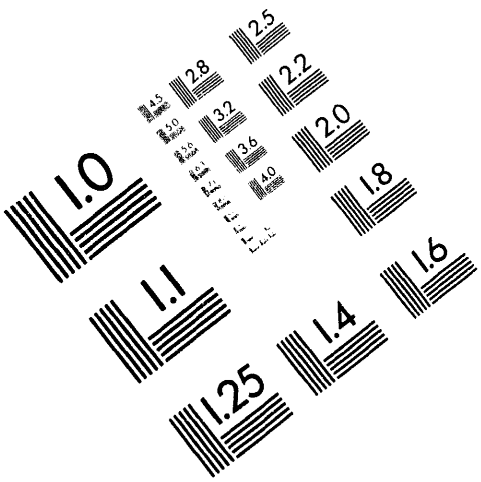

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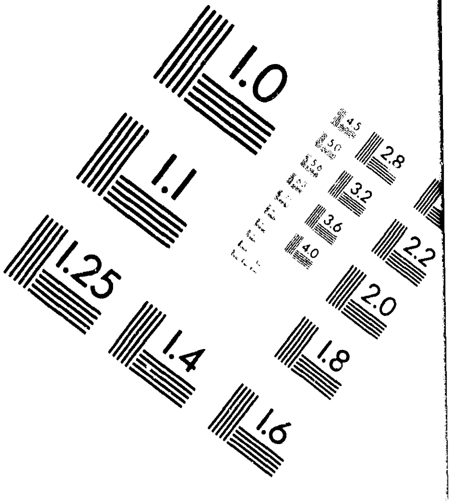

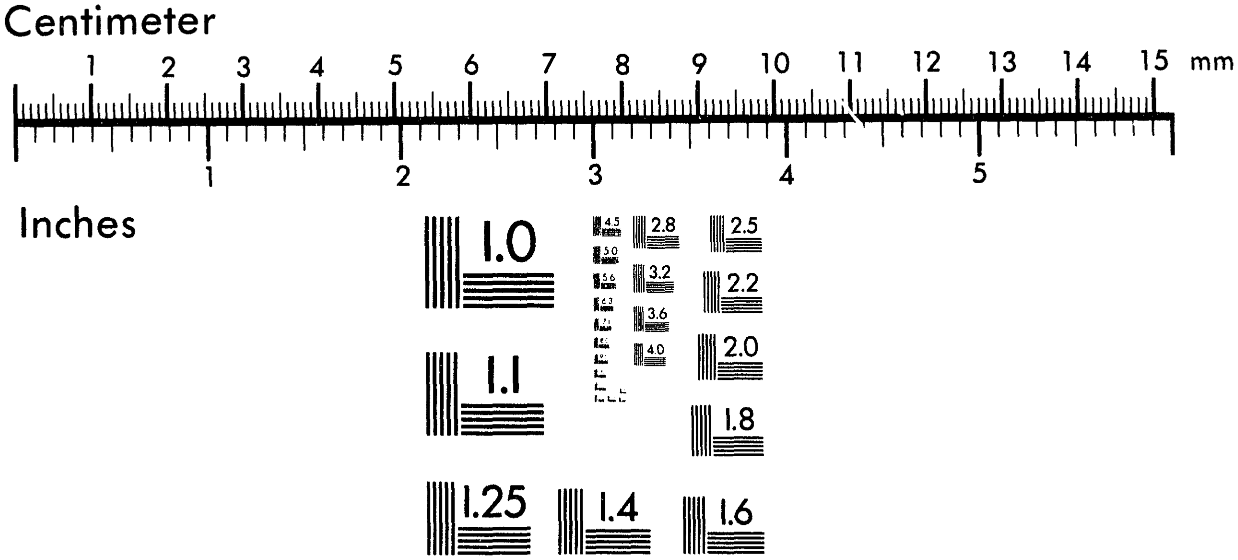

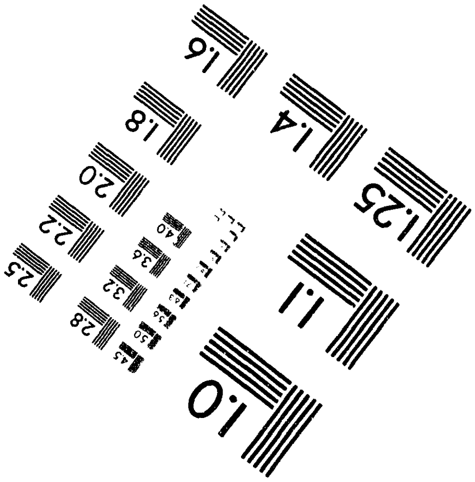

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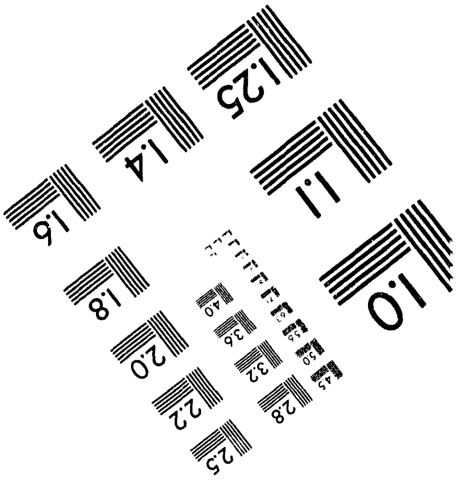

