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Revision 0

The Use of a Vapor Extraction System and Its Subsequent Reduction of Worker Exposure to Carbon Tetrachloride During Retrieval of Hanford's Legacy Waste

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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P.O. Box 1000
Richland, Washington

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Fluor Hanford, Inc.

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Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AEC	Atomic Energy Commission
CCl_4	Carbon Tetrachloride
DOD	Department of Defense
DOE	Department of Energy
EPA	Environmental Protection Agency
ERDA	U.S. Energy Research and Development Agency
GAC	Granular Activated Carbon
HEPA	High Efficiency Particulate Air
LLW	Low-Level Radioactive Waste
MED	Manhattan Engineer District
MEK	Methyl Ethyl Ketone
NIST	National Institute of Standards and Technology
OSRD	Office of Scientific Research and Development
TDU	Thermal Desorption Unit
TLV	Threshold Limit Value
TRU	Transuranic waste
VES	Vapor Extraction System
VOC	Volatile Organic Compounds

Introduction

The Hanford Site is a decommissioned nuclear productions complex located in south eastern Washington and is operated by the Department of Energy (DOE). From 1955 to 1973, carbon tetrachloride (CCl_4), used in mixtures with other organic compounds, was used to recover plutonium from aqueous streams at Z Plant located on the Hanford Site. The aqueous and organic liquid waste that remained at the end of this process was discharged to soil columns in waste cribs located near Z Plant. Included in this waste slurry along with CCl_4 were tributyl phosphate, dibutyl butyl phosphate, and lard oil. (Truex et al., 2001). In the mid 1980's, CCl_4 was found in the unconfined aquifer below the 200 West Area and subsequent ground water monitoring indicated that the plume was widespread and that the concentrations were increasing. It has been estimated that approximately 750,000 kg (826.7 tons) of CCl_4 was discharged to the soil from 1955 to 1973. (Truex et al., 2001). With initial concentration readings of approximately 30,000 parts per million by volume (ppmv) in one well field alone, soil vapor extraction began in 1992 in an effort to remove the CCl_4 from the soil. (Rohay, 1999). Since 1992, approximately 78,607.6 kg (86.65 tons) of CCl_4 have been extracted from the soil through the process of soil vapor extraction and 9,409.8 kg (10.37 tons) have been removed from the groundwater. (EPA, 2006). The success of this environmental cleanup process benefited not only the environment but also workers who were later involved in the retrieval of solid waste from trenches that were in or near the CCl_4 plume.

Solid waste was buried in trenches near Z Plant from 1967 to 1990. The solid waste, some of which was chemically and/or radioactively contaminated, was buried in trenches in steel or fiber drums, fiberboard boxes, fiberglass-reinforced plywood boxes, and steel, concrete, or wooden boxes. Much of this waste was buried with the intention of retrieving it later for permanent disposal and storage. Removal of this solid waste would disturb the soil that was potentially contaminated with CCl_4 and thereby pose a risk to workers involved in the retrieval effort. However, with the success of the VES, worker exposure did not occur.

History

In December of 1941, the United States of America officially entered the Second World War. The decision to enter the Second World War happened to coincide with the Uranium Committee of the Federal Office of Scientific Research and Development (OSRD) decision to sponsor an intensive research project on plutonium. (Gerber, 1993). In the same month as the Battle of Midway, the Army Corps of Engineers formed the Manhattan Engineer District (MED). The primary goal of MED was to construct industrial sized plants geared toward the manufacturing of plutonium and uranium. Construction of such plutonium and uranium manufacturing plants was based largely upon the research conducted at the Metallurgical Laboratory at the University of Chicago. News that Germany was also working to develop atomic weapons gave added urgency to this research and development.

After scouting the country for a suitable location, Colonel Franklin T. Matthias, an Army Commander, settled on the semiarid Pasco Basin of the Columbia Plateau in Southeastern Washington State along the Columbia River, specifically the towns of White Bluffs, Hanford, and Richland. The 586 square mile tract of land that lies north of the City of

Richland met all of the requirements for the location of the country's first large scale plutonium production complex.

In only thirty months that passed from the groundbreaking that occurred in March of 1943 until the end of the war, 554 buildings were constructed; in addition living quarters that had to be built for the workers. The first of nine reactors were built – B, D, and F Reactors; T, B, and U processing canyons; 64 underground, high-level waste storage tanks; and multiple facilities dedicated to fuel fabrication. MED also constructed 386 miles of roads, laid 158 miles of railroad tracks, installed 50 miles of electrical transmission lines, and placed hundreds of miles of fencing. In 1943, in order to support construction efforts, MED increased the overall capacity of the City of Richland transforming a municipality of 918 people into a government town capable of housing 17,500 people. Construction utilized 780,000 cubic yards of concrete and 40,000 tons of structural steel accounting for an overall cost of $230 million. (Gerber, 1992)

Plutonium from the Hanford Site was used to manufacture three nuclear weapons. The first weapon that was constructed was a test bomb and the second nuclear weapon was the atomic bomb that used against the country of Japan in the Second World War. A third nuclear weapon was developed and constructed but never used during wartime. The Hanford Site continued processing plutonium throughout most of the Cold War. When the perceived need for nuclear weapons declined the reactors were shut down. The last reactor, N-Reactor, was eventually shut down in 1989.

Origin of the Hazardous Waste

Retrieving plutonium coupled with the large process operations that this complex undertaking required resulted in vast quantities of waste. Waste included copious amounts of broken and worn out process equipment and piping, used personal protective equipment, including anti-contamination clothing, gloves, booties and more, broken lab glass, used and expired chemicals, and miscellaneous materials that eventually had to be discarded. The waste was usually containerized and placed in the burial trenches that were constructed around each process building and reactor. According to "The History of the 200 Area Burial Ground Facilities" by J. D. Anderson written in 1996, "Since 1944, approximately 4.4 x10^5 m^3 of solid waste from Hanford Site operations; other AEC, U.S. Energy Research and Development Agency (ERDA), and DOE sites; Department of Defense (DOD); and other government agencies have been buried or stored at the 200 Area burial ground facilities." (Anderson, 1996).

Hanford waste primarily consists of transuranic (TRU) waste and low-level radioactive waste (LLW). TRU waste is defined as waste that contains more than 100 nanocuries per gram of alpha emitting transuranic radionuclides with half lives greater than 20 years. (DOE, 1988) All TRU elements are heavier than uranium and therefore classified as transuranic.

Transuranic (TRU) waste and low-level radioactive waste (LLW) were placed in shallow burial trenches between 1944 and 1970. In 1970, the Atomic Energy Commission declared that TRU waste was a separate category of waste and that it should be stored in retrievable containers that were cable of lasting 20 years without decomposing. (Westinghouse Hanford Company, 1992).

In addition to radioactive waste, many different chemicals were used in the Process Facilities at Hanford; the majority of the process chemicals that were used are now classified as dangerous or hazardous. When hazardous chemical waste is found with radioactive waste it is classified as "mixed" waste. There are approximately 31 solid waste sites on the Hanford Site however, this paper focuses on only one, 218-W-4B, which contains mixed waste and chemical contamination. The vapors extracted from this trench were tested for carbon tetrachloride (CCl_4), chloroform, methylene chloride, and MEK. Based on the analytical results, the contaminant of concern from this trench was CCl_4.

