (WDOE 2000b).

The Cleanup Levels and Risk Calculations (CLARC) tables' cleanup levels

MTCA provides risk-based formulas that are used to calculate cleanup levels. For contaminants with available chemical specific data, the calculations for groundwater, soil, and surface water appear in the Cleanup Levels and Risk Calculation (CLARC III) database. The CLARC III database should be used whenever possible, but for some contaminants not listed in CLARC III, it may not be possible to calculate chemical-specific cleanup levels. However, MTCA includes all contaminants and is not limited to only those contaminants identified in the CLARC III database. In some instances, it may be necessary to use surrogates, or a limited "target contaminant" list, when formula cleanup levels are not available. If a chemical does not have a cleanup level listed in one of the MTCA CLARC III Tables for Method A, B, or C, it does not mean there is no cleanup level. Natural background and practical quantitation limits may also be used in accordance with agency guidance (WDOE 2000b).

Cleanup standards, cleanup levels, and remediation levels explained

Cleanup standards are established to protect human health and the environment from exposure to hazardous substances via multiple pathways (e.g., direct contact, ground water, surface water) and to provide a uniform, statewide approach to cleanups that can be applied on a site-by-site basis.

Cleanup standards are established by answering three questions:

1. Will Method B or Method C be used?
2. Where is the point of compliance?
3. What are the applicable, relevant and appropriate requirements that are more stringent than MTCA levels?

Examples of a cleanup standard would be an overall hazard index for a site which does not exceed one (1) or an overall total excess cancer risk for a site which does not exceed 1×10^{-5} . The point of compliance is the physical location on site (as defined in WAC 173-340-200) where cleanup standards must be met. In most cases, cleanup levels will be required to be met everywhere on site [see WAC 173-340-740(6)]. However, in some cases, the point of compliance may be set at the facility boundary or another location on site. The point of compliance is generally established through the RI/FS process and formalized in the proposed cleanup plan/record of decision.

Cleanup levels are the concentrations of hazardous substances that may be left on site without posing an unacceptable risk to human health or the environment. Cleanup levels are established by answering three questions:

1. What are the hazardous substances on the site and how much (concentration and volume/mass)?
2. What are the pathways for release and exposure?
3. What are the results of the risk assessment (Method B or C) for the constituents of concern?

Cleanup levels can generally be found in the CLARC III database. However, the WDOE may set more stringent cleanup levels at some sites, adjusting the levels downward to account for multiple pathways of exposure from multiple constituents of concern (WDOE 2000b).

Remediation levels are applicable at sites where contamination will remain above cleanup standards because of technological limitations. A combination of technologies may be used at any site, based on the different constituents of concern and the affected media. The actual selection of technologies is very site specific. A cleanup action selected for a site will often involve a combination of cleanup activities, such as treatment of some soil contamination and containment of the remainder. Remediation levels are used to identify the concentrations of hazardous substances at which different cleanup action components will be used.

For example, a cleanup action that uses both soil treatment and containment will have a soil remediation level above which soil will be treated, and below which the contaminants will be contained. Remediation levels are not the same as cleanup levels. Remediation levels are used in a sequential fashion to reach the final cleanup level at the point of compliance. While cleanup levels are selected for **all** sites, remediation levels may, or may not be selected, depending on the situation. If a permanent cleanup action is the remedy selected for the site, then no remediation level is necessary.

Selection of a final cleanup action that includes a remediation level requires a determination that each of the minimum requirements specified in WAC 173-340-360 is met, including the requirement that all cleanup actions must comply with cleanup standards.

Point of Compliance

Ground water. In accordance with WAC 173-340-720(8) the point of compliance is the point or points where the ground water cleanup levels established under subsection 3 (Method A cleanup levels for potable ground water), subsection 4 (Standard Method B potable ground water cleanup levels), subsection 5 (Method C cleanup levels for potable ground water), or subsection 6 (Cleanup levels for non-potable ground water) must be attained for a site to be in compliance with the cleanup STANDARDS.

The standard point of compliance shall be established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site. Ground water cleanup levels shall be attained in all ground waters from the point of compliance to the outer boundary of the hazardous substance plume.