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EXECUTIVE SUMMARY

Passive vapor extraction is a technology under development at the U.S. Department of Energy's Hanford Site. The technology exploits the natural flow of air through the subsurface as a means of mobilizing volatile contaminants in the unsaturated zone toward collection points at the surface for treatment. The flow of air through the subsurface is primarily a function of the difference between the barometric pressure and the air pressure in the soil. It is also a function of the permeability of the soil.

Measurements of the natural air flows emanating from wells open to the unsaturated zone in the 200 West Area of the Hanford Site indicate that natural air flow rates in and out of the wells average 1 to 8 stdft^3/min. Maximum air flow rates of 50 stdft^3/min per well have been observed. The differences between the barometric pressure and the air pressure in the soil near the well open intervals are usually no more than several inches of water. The pressure differential arises as a result of the retarded response of the soil air pressure to changes in barometric pressure. The permeability of the soil controls the rate at which air flows into and from the soil. Low permeability soils will exhibit low flow rates and require a longer period of time to equilibrate with a change in barometric pressure. Changes in soil depth and stratigraphy also affect pressure differences and flow rates.

Passive vapor extraction appears viable as a technology that can complement active vapor extraction under certain conditions. Applications of passive vapor extraction include those sites at which the contaminant is primarily contained within a low-permeability stratum. The high air flows achievable using active vapor extraction have little added benefit in this case and require relatively high personnel and energy levels. Additional applications of passive vapor extraction are on the edge of unsaturated zone contaminant plumes where concentrations of volatile contaminants are low. Active vapor extraction is more cost effective in treating the higher concentrations located at the center of the vapor plume.

Demonstration of a passive vapor extraction remediation system is planned for sites in the 200 West Area used in the past for the disposal of waste liquids containing carbon tetrachloride. The passive vapor extraction units will consist of a 4-in.-diameter pipe, a check valve, a canister filled with granular activated carbon, and a wind turbine. The check valve will prevent inflow of air that otherwise would dilute the soil gas and make its subsequent extraction less efficient. The granular activated carbon is used to adsorb the carbon tetrachloride from the air. The wind turbine enhances extraction rates on windy days. Passive vapor extraction units will be designed and operated to meet all applicable or relevant and appropriate requirements.

Based on a cost analysis, passive vapor extraction was found to be a cost-effective method for remediation of soils containing lower concentrations of volatile contaminants. Passive vapor extraction used on wells that average 10-stdft^3/min air flow rates was found to be more cost effective than active vapor extraction for concentrations below 500 parts per million by volume (ppm_v) of carbon tetrachloride. For wells that average 5-stdft^3/min air flow rates, passive vapor extraction is more cost effective below 100 ppm_v.

Annualized costs for passive and active vapor extraction under various flow rate and concentration conditions are summarized in the following table.

ppm CCl_4	Active vapor extraction 500 $stdft^3$/min per unit \$/lb CCl_4	Passive vapor extraction		
		10 $stdft^3$/min per unit \$/lb CCl_4	5 $stdft^3$/min per unit \$/lb CCl_4	1 $stdft^3$/min per unit \$/lb CCl_4
5	\$1,046	\$411	\$813	\$4,040
50	\$110	\$49	\$89	\$412
100	\$58	\$29	\$49	\$211
200	\$32	\$19	\$29	\$110
500	\$16	\$13	\$17	\$49
1,000	\$11	\$11	\$13	\$29
5,000	\$7	\$9	\$10	\$13

ACRONYMS AND ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
ASIL	acceptable source impact level
Bhp	brake horsepower
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERA	Expedited Response Action
FTE	full-time equivalent
FY	fiscal year
GAC	granular activated carbon
HEPA	high-efficiency particulate air
ppm_v	parts per million by volume
PSD	Prevention of Significant Deterioration
RCRA	*Resource, Conservation, and Recovery Act*
TOE	total operating efficiency
VOC	volatile organic compound
WAC	Washington Administrative Codes

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1.0 INTRODUCTION

The technical, regulatory, and economic feasibility of using a new and innovative passive method for remediating soils contaminated with volatile organic compounds (VOCs) is examined in the following sections. This new technology, passive vapor extraction, and its application are described and compared to established in situ soil remediation methods.

1.1 BACKGROUND

Wells with perforated or screened open intervals in the unsaturated zone have been observed to "breathe," i.e., inhale ambient air from the surface and exhale soil gas. This passive breathing of the wells results primarily from pressure differentials that occur between the soil air pressure near the open interval of a well and the barometric pressure.