Carbon Tetrachloride CCl_4

Carbon tetrachloride is a manufactured organic halogen that does not occur naturally. It is a clear liquid with a sweet smell, which has been compared to chloroform. Prolonged or frequent contact with CCl_4 can result in liver, kidney, and central nervous system damage. Because of its low vapor pressure (91 mmHg) relative to atmospheric pressure it vaporizes readily, with the potential to become an inhalation hazard. It has an ionizing potential of 11.47eV and can be detected with an 11.7eV lamp when using an organic vapor monitor. The American Conference of Governmental Industrial Hygienists (ACGIH®) has set the threshold limit value (TLV®), an occupational exposure limit, of 5ppmv as an 8-hour time weighted average. In addition, ACGIH® has given this chemical a skin designation indicating that it can be absorbed through the skin and mucous membranes causing adverse health effects.

® ACGIH and TLV are registered trademarks of the American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240-4148.

218-W-4B Burial Ground

The 218-W-4B burial ground received dry waste from 1967 to 1990. This waste consisted of Low Level and TRU waste as well as miscellaneous debris including rags, paper, cardboard, plastics, and equipment. As of August 1995, the waste volume in the trench was 10,466 m^3 (13,690 yd^3). (DOE, 2006) The burial ground contains thirteen 175m (575 ft) long by 3.7m (12ft) deep trenches filled with waste drums and burial boxes. The drums are stacked in one of two different configurations, a V-trench configuration or a module of vertically stacked drums.

V-Trenches

Initially TRU waste was placed in concrete "V-trenches" as seen in Figures 1 and 2. These are archive photos showing the protective cover being placed on drums in a V-trench. It is thought that this may be a test of cover placement because the inner protective layer has not yet been placed under the cross supports. Figure 3 is a schematic of the final configuration of buried drums in a V-trench complete with a filtered air intake and fan system.

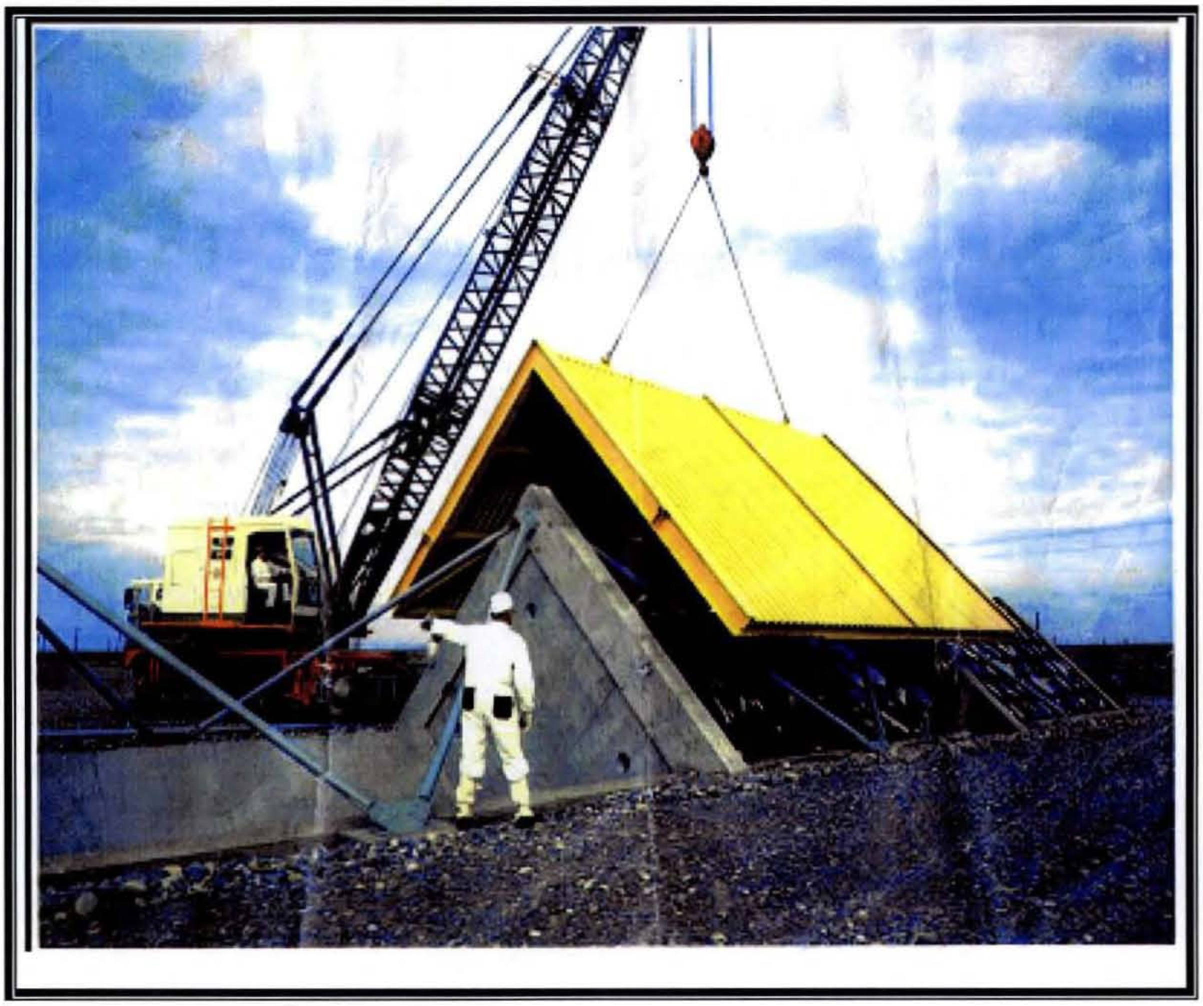

Figure 1. Protective cover placement on drums in a V-trench.

Figure 2. Waste drum configuration in a V-trench.