MTCA **does not** stipulate that the property boundary should be used as the POC. WAC 173-340-720 requires the point of compliance to be established throughout the site, and allows for **approval** of a conditional point of compliance where hazardous substances remain on site as part of the cleanup action (landfill). A conditional point of compliance (CPC) may be established in accordance with WAC 173-340-720(8)(c) when it is not practicable to meet the cleanup level throughout the site within a reasonable restoration time frame. The department may approve a conditional point of compliance that shall be as close as practicable to the source of hazardous substances, and except as provided under (d) of this subsection (off property CPC) not to exceed the property boundary. You have to evaluate the conditional POC with the selection of cleanup alternatives. Where a conditional point of compliance is proposed, the person responsible for undertaking the cleanup action shall demonstrate that all practicable methods of treatment are to be used in the site cleanup. A conditional point of compliance could meet cleanup standards by using a deed restriction, institutional controls, and all practicable methods of treatment (all have to be in place).

When you are developing cleanup levels and standards during the RI/FS stage, it will be assumed that the point of compliance will be throughout the site. If they are above the cleanup levels with the cleanup level being established throughout the site, the WDOE and PLP move into remedy selection and start looking at the different alternatives. At that point in time, the WDOE and the PLP can start looking at remedy alternatives that can include moving the point of compliance to the property boundary but as close to possible to the source of the hazardous substance but not to exceed the property boundary.

A CPC may be established off property in 3 circumstances.

- a. Property abuts surface water
- b. Property near, but not abutting surface water
- c. Area wide brownfield (multiple sites impractical to address separately)

Soil points of compliance depend on exposure pathway. For soil cleanup levels based on the protection of ground water, the point of compliance shall be established in the soils throughout the site.

For soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to fifteen feet below the ground surface.

For soil cleanup levels based on protection from vapors, the point of compliance shall be established in the soil throughout the site from the ground surface to the uppermost ground water saturated zone.

In accordance with WAC 173-340-740 and 745, cleanup standards for soil must use the “reasonable maximum exposure” (RME) (defined as residential land use for most sites). “Unless a site qualifies for use of Industrial soil under 745 soil cleanup levels shall use residential (740 (1) (a)).”

To establish the future and current RME scenario three questions that need to be answered prior to considering the RME Industrial Scenario (Method C):

1. What is the likelihood that the RME scenario would change in the near future?
2. What are the potential adverse affects on ecology/wildlife using Method C - 173-340-7490-7494?
3. What considerations need to be taken for the protection of ground water (go to 745 (1) (iv))?

APPENDIX D
INVESTIGATION COST ESTIMATE

Investigation Cost Estimate	Hourly \$	# of Hours	Flat Rate	Daily Rate	# of Days	Price/Unit	# of Units	Price/Sample	# of Samples	Total
<u>Prime Contract Expenses</u>										
Professional Oversight, including: Project Management, field Supervision, Correspondence, Agency Liaison										
Corporate Management	\$135	50								\$6,750
Project Management	\$95	120								\$11,400
Sr. Project Manager	\$75	1040								\$78,000
Certified Health Physicist/Industrial Hygienist	\$70	640								\$44,800
Administrative Services	\$35	640								\$22,400
Expendable Equipment				\$200	130					\$26,000
Copies/fax/phone/postage...			\$3,000							\$3,000
Document Preparation/Review/Revision										
Focused Feasibility Study			\$55,000							\$55,000
Health and Safety Plan			\$35,000							\$35,000
RI Work Plan			\$45,000							\$45,000
Quality Assurance PjP			\$40,000							\$40,000
RI Report			\$60,000							\$60,000
Air Monitoring Report			\$15,000							\$15,000
Risk Assessment			\$200,000							\$200,000
Mobilization of Equipment and Facilities			\$4,000							\$4,000
Mobilization of Personnel			\$3,500							\$3,500
Demobilization of Equipment and Facilities			\$4,000							\$4,000
Demobilization of Personnel			\$3,000							\$3,000
Laboratory Audits			\$10,000							\$10,000
Data Validation			\$20,000							\$20,000
										\$686,850