Enhancing the natural breathing process creates the potential for increased removal rates of VOCs from the unsaturated zone. Passive vapor extraction refers to the enhancement and application of this breathing phenomenon as a remediation method. Fundamental techniques proposed to enhance the mass flux of VOCs include increasing the soil-gas flow rate and preventing ambient air flow into the extraction well while permitting air flow into the soil some distance away from the well openings.

Active vapor extraction (also referred to as vapor extraction, soil vapor extraction, vacuum extraction, and soil venting) refers to an in situ soil remediation method that uses an applied vacuum to remove VOCs from unsaturated soil. Typically, a vacuum pump capable of producing flows from 20 to 500 $stdft^3$/min and negative pressures as low as -10 inHg are attached to well casings. The casings are perforated or screened at the desired depths to provide pathway to intervals of unsaturated soil. The vacuum pump induces an air flow through the soil that carries volatilized contaminants to the well and then to the surface for treatment and/or discharge.

Active vapor extraction is currently being used to remove VOCs, primarily carbon tetrachloride, from the unsaturated zone at the U.S. Department of Energy's (DOE) Hanford Site. The primary goal of this remediation activity is to reduce the potential for the continued spread of contamination to the groundwater. Removal of the carbon tetrachloride from the unsaturated zone in the 200 West Area is being conducted by the 200 West Area Carbon Tetrachloride Expedited Response Action (ERA), an environmental restoration program.

Based on the initial ERA site evaluation and on an engineering evaluation and cost assessment, the preferred alternative for removal of the carbon tetrachloride from the unsaturated zone was identified in the ERA proposal as soil vapor extraction followed by aboveground treatment (DOE-RL 1991). A wellfield design feasibility study to delineate the optimum design of the existing wells and placement and type of new wells is described in the ERA proposal. As part of that study, the feasibility of using enhanced passive vapor extraction is being evaluated as a complementary soil remediation process to active vapor extraction.

Data collection and evaluation tasks designed to support the passive vapor extraction feasibility study during fiscal year (FY) 1993 and FY 1994 are described in the *FY 93 Wellfield Enhancement Work Plan* (Rohay and Cameron 1993) and the FY 1994 Wellfield Optimization and Site Characterization Task Plan (Rohay 1994). Activities included monitoring parameters associated with the natural flow from wells; investigating the feasibility of enhancing the passive extraction of VOC from wells; numerical modeling of passive vapor extraction; and integrating the natural flow factors, modeling results, and known administrative issues into a feasibility study of implementing a passive vapor extraction system. This report presents the feasibility study originally outlined in the FY 1993 work plan.

1.2 SITE DESCRIPTION

Carbon tetrachloride was used in solvent extraction processes at Z Plant (now called the Plutonium Finishing Plant) in the 200 West Area to recover plutonium from aqueous streams containing plutonium nitrate. Both organic and aqueous liquid wastes from these processes were routinely discharged to the soil column between 1955 and 1973, when ground disposal was ceased (DOE-RL 1991). The unsaturated zone beneath the carbon tetrachloride disposal sites is approximately 65 m thick and is composed primarily of sands and gravels.

1.2.1 Waste Disposal

The carbon tetrachloride disposal sites include the 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-18 Crib (Figure 1). The 216-Z-9 Trench operated from 1955 to 1962 to receive all solvent and aqueous waste from the Recuplex facility at Z Plant. From 1964 to 1969, aqueous and organic waste from the Plutonium Reclamation Facility, which replaced the Recuplex facility, was discharged to the 216-Z-1A Tile Field. The 216-Z-18 Crib operated from 1969 to 1973 and received aqueous and organic wastes from the Plutonium Reclamation Facility.