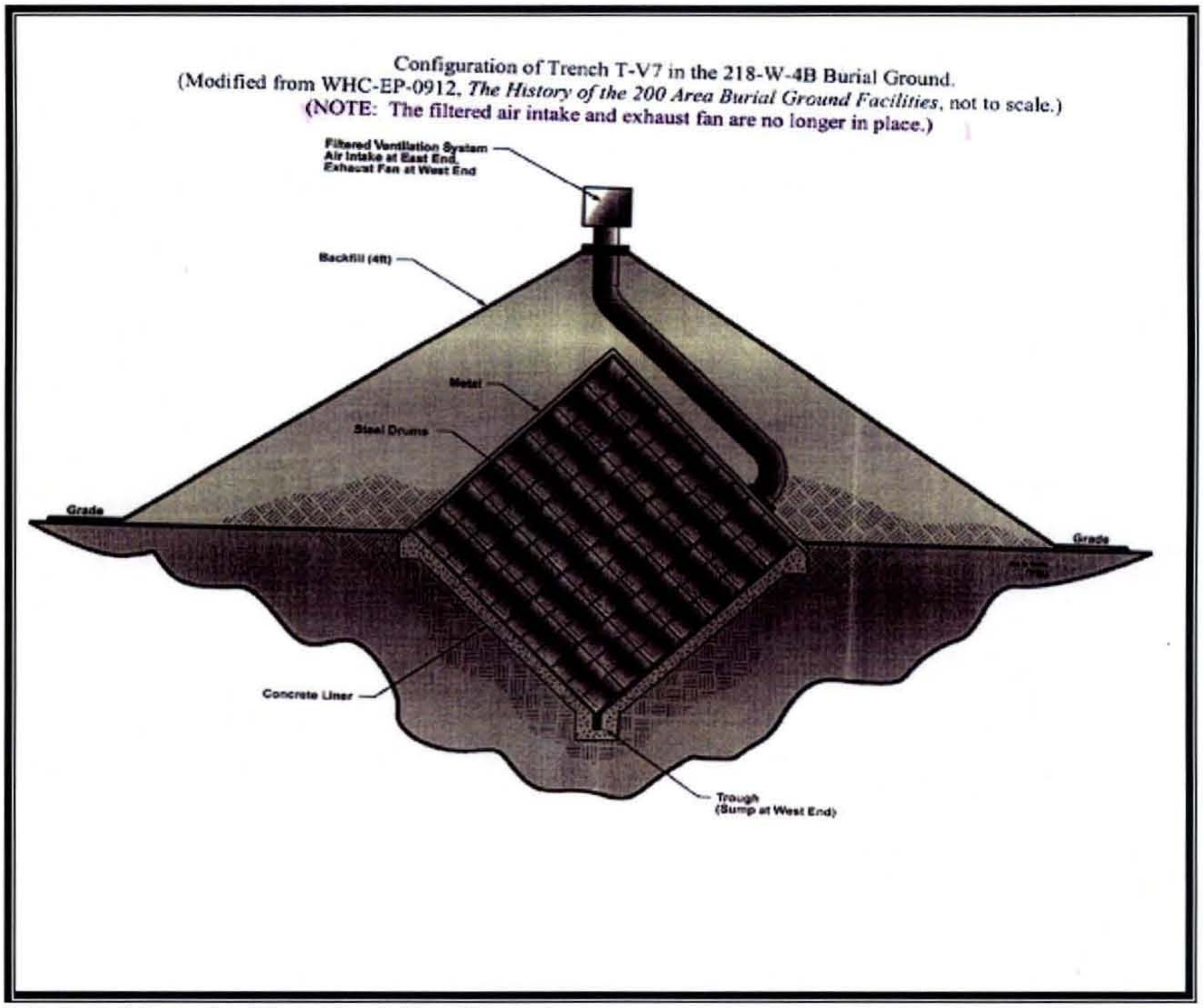

Figure 3. Schematic of drums buried in a V-trench.

However, this configuration was found to put too much weight on the bottom row of drums and proved to be expensive to build.

Vertically Stacked Modules

In 1972 an asphalt pad disposal system was used. In this system, a slightly mounded asphalt pad was constructed in the bottom of the trench. The mounded shape allowed for water runoff on the sides. Drums were placed on the asphalt pad and covered with fire retardant, 0.64 cm (0.25 inch) thick plywood sheets. Another layer of drums was placed on the plywood followed with another layer of plywood, and so forth. Typically, the drums were arranged 12 wide by 12 deep by 4 drums high. When the stack was complete it was covered with 30 mL (1-oz) polyvinyl chloride laminated nylon sheeting. This was followed with a 1.9 cm (0.75 inch) thick plywood sheet, see Figure 4. Vent pipes made of polyvinyl chloride were installed through the plastic sheeting and taped to it for support. The vent pipes, or vent risers, extended from near the bottom of the modules to several feet above grade. The modules were then covered with a 1.2 m (4-ft) thick layer of soil. (DOE, 2006).

Typical Storage Module in Low-Level Burial Ground Retrievable Storage Units Showing Vent Riser. (Modified from PNL-6820, *Hydrogeology of the 200 Areas Low Level Burial Grounds, An Interim Report.*)

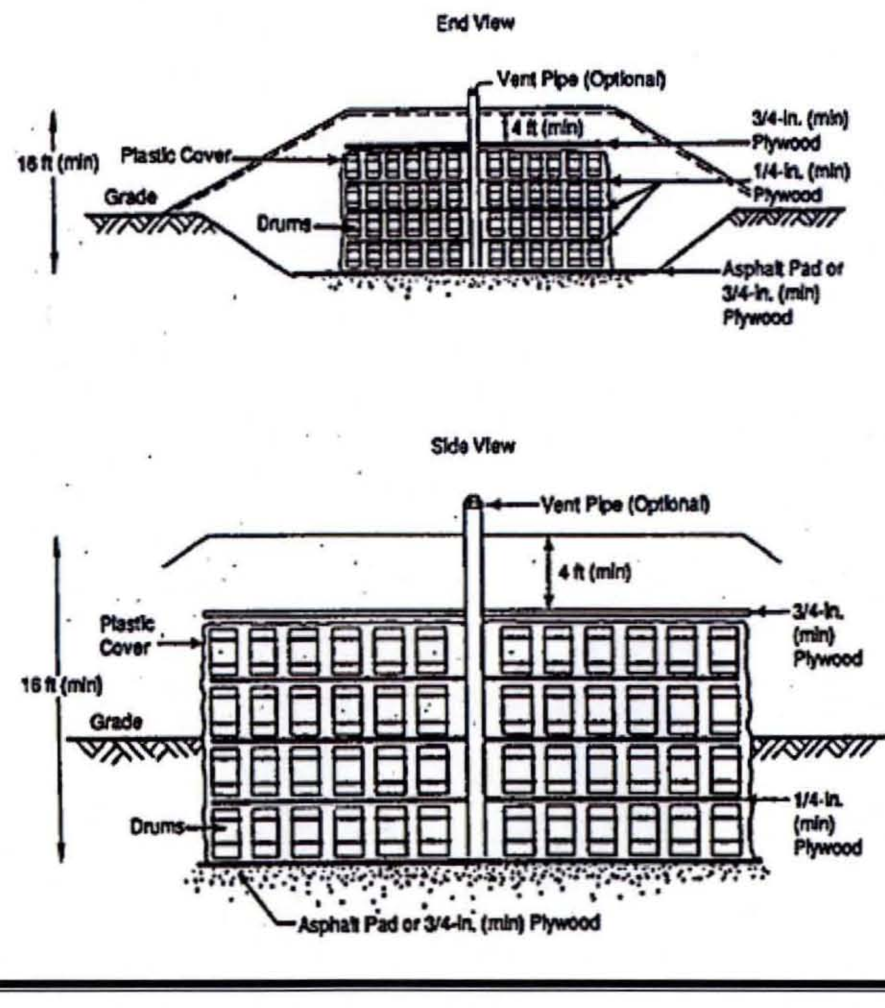

Figure 4. Schematic of waste drum stacking in burial trenches.

Trench T-07 in the 218-W-4B burial ground contains seventeen capped vent risers through which soil vapor emissions can be sampled. As mentioned in the previous section, CCl_4 is prevalent in the surrounding soil due to past disposal practices and so in preparation for excavating the waste drums, air samples for volatile organic compounds (VOCs) were taken from the vent risers during 2006. Data is presented here from two sampling events conducted in the last two quarters of that year.

Vapor Extraction System (VES)

The vapor extraction system (VES) removes CCl_4 by creating a negative pressure in the vent riser which pulls the CCl_4 vapor from the soil. Because of its volatility, the negative pressure and air flow created by the VES converts any liquid CCl_4 into the vapor phase. Therefore, any liquid CCl_4 is also removed, though only as a vapor.

The VES is an extraction and scrubbing system. CCl_4 vapor is pulled from the soil and sent through a high efficiency particulate air (HEPA) filter to remove particulates before it is sent through a series of adsorbing canisters. When the air is cleaned it is released to the environment. The scrubbers consist of a series of two hundred pound containers of granular activated carbon (GAC). Once the GAC canister becomes saturated it is removed from the system and a replacement inserted. The saturated canister is transported offsite for regeneration. Figure 5 shows a portable vapor extraction system with one HEPA filter (stainless steel container) and one water separator (55-gallon drum). The GAC filters, which are approximately seven feet tall and about four feet in diameter are not shown in this picture. When the VES is in operation the two GAC filters are set in place using a fork lift and assembled in series. Real time samples are taken at the primary GAC inlet and outlet and the secondary GAC outlet. These readings are used to determine when the primary filter is in need of change out.