Investigation Cost Estimate	Hourly \$	# of Hours	Flat Rate	Daily Rate	# of Days	Price/Unit	# of Units	Price/Sample	# of Samples	Total
<u>Subcontractor Expenses</u>										
GPR										
Mobilization			\$1,000							\$1,000
Equipment Rental				\$750	10					\$7,500
Data Collection				\$1500	10					\$15,000
Data Processing				\$1,500	10					\$15,000
Per Diem (for two)				\$170	10					\$1,700
Analysis and Reporting Costs			\$5,000							\$5,000
										\$45,200
Geoprobe										
Mobilization			\$2,000							\$2,000
Installation Cost/probe						\$1,000	64			\$64,000
Sampling Costs/probe						\$500	64			\$32,000
Cost of Soil Analysis/sample								\$650	64	\$41,600
Cost of Soil Gas Analysis/sample								\$200	64	\$12,800
Per Diem (for two)				\$170	35					\$5,950
Data Analysis and Site Report			\$30,000							\$30,000
										\$188,350
Gas Sampling at Existing Boreholes										
Sample Collection Disposables				\$200	26					\$5,200
Sample Technician to collect sample	\$70	26								\$1,820
Cost of Soil Gas Analysis/sample @ 25'								\$200	117	\$23,400
Cost of Soil Gas Analysis/sample @ 45'								\$200	143	\$28,600
										\$59,020

Investigation Cost Estimate	Hourly \$	# of Hours	Flat Rate	Daily Rate	# of Days	Price/ Unit	# of Units	Price/ Sample	# of Samples	Total
Slant Borehole										
Drilling Cost/borehole						\$46,800	2			\$93,600
Site Geologist	\$70	160								\$11,200
Sample Collection Disposables				\$200	15					\$3,000
Cost of Soil Analysis/sample								\$1,225	40	\$49,000
Cost of Physical Analysis/sample								\$150	40	\$6,000
Cost of Soil Gas Analysis/sample during drilling								\$200	20	\$4,000
Per Diem (for three)				\$255	15					\$3,825
Cost of Soil Gas Analysis/sample for monitoring at the 25' screen								\$200	26	\$5,200
Cost of Soil Gas Analysis/sample for monitoring at the 45' screen								\$200	26	\$5,200
Dye Test			\$5,000							\$181,025
Groundwater Well										
Drilling Cost/borehole						\$126,000	2			\$252,000
Site Geologist	\$70	200								\$14,000
Sample Collection Disposables				\$200	21					\$4,200
Cost of Soil Analysis/sample								\$1,225	10	\$12,250
Cost of Soil Gas Analysis/sample								\$200	14	\$2,800
Cost of Groundwater Analysis/sample								\$1,225	16	\$19,600
Per Diem (for three)				\$255	21					\$5,355
GW Monitoring at Existing Wells										\$310,205
Sample Collection Disposables				\$200	8					\$1,600
Sample Technician to Collect Samples	\$70	8								\$560
Cost of Groundwater Analysis/sample								\$1,225	40	\$49,000
										\$51,160

Investigation Cost Estimate	Hourly \$	# of Hours	Flat Rate	Daily Rate	# of Days	Price/ Unit	# of Units	Price/ Sample	# of Samples	Total
Total										\$1,526,810
15% Contingency										\$1,755,832
B & O Tax (3.5%)										\$1,817,286
<u>Assumptions</u>										
Core Investigation lasts 6 months (1040 hours)										
Field Work Lasts 4 months (640 hours)										
US Ecology will provide temporary facilities for prime and subcontractors										
GPR rate 1,500 linear feet sampled/day										
Geoprobe installed at a rate of 2/day										
Drilling costs \$360/linear foot, independent of angle										
Drilling rates include 2 employees for operation										
Per Diem Rate is government rate (\$85/day)										

APPENDIX E
INITIAL DESIGNS DISCUSSED DURING THE DQO PROCESS

During the DQO process, the WDOE presented Table C-1, which provides the maximum number and type of sample locations to support the remedial investigation. Table C-1 lists the area of interest within the LLRW Site, draft trench information, potential location and number of samples, sample logic, and estimated costs. The detailed sampling and analytical program is expected to incorporate some of the elements of Table C-1. Table C-1 also links the information to be developed from the samples to the appropriate DS#. Appendix D is an Excel spreadsheet with additional cost estimates and calculations. It was emphasized in the course of the DQO workgroup meetings that the considered designs likely include more sampling than will ultimately be performed.