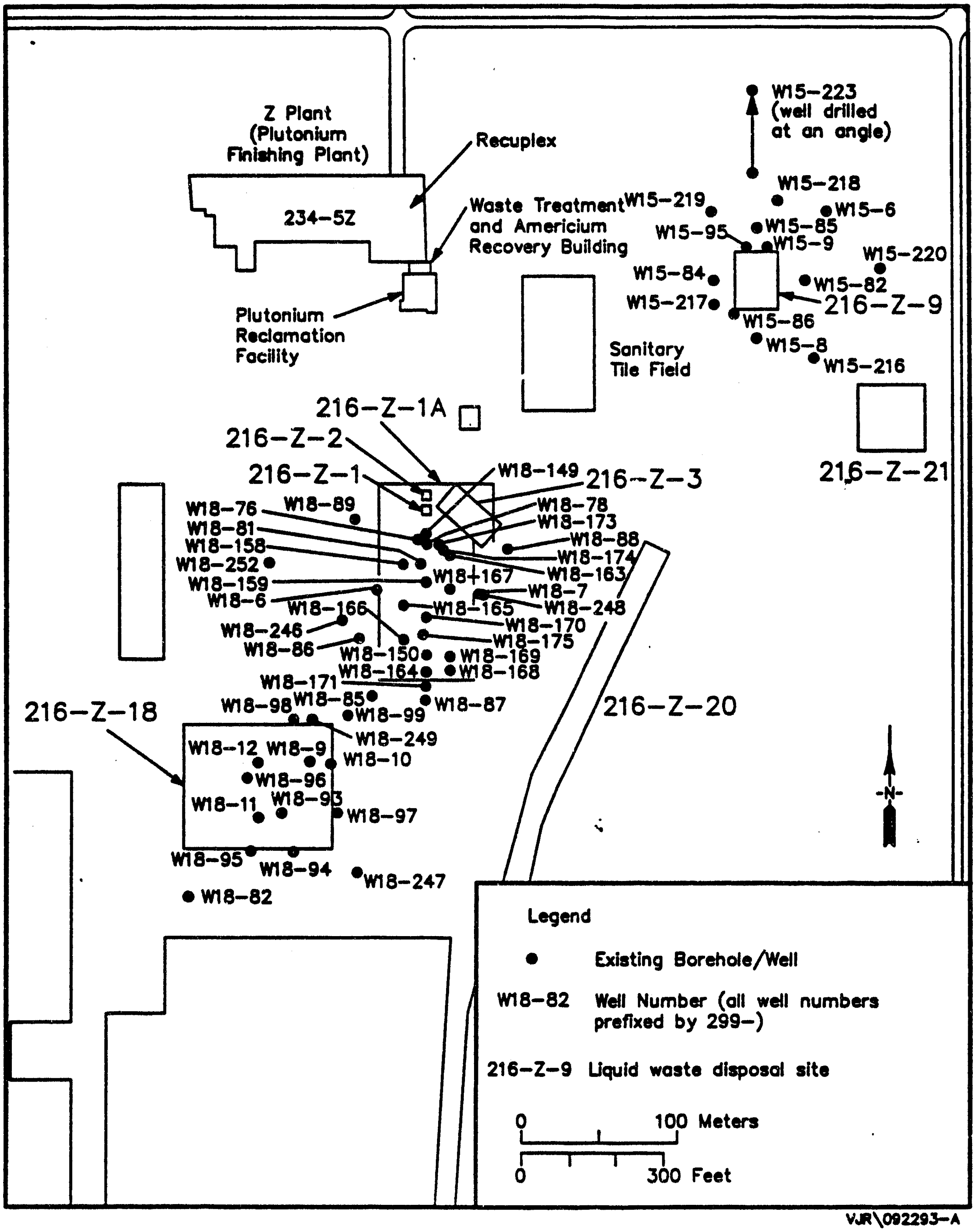
Approximately 577,000 to 922,000 kg (363,000 to 580,000 L) of carbon tetrachloride was discharged to the soil column at the carbon tetrachloride disposal sites between 1955 and 1973 (DOE-RL 1991). The total amount of carbon tetrachloride disposed to the soils represents less than one-tenth of the total liquid (mostly aqueous) disposed to the sites.

1.2.2 Characteristics of the Site

The topography of the Hanford Site is relatively flat with elevations ranging from 120 m (394 ft) above mean sea level along the Columbia River to greater than 1,000 m (3,280 ft) at Rattlesnake Mountain. The 200 West Area is also relatively flat with elevations ranging from 200 to 225 m (656 to 738 ft) above mean sea level.

The climate at the Hanford Site includes summers that are warm and dry and winters that are cool with occasional precipitation. The mean annual precipitation at the Hanford Meteorology Station (adjacent to the 200 West Area) is 16 cm (6 in.). The average wind direction is from the west-northwest with an average wind speed of 4.8 km/h (3 mi/h).

Figure 1. Carbon Tetrachloride Disposal Sites and Associated Wells.



The geology of the 200 West Area consists primarily of basalts overlain by fluvial and glaciofluvial sediments (Figure 2). The sediments are, from youngest to oldest:

- Hanford formation - glaciofluvial gravels, sands, and silts deposited by middle to late Pleistocene cataclysmic flood waters
- Early "Palouse" soil - silt and fine sand, possibly fluvial or fluviolacustrine
- Plio-Pleistocene unit - basaltic detritus and a carbonate-rich paleosol, often referred to as the caliche layer
- Ringold Formation - a series of alluvial sands and gravels, and overbank and lacustrine deposits of late Miocene to Pliocene age.

The unsaturated zone, which consists of sediments of the Ringold Formation, Plio-Pleistocene unit, early "Palouse" soil, and Hanford formation, ranges in thickness from 58 to 82 m (190 to 269 ft) across the 200 West Area and from 60 to 66 m beneath the carbon tetrachloride sites. Because the Plio-Pleistocene unit (caliche layer) is less permeable than the other units, it may temporarily divert or perch liquid and/or dense vapors and may result in slower travel times through it. Vapor extraction tests indicate that the air permeability of the Hanford formation is 2×10^{-8} to 5.6×10^{-8} cm^2.