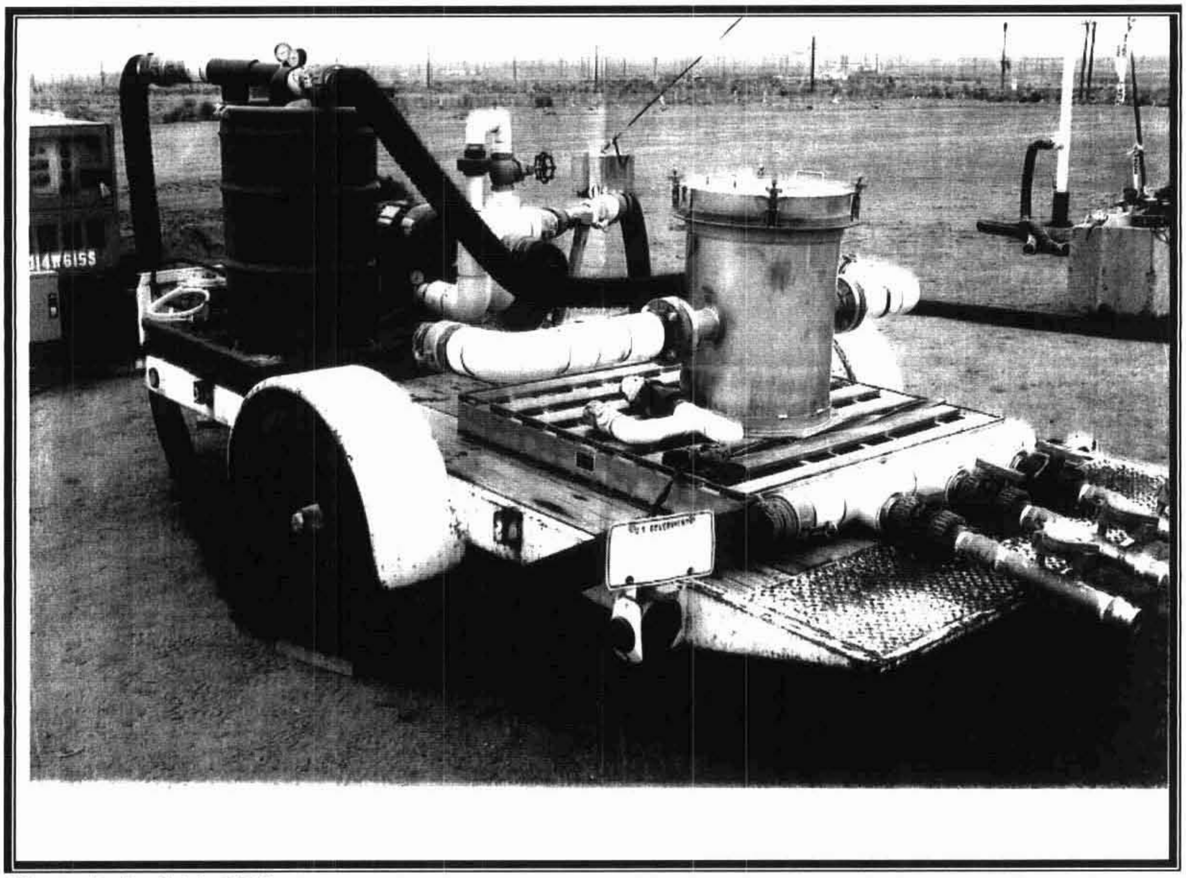

Figure 5. Portable VES.

Sampling the Trench Vapors

In August and September of 2006, the Fluor Hanford Environmental Group collected vapor samples from 14 of the 17 vent risers in 218-W-4B Trench 7 to determine if the VES would be required prior to retrieving waste from this burial ground. (Fluor, September 2006). Figure 6 shows a schematic view of the vent-riser sampling method layout and Figure 7 shows the numbered vent-risers in Trench 7. The vent cap was removed from the selected riser and a 50-foot piece of Teflon[1]-lined Tygon[2] tubing was lowered to the bottom of the riser. The tubing was marked at 0.3m (1 foot) intervals to gage the depth of the sample and a metal filter was placed on the end of the tubing to prevent soil from entering it. The tubing was retracted 0.1m (0.25 feet) to ensure the filter was not sitting on the floor of the trench. A sample pump was used to extract the vapor from the trench for field analysis. The pump, which was set at a flow rate of 3.5 to 4 LPM, ran for 5 minutes to draw vapors through the tubing and purge it prior to collecting a sample. Vapor samples, typically four per riser, were then collected in Tedlar[3] bags and field analyzed with a Bruel & Kjaer 1302 Photoacoustic Gas Analyzer[4]. Three samples were also collected in SUMMA[5] canisters and sent for laboratory analysis. The B&K 1302 Photoacoustic Gas Analyzer was calibrated at the factory to carbon tetrachloride, chloroform, methylene chloride, and methyl ethyl ketone. The instrument was also challenged each day using two calibration gas standards consisting of 25.37ppmv CCl_4 and 200ppmv CCl_4 to assure functionality. The instrument responded at better than 82% recovery with each challenge. Sample depths within the risers varied from 2.3 meters below grade to 5.0 meters below grade. Eighty-five Tedlar bag samples collected in August 2006 were analyzed; 33 were below the detection limit or could not be analyzed due to bag failure. Of the remaining 52, readings ranged from 1.33ppmv to a maximum of 7,580ppmv CCl_4. The SUMMA canister samples collected on September 5, 2006 were analyzed in a laboratory using a gas chromatograph/mass spectrometer using a modified EPA Method TO-15, (EPA/625/R-96/010b, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air). The analytical result for

[1] Teflon is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.
[2] Tygon is a registered trademark of Norton Performance Plastics Corporation, a Saint-Gobain Company, Akron, Ohio.
[3] Tedlar is a registered trademark of E. I. du Pont de Nemours and Company, Wilmington, Delaware.
[4] 1302 Photacoustic Gas Analyzer is a trademark of Brüel and Kjær, S&V, Nærum, Denmark.
[5] SUMMA is a registered trademark of Moletrics, Inc., Cleveland, Ohio.

Vent Riser T-07-4 was 66ppmv and the two samples taken at Vent Riser T-07-6 were 42ppmv and 140ppmv. (Fluor, December 2006).

On November 16, 2006 nine Tedlar bag samples and four SUMMA canister samples were collected from the four vent risers that had not been sampled in August. Sample depth varied from 1.8 meters (5.9 feet) to 4.5 meters (14.76 feet) and results ranged from 1.14 ppmv to a high of 858 ppmv for the field samples and 0.96 ppmv to a high of 2,900 ppmv for the analytical results from the SUMMA canisters. (Fluor, December 2006).