The general approach was to use GPR to identify any preferential pathways due to clastic dikes and sub-surface characterization. This will be done around the perimeters of most trenches as shown in Figure C-1. Depending upon the data developed from these investigations, additional sampling may be required in specific areas beyond what has been identified in Table C-1.

During the discussion of the sampling design the following consensus agreements were developed:

- The design focuses on sampling from three zones: around the trenches, the resin tank area, and the groundwater.
- No sampling will be done through the trenches nor will samples be collected in any areas where drillers or the drilling rig may encounter buried waste.
- The trenches ultimately will be capped; however, no cap is foreseen over the resin tank area. Capping the resin tank area would prohibit vehicle access to the other trenches and this cannot be done while active burial is still occurring at the site. For this reason, another interim alternative may be necessary. The RI/FS should also generate data that will allow an evaluation of whether a cap is needed for the final remedy of the resin tank area.
- The water overflow that flooded the resin tank area and the area along the northeast corner of the site may have caused vadose zone contamination; non-rad data that meet today's QA/QC criteria are not available for this area. Sampling the resin tank area was a higher priority because of the lack of data that meet current QC criteria.
- It is most likely that any new wells, resulting from the feasibility study process, will become part of the long term monitoring system. The determination on the need for additional groundwater monitoring wells will not be made until the RI/FS process is complete.

Geoprobos will be used around the trenches to assess contamination in the vadose zone as shown in Figure C-2. In addition, soil gas will be collected from these areas. Using the data from the geoprobos and GPR, slanted borings will be located where the potential for contamination seems highest. These locations may differ from those presented in Figure C-3. The need for, and location of, any new wells will be determined after a dye test has been performed.

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample		Logic	Cost Estimate	
			Location	# of sample locations			
1,3	Areas around the trenches and around the resin tanks		Perform GPR around trenches, edges of trenches, and to define resin tank locations. Do not perform on top of trenches Do around boundaries of trenches, around resin tanks area. Make sure roads are NOT watered before GPR is done. Sample soil gas from existing well VW-100. Sample August through January, biweekly	Site wide	0	GPR will take approximately 10 days to complete. It will provide preferential pathways, subsurface anomalies, grain sizes, and moisture content Trench 12 will be the next open trench (GPR may be minimized in this area depending upon activities)	\$44,200
1,3	Trenches 16 & 18	Trench 18 active now. Elastic Dike was observed in 2002 photograph.	Geoprobe south end and east side of trench.	3	6		\$7,100
1,3	Trench 13 & 14	West portion of Trench 14A active now.	Geoprobe on both east and west ends of trenches, north side of trench 13, and southern property boundary.	7	14		\$16,500
1,3	Trench 12	Sample to confirm no mixed waste is present. Trojan reactor disposed August 1999 – No Action – 8,490 ft ³ w/1.54 million curies.				Rad only disposal	
1,3	Trench 11A	Contain mixed waste, including drums from closeout of resin tank area.	Place one probe on east side and one probe on south side of trench.	2	4	2000 drums of resins in the trench. Characterization of the vadose zone under the trench is needed.	\$4,700
1,3	Trench 11B	Active, now in use. Contains caissons (vertically placed corrugated steel culverts) as described in trenches 4A&B.	Potential slanted boring on the east side. Two Geoprobos on west side	2	4	Old but open, drums in trench	\$4,700