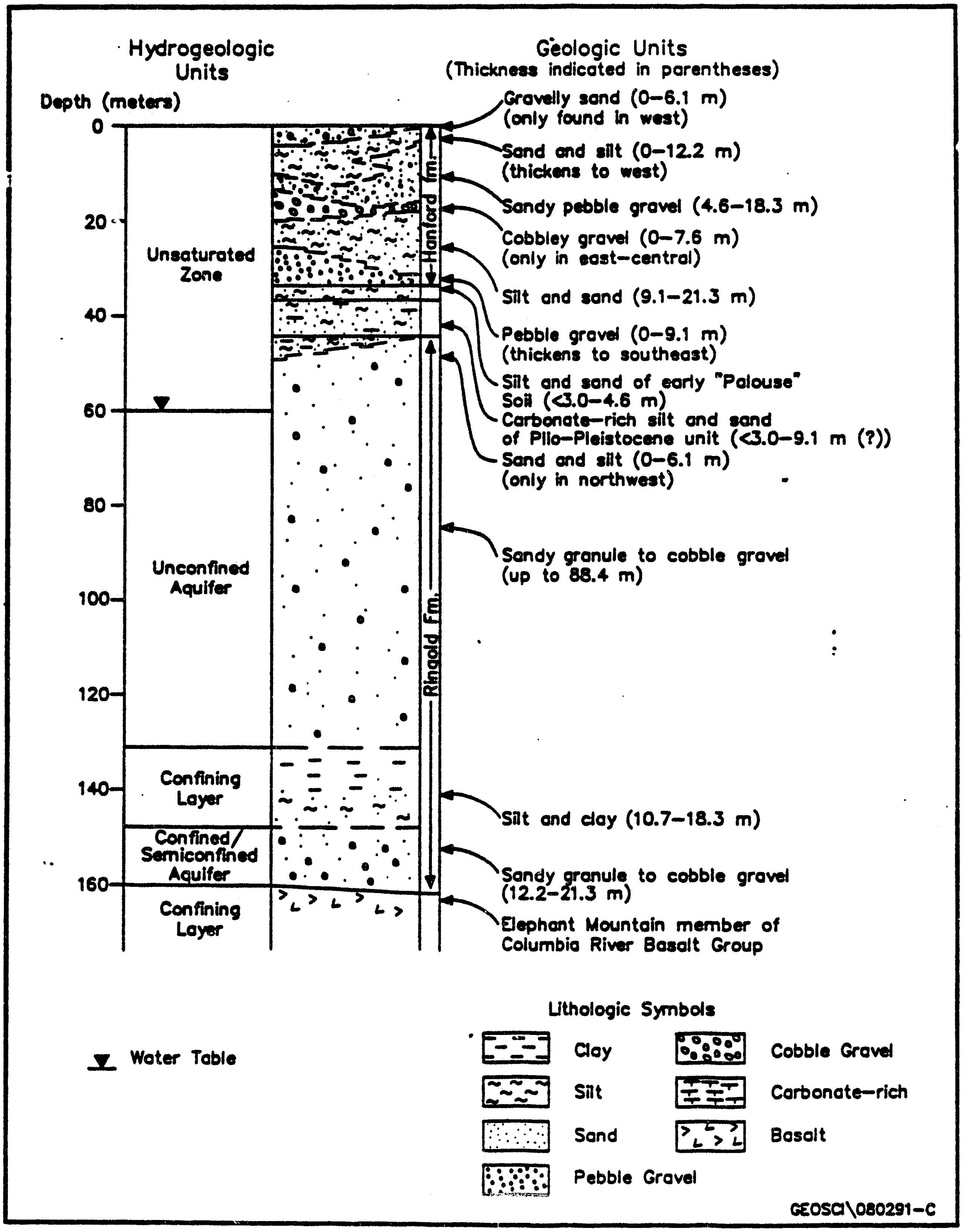
The uppermost aquifer in the 200 West Area is unconfined and located within the Ringold Formation. The saturated thickness of the uppermost aquifer ranges from 67 to 113 m (220 to 371 ft). Groundwater flow directions are generally radial outward from the southwest portion of the 200 West Area primarily because of the continuing influence of the residual groundwater mound underlying the decommissioned 216-U-10 Pond. Recharge to the aquifer is primarily artificial recharge from waste disposal activities.

1.2.3 Extent of Contamination

Results of previous characterization activities for the carbon tetrachloride site were used to refine the site conceptual model of the carbon tetrachloride behavior and distribution (Last and Rohay 1993). In this refined conceptual model, the highest concentrations of carbon tetrachloride are located in the vicinity of the 216-Z-9 Trench; concentrations in the vicinity of the 216-Z-1A Tile Field and 216-Z-18 Crib are typically one to two orders of magnitude lower. Carbon tetrachloride vapor has been detected throughout the unsaturated zone, at depths ranging from the surface to 63 m (207 ft) below ground surface, but the highest concentrations appear to be associated with the early "Palouse" and Plio-Pleistocene layers.