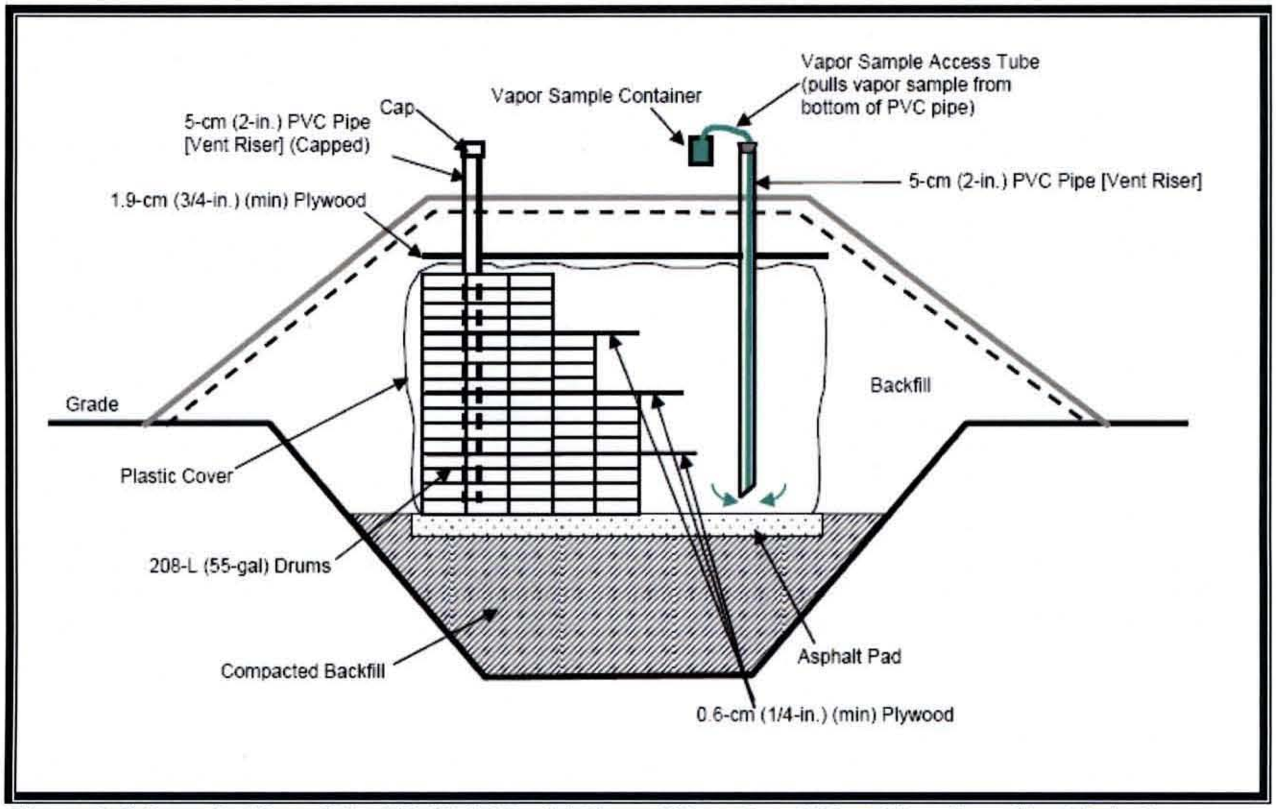

Figure 6. Schematic View of the 218-W-4B Burial Ground Trench and Vent-Riser Sampling Method

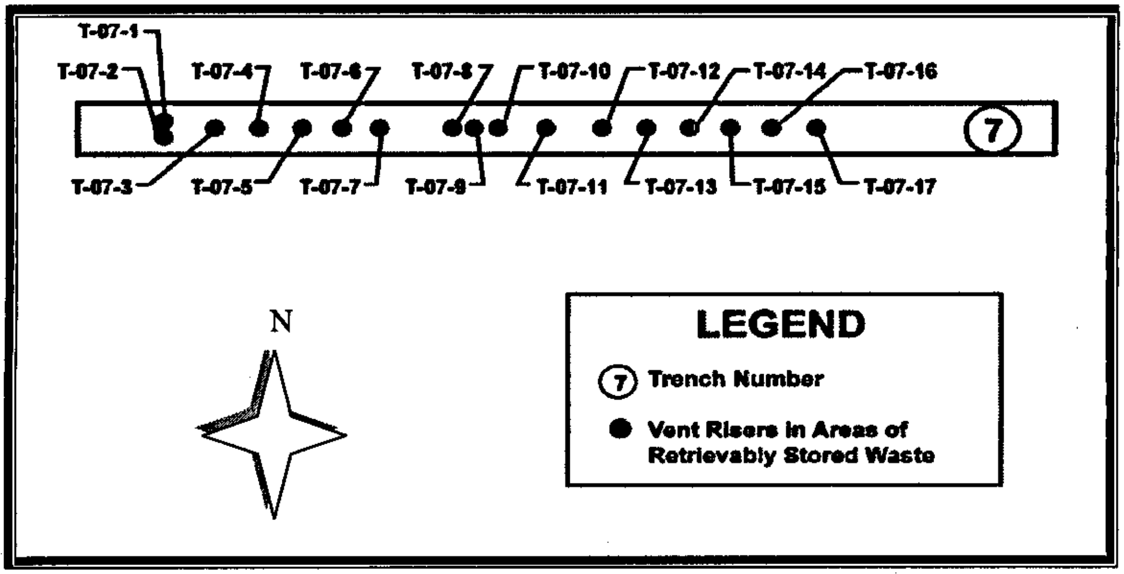

Figure 7. Numbered Vent Risers in Trench 7

Table 1 shows the results of the SUMMA canister sampling from September and November 2006. Table 2 and Table 3 are a compilation of the field data from August and November respectively.

Table 1.
SUMMA Canister Results for Carbon Tetrachloride.

SUMMA Canister Analytical Results for Carbon Tetrachloride

Date Collected	Vent Riser	Sample Number	Result ppmv
9/5/2006	T-07-04	B1KKB7	66
9/5/2006	T-07-06	B1KKB5	42*
9/5/2006	T-07-06 Duplicate	B1KKB6	140*
11/16/2006	T-07-07	B1M5F7	3.9
11/16/2006	T-07-08	B1M5F8	380
11/16/2006	T-07-09	B1M5F9	2,900
11/16/2006	T-07-18	B1M5H0	0.96

* Analyte was identified at a secondary dilution factor.

Table 2. Field Data from Vent-Riser Sampling – August 23, 24, & 29, 2006

Vent Riser	Depth Below Grade (meters)	Sample Number	Result ppmv
T-07-1	4.4	B1KWD1	1.33
		B1KWD2 D	1.33
		B1KWD3	1.73
		B1KWD4 D	1.73
T-07-2	4.3	B1KWC7	ND
		B1KWC8 D	ND
		B1KWC9	1.59
		B1KWD0 D	1.62
T-07-3	4.9	B1KWC3	18.5
		B1KWC4 D	18.6
		B1KWC5	18.9
		B1KWC6 D	18.9
T-07-4	4.9	B1KWB7	7,320
		B1KWB8	7,340
		B1KWB9	7,450
		B1KWC0 D	7,580
		B1KWC1	7,560
		B1KWC2 D	7,460
T-07-5	3.4	B1KWB3	9.65
		B1KWB4 D	9.55
		B1KWB5	4.08
		B1KWB6 D	4.02
T-07-6	4.7	B1KW95	1,550
		B1KW96 D	1,550
		B1KW97	1,690
		B1KW98 D	1,660
		B1KW99	98.2
		B1KWB0 D	97.6
		B1KWB1	34.4
		B1KWB2 D	34.5

Vent Riser	Depth Below Grade (meters)	Sample Number	Result ppmv
T-07-10	4.7	B1KW93	809
		B1KW94 D	804
T-07-11	4.6	B1KW89	82.9
		B1KW90 D	83.3
		B1KW91	53.9
		B1KW92 D	54
T-07-12	4.7	B1KW87	24.7
		B1KW88 D	24.8
T-07-13	3	B1KW83	1.58
		B1KW84 D	1.63
		B1KW85	1.37
		B1KW86 D	1.39
T-07-14	5	B1KW79	4.36
		B1KW80 D	4.32
		B1KW81	4.74
		B1KW82 D	4.52
T-07-15	4.1	B1KW75	ND
		B1KW76 D	ND
		B1KW77	ND
		B1KW78 D	ND
T-07-16	3.4	B1KW71	2.8
		B1KW72 D	2.79
		B1KW73	2.67
		B1KW74 D	2.64
T-07-17	2.3	B1KW67	2.65
		B1KW68 D	2.62
		B1KW69	2.67
		B1KW70 D	2.64

D = Duplicate of above sample

ND= Not detected

Table 3. Field Data from Vent-Riser Sampling – November 16, 2006

Vent Riser	Depth Below Grade (meters)	Sample Number	Result ppmv
T-07-7	4.4	B1M5C8	6.13
		B1M5C9	45.5
T-07-08	4.3	B1M5D0	858
		B1M5D1	361
		B1M5D6	855
T-07-09	4.5	B1M5D2	1.16
		B1M5D3	1.14
T-07-18	1.8	B1M5D4	15.8
		B1M5D5	19.3

Based on the elevated results it was determined that the VES would be utilized prior to excavation and retrieval of waste.