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample			Cost Estimate
			Location	# of sample locations	# lab samples	
1,3, 6, 8, 10	10	Likely to contain scintillation fluids. Contains mixed waste	Geoprobe w/potential slant boring, east and west side of trench, also between trenches 10, 11A, and 11B Collect soil gas samples August through January, biweekly at VW-102 well	4 1 sample 26 weeks 13 events	8 13	\$9,000 \$2,600
1,3	9	Likely to contain scintillation fluids. Contains mixed waste.	Geoprobe east and west ends (corner/mid-line/corner)	6	12	\$14,000
1,3	8	Likely to contain scintillation fluids. Contains mixed waste.	Geoprobe east and west sides (potential slant boring site)	2	4	\$4,700
1,3	7	Likely to contain scintillation fluids. Contains mixed waste	Geoprobe east and west ends at midpoint	2	4	\$4,700
1,3	6	Likely to contain scintillation fluids. Contains mixed waste	Geoprobe east and west ends, and at midpoint on north side.	3	6	\$7,100
1,3	7A	Glove boxes in concrete and a stabilized liner.	Trench 7A was open from 6/31/85 – 7/16/85, has 14 metal glove-boxes that are inside engineered concrete barriers, and 1 solidified resin liner in it.			
1,3	RXT	Metal head of the reactor and steel reactor vessel, no fuel is in the trench				
6,8, 10	5	Known to have containerized/absorbed liquids disposed in the trench. Contains scintillation fluids. Contains mixed waste.	Resample soil gas from existing borings, including VW-101. At both the 25 and 45 foot screens Sample August through January, biweekly.	10 sample 26 weeks 13 events	130	\$26,000

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample			Cost Estimate
			Location	# of sample locations	# lab samples	
1,3	4A&B	May contain mixed waste. Trench 4A, which was open from 4/30/82-6/18/82, was designed for dewatered feedwater heaters from J.A. Fitzpatrick power plant. Trench 4B, open from 7/9/84-8/23/85, contains the contents of six (6) IF-300 shipping casks that contained activated hardware (very high radiation levels). There are four caissons (not wells); two were used for the disposal of "hot sources". The caissons are four 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.	Place Geoprobe at mid-point on east and west ends of trenches. Place trench 4A Geoprobe as close to 4B caissons as possible.	4	8	\$9,400
1,3	1-4	Contain waste in metal drums, fiber-board drums, and cardboard boxes. Likely to contain scintillation fluids. Contains mixed waste.	Perimeter Geoprobos on north, east and west sides of trenches 1, 2, 3, and 4.	11	22	\$22,000
6,8, 10	Chemical	Known to have 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 cu ft of non-rad material.	Geophysical wells already present. Collect soil gas samples August through January, biweekly, from all four wells. At both the 25 and 45 foot screens	8 samples 26 weeks 13 events	104	\$20,800

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample		Logic	Cost Estimate	
			Location	# of sample locations			# lab samples
1,3	Resin tank	<p>5 tanks (2-1,000 gal., 3-23,000 gal) built in 1960s, contained liquids from laundering activities and ion exchange resins from Navy nuclear plants.</p> <p>During the 1985 snow runoff pooled water entered the tanks and filled to the riser. Changing liquid levels in the riser indicated liquid release from tanks, estimated at 100-120 gal.</p> <p>Resins removed from tanks in fall 1985, drummed and disposed in trench 11A.</p> <p>Two 1000-gallon tanks were removed. Heels from larger tanks were sampled; waste did designate as WA extremely hazardous waste. The three larger tanks were filled with cement and closed in place due to the high rad levels.</p> <p>In May 1988, eight soil borings were taken adjacent to the underground tanks. Composite samples were analyzed for two out of the eight boring locations with one background composite. One organic was detected in two different composite samples (USE 1988).</p> <p>Five additional holes were drilled and sampled around Tank #1. "There was very good agreement between the rad levels and the extent of discoloration."</p> <p>Tank Farm Trench (resin tank area) closed on August 12, 1988. The disposal unit is 18 feet deep with eight (8) feet of cover above the tanks.</p>	<p>GPR to define the exact boundary of the tanks.</p> <p>Need to define the extent of the runoff contamination from the 1985 event. Set up network of Geoprobos in overflow area</p> <p>Geoprobos around perimeter of resin tank area, Geoprobos must go 10-18ft to get to bottom of tanks.</p> <p>Potential slanted boring under resin tanks.</p>	<p>10</p> <p>4</p>	<p>20</p> <p>8</p>	<p>Over the tanks, 8 feet of clean fill was placed to bring the level back to grade. At most one foot more has been added above grade as an erosion barrier.</p> <p>As for the run-off area to the southeast, further research will be needed by both WDOH and WDOE (records review) to determine how much clean material was brought in to bring the area back up to grade.</p> <p>Five original, three tanks closed in place, filled w/concrete. 8 ft of fill, 18 ft to bottom of tank. How far out did 8ft of fill go?</p> <p>Resin pile on east side of tanks. Need to identify where pile is exactly.</p> <p>No lab data, no QA/QC, only two of eight samples were submitted for laboratory analysis. Composite samples are not appropriate for cleanup verification. Data not defensible for regulatory purposes.</p>	<p>\$23,500</p> <p>\$9,400</p>