At the 216-Z-9 Trench, the carbon tetrachloride concentrations appear to be highest adjacent to and north of the disposal facility. The soil-gas survey results indicate that the highest near-surface soil-gas concentrations of carbon tetrachloride (72 parts per million by volume [ppm_v]) and chloroform are located just north of the 216-Z-9 Trench. The highest subsurface carbon tetrachloride vapor concentrations (over 10,000 ppm_v) were measured in wells and deep soil-gas ports near the trench. The highest carbon tetrachloride concentrations (up to 37.8 ppm) detected in sediment samples were from a well

Figure 2. Generalized Hydrostratigraphic Column for the Z Plant Area.



drilled adjacent to the trench in 1992 (299-W15-217). In addition, concentrations of carbon tetrachloride extracted from wells in the 216-Z-1A/Z-18 wellfield during vapor extraction operations typically range from 200 to 1,000 ppm_v; concentrations extracted from wells in the 216-Z-9 wellfield have been as high as 28,500 ppm_v.

Sediment and subsurface soil-gas samples indicate that the highest concentrations of carbon tetrachloride in the unsaturated zone are associated with the early "Palouse" soil and the top of the Plio-Pleistocene unit, located at a depth of approximately 35 to 40 m. The early "Palouse" soil is a fine-grained unit with high porosity, small pore-size distribution, and relatively low hydraulic conductivity; the Plio-Pleistocene unit is a calcium carbonate-cemented horizon with very low hydraulic conductivity. Numerical flow simulations appear to support the contention that the early "Palouse" soil is the primary repository for carbon tetrachloride and other VOCs.

Well construction and wastewater disposal histories suggest that some of the older existing wells, including deep groundwater wells, had the potential to provide a vertical conduit for the downward migration of carbon tetrachloride and other contaminants directly to the aquifer. However, column pore volume estimates and numerical model simulations suggest that, at the 216-Z-9 Trench, the wastes likely reached the water table irrespective of whether poorly sealed wells provided a preferential pathway.

Perched water has been encountered at the 216-Z-9 Trench above the Plio-Pleistocene unit. The source of this perched water is probably the currently active 216-Z-21 disposal facility southeast of the trench.

Concentrations of dissolved carbon tetrachloride detected in the upper 10 m of the unconfined aquifer (as defined by the 10-p/b contour) have accounted for approximately 2% of the total carbon tetrachloride inventory (DOE-RL 1991, Appendix B). The dissolved plume is estimated to cover an area of 13 km^2 and appears to be emanating from the area of the disposal sites and extends primarily to the north. The highest concentrations observed have been 7,000 to 8,000 ppb, which is approximately 1% of the solubility limit of carbon tetrachloride in water.

Sampling data from one well (299-W15-6) also suggest that carbon tetrachloride occurs deep within the aquifer, at least near the 216-Z-9 Trench, where dissolved carbon tetrachloride was detected 52 m below the water table. However, the well itself may have provided the preferential pathway for the vertically distributed contaminants.

Carbon tetrachloride has also been detected in the 200 West Area away from the disposal sites. During drilling and monitoring throughout the 200 West Area since 1987, carbon tetrachloride vapor has been detected in borings both above and below the Plio-Pleistocene unit. Most of the reported detections were below the Plio-Pleistocene unit, although wells west, northwest, and south of the 216-Z-1A/Z-18 area had detections both above and below the caliche.

Plutonium and americium have been detected in the soils at the 216-Z-1A Tile Field, and naturally occurring radon was detected in the vapor extracted from the tile field. Plutonium and americium were also present in the soil at the 216-Z-9 Trench and strontium and americium at the 216-Z-18 Crib.

2.0 TECHNICAL ANALYSIS

A comparison of the technical capabilities and limitations is presented below for passive vapor extraction and active vapor extraction.