Industrial Hygiene Field Instruments

During the vent riser sampling operations, industrial hygienist took area and source readings using either a Thermo Electron Corporation[6] Model 580B organic vapor monitor with an 11.8eV lamp or a MiniRae 2000[7] with an 11.7eV lamp. Both instruments received their manufacturer required calibration and were also challenged prior to and following each sampling event. A standard span gas that is National Institute of Standards and Technology (NIST) traceable was used to calibrate and to challenge the instrument. The gas had a concentration of 10 ppmv CCl_4 and the instruments were

[6] Thermo Electron Corporation is a registered trademark of Thermo Electron Corporation, Franklin, Massachesetts.
[7] MiniRae 2000 is a registered trademark of RAE Systems, Incorporated.

required to read within ±2ppmv to pass the challenge test. A 25-mm filter in a Delrin filter holder and a humidity tube were connected to the sample probe to protect the instrument from radiation and humidity respectively.

All readings taken in the worker's breathing zone during vent riser testing operations were below the instruments' limit of detection. The Thermo Electron 580B and the MiniRae 2000 have a measurement range of 0 to 2000 ppmv with a minimum readout of 0.1 ppmv.

VES Operations

Based on the results of the August and November 2006 sampling, VES activities were focused mainly on vent risers 4 and 6, though other risers were utilized for extraction as well. The waste drums in Trench 7 associated with these vent risers were arranged in modules with each module measuring 7m X 7m X 4m (23 ft X 23 ft X 13 ft), see Figure 4. Each module was separated from one another by a plastic sheet covering. Airflow between modules was very limited to non existent and the majority of modules had only one vent riser. Based on air volume calculations made in October 2006, if two modules were to be connected to the VES through vent risers 4 and 6 the total volume would be 392 m^3 (13,843 ft^3). Assuming 20% of this to be free airspace there would be 78 m^3 (2,765 ft^3) of air available for extraction. With a flow rate of 1.4 to 2.8 m^3/min (50 to 100 ft^3/min), running the VES for six hours per day would remove between 504 and 1008 m^3 (17,798.5 to 35,597 ft^3) of air. This is approximately 6.5 to 12.9 air changes per day. Based on these calculations it was decided to run the VES for six hours a day, five days a week and to continue this schedule until vapor levels fell to 10 ppmv or lower.

During VES activities the industrial hygienists again used the Thermo Electron 580B and the MiniRae 2000 to monitor organic vapors at point sources and in the general work area. Gab samples were also collected and analyzed.

There were 56 direct reading data points taken in the general work area in December 2006 and January 2007 during VES operations. Forty-eight of these readings were below the instrument's limit of detection. The remaining eight reading ranged from 0.1 ppm to 1.4 ppm. There were 36 readings taken at the inlet and outlet to the GAC filters as well as at the stack. Twenty-one of these were below the instrument's limit of detection. The remaining fifteen readings ranged from 0.1 to 133 ppm. The 133 ppm was found at a hose connection on the VES. When this connection was tightened the readings fell to 6.3 ppm. Personal samples were taken in the worker's breathing zone and sent to a laboratory for analysis. Results for these samples were below the method's limit of detection.

The VES operation is a closed system and, as can be seen by the readings in Table 4, it worked quite well in containing and scrubbing the vapors, thus eliminating exposure to the workers in the general work area.

Table 4. Direct Reading Results during VES Activities

Report #	Date	Location	Activity	Sample	Area ppm	Source ppm
IHSF-00246	12/18/2006	VR 4/6	VES	At positive pressure fitting		1.4
				VES Area	0.2	
				Primary GAC inlet sample port		83
				Primaory GAC inlet sample port area	0.2	
				Primary GAC outflow sample port		0.2
				Primaory GAC inlet sample port area	0.1	
				Primary GAC outflow sample port	<D	
				VES hose connect just past P1-04 gage		133
				VES hose connect just past P1-04 gage, area	1.4	
				VES hose connect just past P1-04 gage, after tightening		6.3
				VES hose connect just past P1-04 gage, area after tightening	<D	
				VES area shutdown	<D	
IHSF-00239	12/19/2006	VR 4/6	VES	Inlet; repair of tube	<D	<D
				Around seals, general area	<D	<D
				Around seals, general area	<D	<D
				Sample ports & work area	<D	<D
				Sample ports & work area	<D	<D
				Sample ports & work area	<D	<D
				Sample ports & work area	<D	<D
IHSF-00247	12/21/2006	VR 4/6	VES	VES at positive pressure fitting		0.1
				VES area	<D	
				Primary GAC inlet sample port		68
				Primary GAC inlet sample port, area	<D	
				Primary GAC outflow sample port	<D	<D
				Secondary GAC outflow sample port area	<D	
				Primary GAC inlet sample port area	<D	
				Primary GAC outflow sample port	<D	
				Secondary GAC outflow sample port area	<D	
IHSF-00254	12/27/2006	VR 4/6	VES	VES sample port area	<D	
				Exhaust stack tech smear	<D	
				Exhaust stack tech smear	<D	
				VES sample port area	<D	

Table 4. Direct Reading Results during VES Activities (continued)

Report #	Date	Location	Activity	Sample	Area ppm	Source ppm
IHSF-00270	1/4/2007	218-W-4B, Trench 7	VES risers 4 & 6, N side	VES sample port area	<D	
				Exhaust stack inlet area	<D	
IHSF-00273	1/5/2007	218-W-4B, Trench 7	VES risers 4 & 6, N side	VES sample port area	<D	
IHSF-00278	1/8/2007	218-W-4B, Trench 7	VES, risers 4 & 6	VES sample port area	<D	
IHSF-00295	1/6/2007	218-W-4B	VES risers 4 & 6	Inlet to GAC #1	<D	<D
				Outlet to GAC #1	<D	<D
				Outlet to GAC #2	<D	<D
IHSF-00296	1/9/2007	218-W-4B, Trench 7	VES risers 4 & 6	(580B) VES sample port area	<D	
				(MiniRae) VES sample port area	<D	
IHSF-00305	1/10/2017	218-W-4B, Trench 7	VES unit on N side, risers 4 & 6	VES area, troubleshooting	<D	
IHSF-00310	1/11/2007	218-W-4B, Trench 7	VES N side risers 4&6	Riser 4	<D	
				Riser 6	<D	
IHSF-00315	1/12/2007	218-W-4B	VES Risers 4&6	GAC Inlet #1. Sampling Riser 4	<D	<D
"System drained and shutdown for the weekend."				GAC Outlet #1. Sample Riser 4	<D	<D
				GAC Outlet #2. Sample Riser 4	<D	<D
				GAC Inlet #1, Sample Riser 6	<D	<D
				GAC Outlet #1. Sample Riser 6	<D	<D
				GAC Outlet #2, Sample Riser 6	<D	<D
				Disconnection of lines. Drain lines & system shutdown.	<0.2	<0.2