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample Location		# of sample locations	# lab samples	Logic	Cost Estimate
6,8, 10	East boundary		Geoprobe for soil gas		4	8	On property boundary to see if contaminants are moving off-site.	\$9,400
2,4a,4b,9,10,13	Groundwater		Dye test MW13, monitor for detection in MW3 and MW9. Need to coordinate dye testing with DOE to ensure data collection from wells #299-E13-11, #299-E13-43, and #699-33-56 (NRDWL?). Drill two additional groundwater monitoring wells Well sampling at all previously existing and new wells, four quarters minimum.		1 2		Section 1.5.3 and Appendix B present the well screening information and water level development information and water level versus screening information. Existing wells appear to be appropriately screened at the water level. Based on 1993-1996 groundwater measurements from MW9A and MW 9 (which were drilled to the lower bound of the aquifer), there is a 90ft saturated zone under the site and a flat groundwater gradient. Different stratigraphy in the soil may explain different concentrations between wells. Data collected in 2000 show tritium contamination in MW13 and MW3 at elevated levels, which are continuing to increase. Measurements in wells MW10, MW8, and MW5 have detected tritium at less than half the levels detected in MW13 and MW3.	\$5,000 \$299,000 \$50,000
				# new wells - TBD after initial quarterly monitoring for COCs. 4 quarters		40		

Table C-1. Proposed Sampling Design. (6 sheets)

DS #	Area	Trench Information	Type sample		Logic	Cost Estimate
			Location	# of sample locations		

Assumptions:

- ∅ \$4000/day for GPR
- ∅ \$2350/geoprobe
- ∅ \$650/sample for geoprobe soil analytical
- ∅ Slant borehole sampling and cost estimate based on previous experience at LLRW. Based on 130ft long borings with sampling at 2.5-ft intervals between 70 and 90-ft bgs and a maximum of 20 samples.
- ∅ all slant boreholes will require soil gas analysis at both the 25 and 45 foot screens
- ∅ Groundwater well cost estimate based on 350ft to groundwater, soil gas samples collected at 10ft intervals between 40 and 100ft bgs (14 samples), soil samples collected at 5ft intervals between 80-100ft bgs (10 samples), and groundwater samples collected at 5ft intervals between 100-110 and 300-320ft bgs (16 samples).
- ∅ \$360/ft to drill a borehole
- ∅ \$200/sample for soil gas analytical
- ∅ \$1225/sample for soil analytical during drilling
- ∅ \$150/sample for soil physical analysis
- ∅ \$1225/sample for groundwater analytical

Figure C-1. Ground Penetrating Radar Areas.