2.1 PASSIVE VAPOR EXTRACTION

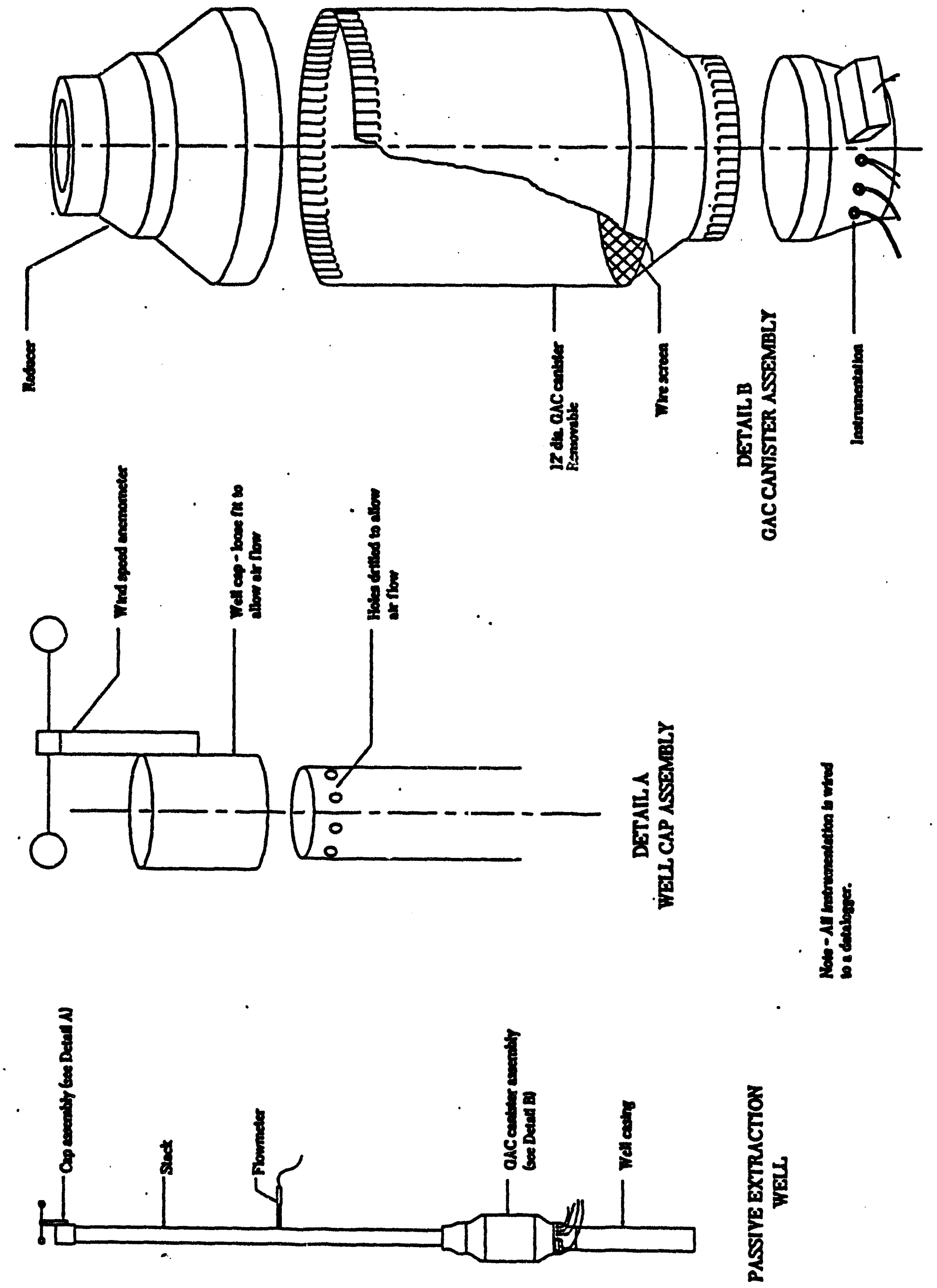
Passive vapor extraction is proposed as a complementary technology to be used in conjunction with standard active vapor extraction methods. Active vapor extraction would be used to extract soil gas from areas of high VOC concentration and within zones exhibiting high vapor phase permeability. Enhanced passive vapor extraction would be used in areas of lower VOC concentration and in relatively impermeable soils where extraction rates are limited by gaseous diffusion. A primary advantage of passive vapor extraction is lower capital and operating costs. The low cost of passive vapor extraction allows for many small passive vapor extraction systems to be installed on individual wells within a contaminated site and to be operated for extended periods of time. This allows for remediation of sites in which soil-gas transport is limited by diffusion.

2.1.1 Passive Airflow Data

Wellhead monitoring stations have been used to measure temperatures, pressures, air flow, humidity, and VOC concentrations at many wells located within the carbon tetrachloride plume beneath the 200 West Area of the Hanford Site. Each monitoring station includes a canister containing granular activated carbon (GAC) in line with and below an exhaust stack. The canister, which is open at its top and bottom, and stack are secured to the top of the selected well. Instrumentation is inserted below the base of the GAC canister. This configuration is shown in Figures 3 and 4. Typical instrumentation includes type-K thermocouples, a humidity sensor, a barometric pressure gauge, a differential pressure gauge, a hot-wire anemometer (flow meter), a wind speed cup anemometer, and a data logger. These instruments are described in Rohay and Peters (1994).