Table 4. Direct Reading Results during VES Activities (continued)

Report #	Date	Location	Activity	Sample	Area ppm	Source ppm
IHSF-00321	1/15/2007	218-W-4B, Trench 7	VES N side risers 4&6	VES inside PI-04 connection.		1.7
VES disassembly				VES inside PI-04 connection	0.4	
VES disassembly				VES hose for riser 6		22.4
VES disassembly				VES hose for riser 6	1.1	
VES disassembly				VES hose for riser 4		1.8
VES disassembly				VES hose for riser 4	0.4	
IHSF-00378	1/31/2007	218-W-4B	VES	at connection breaking hose connections	<D	<D
Hose system opened to remove activated carbon canisters				inlet sample port prior to breaking seal		21
				GAC inlet connection (inside) breaking hose connections		2.4
				GAC inlet connection (outside) breaking hose connections	<D	
				at connection (inside) breaking hose connections		2.1
				worker zone around connection breaking hose connection	<D	
				system starup; checking hose connection VES operation	<D	<D
IHSF-00379	1/31/2007	218-W-4B, Trench 7 (unit on North side)	VES, riser 6 only	VES & sample ports at GAC VES sampling	<D	
IHSF-00364	1/29/2007	218-W-4B	VES HEPA vacuum	Around HEPA container	<D	<D
Drum retrieval. Reading lasted <2 seconds.				Lid opening, down wind side		12
				lid opening, drum retrieval	0.2	
				Worker area, drum retieval	<D	
				inside (bottom) of HEPA assembly, drum retrieval		0.4
				Worker area, drum retrieval	<D	

Excavation

Excavation is initially conducted remotely using an excavator with all workers outside of the work area. When the drums have been exposed it is often necessary for workers to manually remove the final dirt, top plywood cover, and to cut into the plastic that covers the module. When workers enter the excavation area, industrial hygiene is present to monitor with direct reading instruments to ensure the workers are not exposed to elevated levels of organic vapors.

In 2007, monitoring around the perimeter of the excavation area indicated levels of organic vapors that were below the instrument's limit of detection. Readings in the work area were, with the exception of one reading, below 1 ppm with the majority of the readings being below the instrument's limit of detection. Readings taken in the holes of breached drums or breached plastic (tarps) did show elevated levels of organic vapors; these readings are shown in Table 5.

Table 5. Direct Reading Data during Excavation Work to Expose Waste

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-00297	1/9/2007	218-W-4B, Trench 7	Excavation	Trench 7	<D	<D
IHSF-00311	1/11/2007	218-W-4B, Trench 7, Module 16	Excavation	T7 Mod 16 Floor		1.4
				T7 Mod 16	<D	
IHSF-00322	1/15/2007	218-W-4B, Trench 7, Module 15	Excavation	T7 Mod 15 soil excavation	<D	
				T7 Mod 15 inside tarp		83.4
				T7 Mod 15, area outside tarp	2.3	
IHSF-00325	1/16/2007	218-W-4B, Trench 7, Module 15	Excavation	T7 Mod 15 inside tarp		1.9
				T7 Mod 15 area outside tarp	<D	
				T7 Mod 15	<D	
IHSF-00326	1/17/2007	218-W-4B, Trench 7, Modules 15 & 16	Excavation	T7 Mod 16	<D	
				T7 Mod 15 inside tarp		0.9
				T7 Mod 15 outside tarp	<D	
IHSF-00330	1/18/2007	218-W-4B, Trench 7 Modules 15 & 16	Excavation	T7 Mod 16	<D	
				T7 Mod 15	<D	
				T7 Mod 15 at hole where riser 4 comes thru		2.8
				T7 Mod 15 area around riser 4	<D	
				T7 Mod 15	<D	
IHSF-00349	1/19/2007	218-W-4B, Trench 7, Module 15	Excavation	inside south tarp	<D	<D
				at hole where riser 4 comes through		2.2
				area	<D	

Table 5. Direct Reading Data during Excavation Work to Expose Waste (continued).

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-00351	1/22/2007	218-W-4B, Trench 7, Module 15	Excavation	inside south tarp	<D	<D
				at hole where riser 4 comes through		2.2
				area	<D	
IHSF-00372	1/30/2007	218-W-4B, Trench 7, Module 16, Tier 4 (top)	plywood/tarp removal. Prep for retrieval	T7 Mod 16, Tier 4 retrieval prep	<D	<D
IHSF-01106	7/5/2007	218-W-4B; Module 10	Excavation			
Monitoring around drums at various levels.				218-W-4B, Module 10	<D	<D
IHSF-01189	7/20/2007	218-W-4B; Trench 7, Module 13/14, 14/15 "Plugs"	Excavation	T7, Mod 14/15 work area perimeter & around drums	<D	<D
I to 5 inches from tarped drums and inside breached tarping; at breached drums; at plugs between the modules.				T7, Mod 14/15	0.3	0.3
				T7 Mod 14/15	<D	<D
				T7, Mod 13/14	<D	<D
IHSF-01271	8/6/2007	218-W-4B; Trench 7, Module 9	Excavation			
I to 5 inches from tarped drums and inside breached tarping; also spoils pile.				T7, Mod 9, South side	<D	<D
IHSF-01378	8/29/2007	218-W-4B, Trench 7, Module 10/11 South side	Excavation	T7 Mod 10/11, Plug, South side	<D	<D
				T7 Mod 11 Perimeter	<D	<D
				T7, Mod 11 SE corner (5 inches from drum)		38
				T7, Mod 11, SE corner, 2 inches from drum		50
BZ readings <D				T7, Mod 11, SE corner (Breached Bag)		186
BZ readings <D				Securing drum with plastic/covering and posting area	<D	<D

Table 5. Direct Reading Data during Excavation Work to Expose Waste (continued).

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-00502	2/27/2007	218-W-4B, Trench 7, Module 1 and 14	Excavation	T7, Mod 1 hole in plywood		1.1
				T7 Mod 1	0.2	
				T7, Mod 2 N side, hole in tarp.		3.7
				T7, Mod 2, N side	0.1	
				T7, Mod 2	<D	
				T7, Mod 14, S side	<D	<D
				T7, Mod 14, S side, hole in tarp		21.3
				T7, Mod 14 S side	<D	
				T7, Mod 1	<D	<D
				T7, Mod 14, at base of vent pipe, under plywood		24
				T7, Mod 14, work area around vent pipe	<D	
				T7, Mod 24 N side, hole in tarp		36.3
				T7, Mod14, N side work area	0.1	
				T7, Module 14, NE corner hole in tarp		22.4
				T7, Mod 14, NE corner work area	<D	
				T7, Mod 14 W side hole in tarp		10.1
				T7, Mod 14 W side work area	<D	
				T7, Mod 1, NE corner - dirt still on waste drums	<D	<D
				T7, Mod 14, W side work area	<D	
IHSF-01385	8/30/2007	218-W-4B, Trench 7, Module 7, 8, & 9	Excavation North side	T7, Mods 7, 8, 9, North	<D	<D
Area perimeter, area source approx 1 to 5 inches from tarped drums and or plywood; area sourch 1 inch inside breached tarping.				T7, Mod 9, Top	<D	<D
				T7, Mod 8, subsidence		3
				T7, Mod 8, downwind one foot from hole opening	0.3	
				T7, Work area around Mod 8	<D	
				T7, Mod 8, subsidence		<D
				T7, Mods 7, 8, 9, Top	<D	<D
				T7, Mods 7, 8, 9, N Face	<D	<D
				T7, Mods 7, 8, 9 N Face Inside breached tarp		5.4
				T7, Mods 7, 8, 9 N Face Inside breached tarp		3
				T7, Mods 7, 8, 9 N Face Inside breached tarp		2.8
				T7, Mods 7, 8, 9 N Face Perimeter in Trench		0.2

It is evident by the readings inside tarps and holes in drums that an organic vapor is present at elevated levels. However, the vapor does not stay in the work area as is evident by the overwhelming number of non-detect readings in the general work area. Integrated samples taken on workers engaged in this activity all resulted in readings that were below the analytical method's limit of detection for a variety of organic vapors.