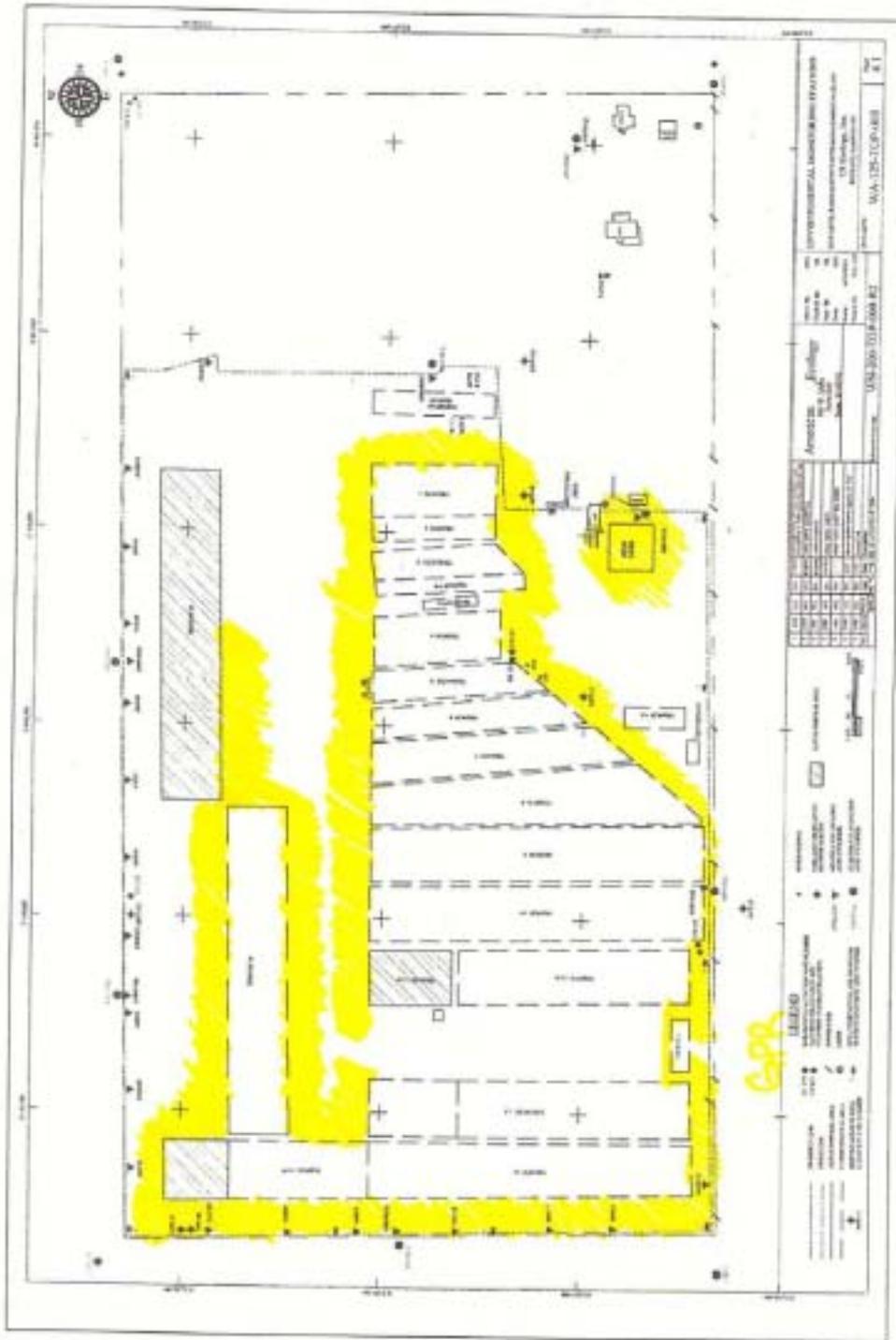
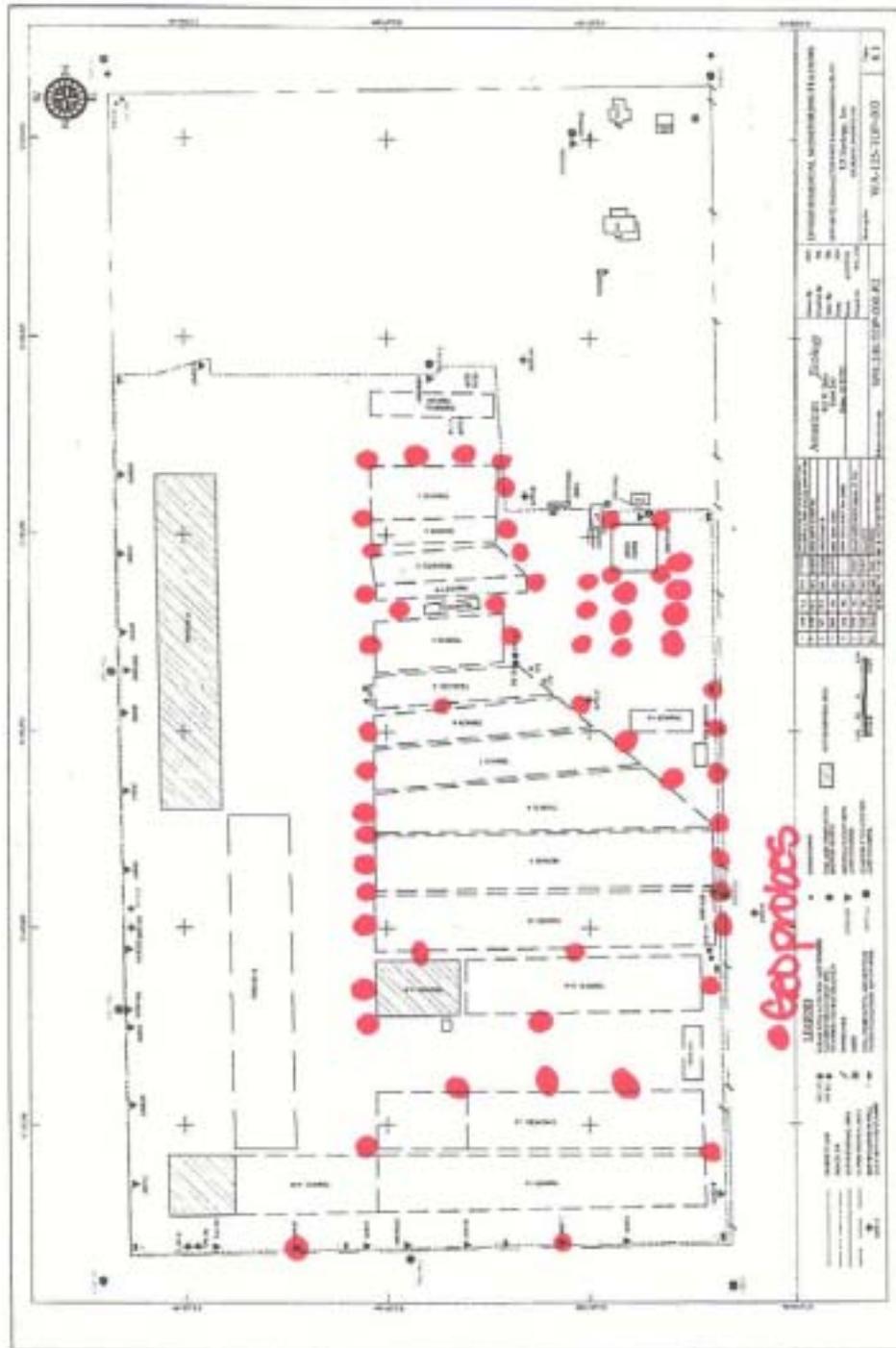