Retrieval

After the top level of the drums of waste has been exposed they are ready for retrieval. During this step in the process the workers are required to wear respiratory protection because of alpha radiation associated with the waste. Personal sampling using thermal desorption unit (TDU) tubes have indicated no exposure to organic vapors. All results for organic vapors including CCl_4 have been at or below the method's limit of detection. Almost all direct reading data throughout 2007 retrieval operations have been less than detectable for area and perimeter readings. Point sources, such as breached drums or tarping, have resulted in elevated readings as is evident by the 90 ppm found in a hole in a drum on July 6, 2007. This confirms that the waste within the drums is chemically contaminated and should be handled with caution. A selection of collected data is tabulated in Table 6.

Table 6. Direct Reading Data for Retrieval Operations.

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-01105	7/2/2007	218-W-4B	Moving burial box			
Lifting Burial Box 105KE7800095 from the West side of -4B.				around box prior to and after move	<D	<D
IHSF-01117	7/6/2007	218-W-4B, Trench 7	Retrieval	T7, drum retrieval	<D	<D
				T7, at hole in drum		90
				T7, inch from hole in drum	<D	
				T7, drum retrieval	<D	<D
IHSF-01112	7/9/2007	218-W-4B, Trench 7, Module 15	Retrieval of waste	South side of drums, pre-shift operations	<D	<D
				South side of drums, retrieval	<D	<D
				South side of drums	<D	<D
				south side of drums	<D	<D
IHSF-01165	7/10/2007	218-W-4B, Trench 7, Module 15	Retrieval			
Tasks-T001-Assessment of potential area/perimeter chemical contamination module footprint and around drums prior to retrieval or routine assessment.				N, S, E, W perimeter and general area of drums	<D	
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				South side retrieval drum		<D
T-003 Assessment of area/source chemical contamination at drum breach/hole.				S side- small hole in side of drum		0.1
T-003 Assessment of area/source chemical contamination at drum breach/hole.				S side - breached drum wall - bottom of drum		<D
T-003 Assessment of area/source chemical contamination at drum breach/hole.				W side - disintegrated bottom wall		0.3
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side application of cladding to reinforce drum wall	<D	<D
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side- retrieval	<D	<D
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side - area monitoring between plywood sheet opening to next tier		<D
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side retrieval	<D	<D

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-01165	7/10/2007	218-W-4B, Trench 7, Module 15	Retrieval			
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side retrieval	0.1	0.1
T-003 Assessment of area/source chemical contamination at drum breach/hole.				W side retrieval - small hole in cover of drum		0.5
T-002-Assessment of potential area/source chemical contamination during routine waste retrieval				W side retrieval	<D	<D
T-003 Assessment of area/source chemical contamination at drum breach/hole.				General area of drums	<D	
IHSF-01177	7/13/2007	218-W-4B, Trench 7, Modules 15 & 16	Retrieval Misters running	Mods 15/16 Retrieval	<D	<D
IHSF-01204	7/25/2007	218-W-4B, Trench 7, Module 2, Tier 3	Retrieval Misters running	T7, Mod 2, Tier 3, Drum retrieval prep	<D	<D
				T7, Mod 2, Tier 3, Drum retrieval	<D	<D
				T7, Mod 2, Tier 3, Drum hole		18
				T7, Mod 2, Tier 3, Drum retrieval	<D	
IHSF-01211	7/26/2007	218-W-4B, Trench 7	Retrieval Misters running	Exterior of drums waiting to be overpacked; S side module	<D	<D
				Exterior of drums waiting to be overpacked	<D	<D
				South side of drums	<D	<D
				Exterior of drums waiting to be overpacked	<D	<D
IHSF-01220	7/30/2007	218-W-4B, Trench 7, Module 14, Tier 3	Retrieval Misters running	T7, Mod 14, Tier 3, Drum retrieval prep	<D	<D
				T7, Mod 14, Tier 3, Drum retrieval	<D	<D

Table 6. Direct Reading Data for Retrieval Operations (continued).

Table 6. Direct Reading Data for Retrieval Operations (continued)

Report #	Date	Location	Activity	Sample	Area	Source
IHSF-01228	7/31/2007	218-W-4B, Trench 7, Module 14, Tier 3	Retrieval Misters running			
				T7, Mod 14, Tier 3, drum retrieval	<D	<D
				T7, Mod 14, Tier 3, drum retrieval		18.1
				T7, Mod 14, Tier 3, drum retrieval	<D	<D
				T7, Mod 14, Tier 3, drum retrieval		42.7
				T7, Mod 14, Tier 3, drum retrieval	<D	<D
IHSF-01262	7/31/2007	218-W-4B, Trench 7, Module 14	Retrieval			
T001-Assessment of potential area/perimeter chemical contamination around/atop Module 13.				N, W, E, S perimeter of drums	<D	
T-002-Assessment of potential area/source chemical contamination 1-inches to 5-inches from drums.				Mod 14, drums	<D	<D
T-003, Assessment of potential area/source chemical contamination approximately 1-inch inside breached tarping and at breached drums.				Mod 14, drums	<D	<D
T-002-Assessment of potential area/source chemical contamination 1-inches to 5-inches from drums.				Mod 14, drums	<D	<D
T001-Assessment of potential area/perimeter chemical contamination around/atop Module 13.				N, W, E, S perimeter of drums	<D	
T-002-Assessment of potential area/source chemical contamination 1-inches to 5-inches from drums.				Mod 14, drums	<D	<D
T-003, Assessment of potential area/source chemical contamination approximately 1-inch inside breached tarping and at breached drums.				Mod 14, drums	<D	<D
T001-Assessment of potential area/perimeter chemical contamination around/atop Module 13.				N, W, E, S perimeter of drums	<D	
IHSF-01259	8/3/2007	218-W-4B, Trench 7, Module 13, Tier 4	Drum retrieval in weather enclosure			
water misters running				T7 Mod 13	<D	<D

Conclusion

During an almost 20 year period approximately 750,000 kg (826.7 tons) of CCl_4 was released into the soil on the Central Plateau of the Hanford Site. Elevated levels of CCl_4 vapors, over 7000 ppmv, have been detected in the soil vapors of the 218-W-4B burial ground. However, using the Vapor Extraction System allowed work to be conducted in this burial trench without chemical exposure to the workers. All breathing zone samples of personnel working in Trench 7 have been at or below the analytical method's limit of detection. Direct reading instruments have shown almost consistent readings of less than detectable in the general work area with elevated readings confined to point sources. Given the levels of CCl_4 first identified one can conclude that the VES was a successful engineering control that protected the health and safety of the workers and will be the control of choice for the next burial ground that is contaminated with carbon tetrachloride and other organic vapors.

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