Figure C-2. Geoprobe Locations.



APPENDIX F
DATA VALIDATION REQUIREMENT SUMMARY

Level A (minimum requirements for all data) - This level of data validation will include the verification of required deliverables, requested versus reported analyses, evaluation of requested versus achieved analyte detection limits, and evaluation and qualification of results based on analytical holding times. No other validation, transcription, or calculation checks will be performed.

Level B - This level of data validation will include Level A validation, verification of transcription errors (if not already performed prior to receipt of the data package by the data validator), and evaluation and qualification of results based on method blank result criteria. No calculation checks will be performed.

Level C - This level of data validation will include Level A and B validation and the evaluation and qualification of sample results based on matrix spike (MS), laboratory control sample (LCS), and laboratory duplicate or MS/matrix spike duplicate (MSD) (as appropriate to the method). Field blanks, field duplicates, and field splits (if information is provided) will be examined. No other validation or calculation checks will be performed.

Level D - This level of data validation will include Level A, B, and C validation and the additional qualification of results based on the evaluation of initial and continuing instrument calibrations (standards and blanks) and, where applicable to the particular method; instrument tuning; analytical sequence; internal standards performance; other QC checks that are performed as required by the particular analytical method; and compound identification.

Calculation checks of both sample and QC results will be performed at a frequency of 20%, or at least one sample and QC group will be recalculated, whichever is greater. The QC samples or a QC group will be defined as at least one of the following, as appropriate to the method: method blank, MS&LSD, surrogate, duplicate, LCS, and internal standard.