The rate that air flows into or from a well was found to be a function primarily of the difference between barometric and subsurface air pressure and the depth of the well's open interval. These relationships are shown graphically in Figures 5, 6, and 7 using data collected from two wells (299-W18-246 and 299-W18-247) with similar construction, located 160 m (525 ft) apart and with open intervals at similar depths (Figure 1). Well 299-W18-247 was sealed and the pressures monitored, while well 299-W18-246 was unsealed and the air flows monitored. For well 299-W18-247, the pressure at the upper open interval (36 to 39 m [119 to 129 ft] below ground surface) mirrors the barometric pressure but with a small time lag (Figure 5). The pressure at the lower open interval [49 to 52 m (162 to 172 ft) below ground surface] also shows a small time lag relative to the barometric pressure, but the lower interval pressure variations are significantly damped. This damping effect is a result of a caliche layer located between the two open intervals.

Figure 3. Wellhead Monitoring Station Configuration.



DETAIL B
GAC CANISTER ASSEMBLY

DETAIL A
WELL CAP ASSEMBLY

PASSIVE EXTRACTION
WELL

Note - All instrumentation is wired to a datalogger.

Figure 4. Example Wellhead Monitoring Station.

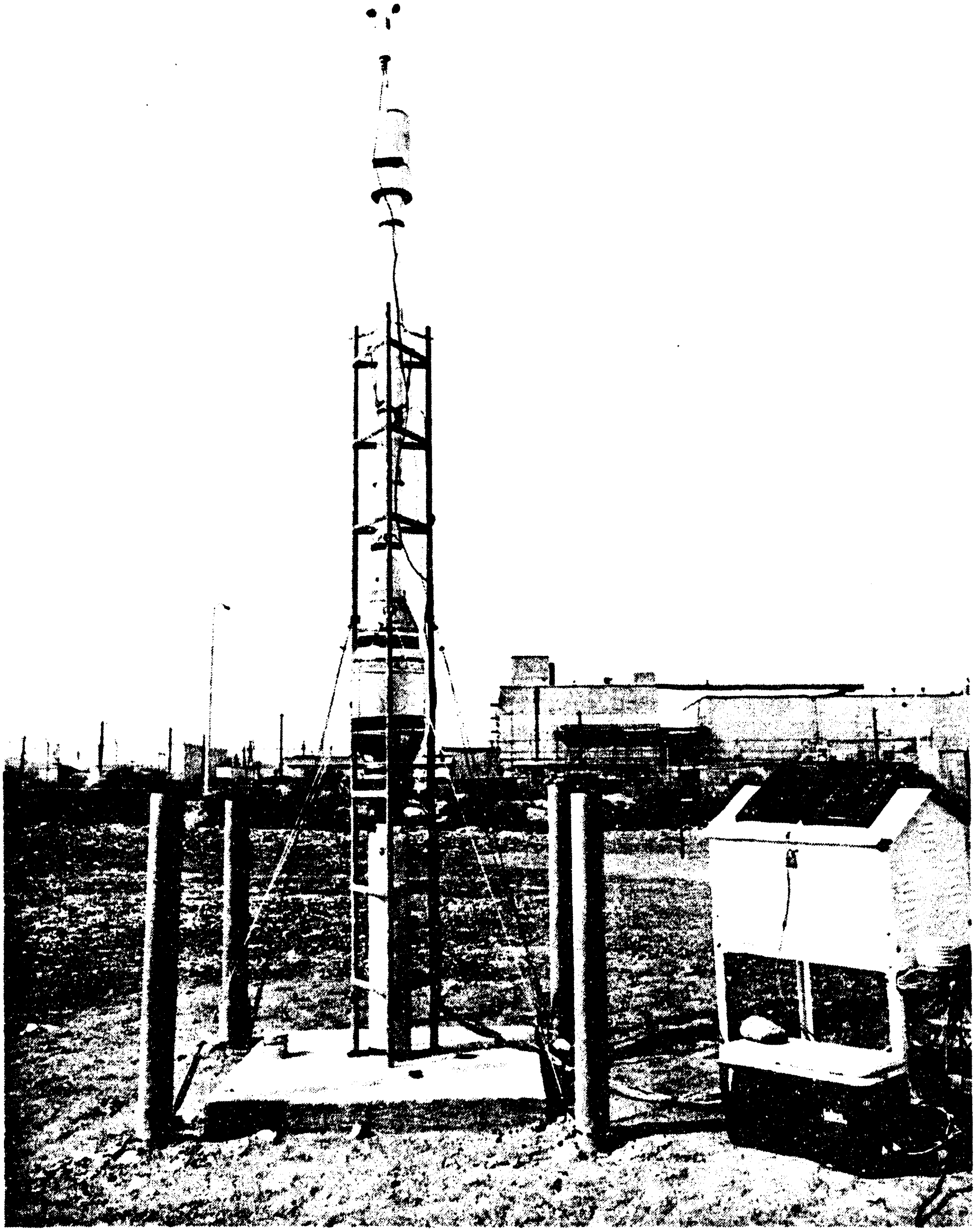


Figure 5. Sealed Well and Barometric Pressure for Well 299-W18-247.

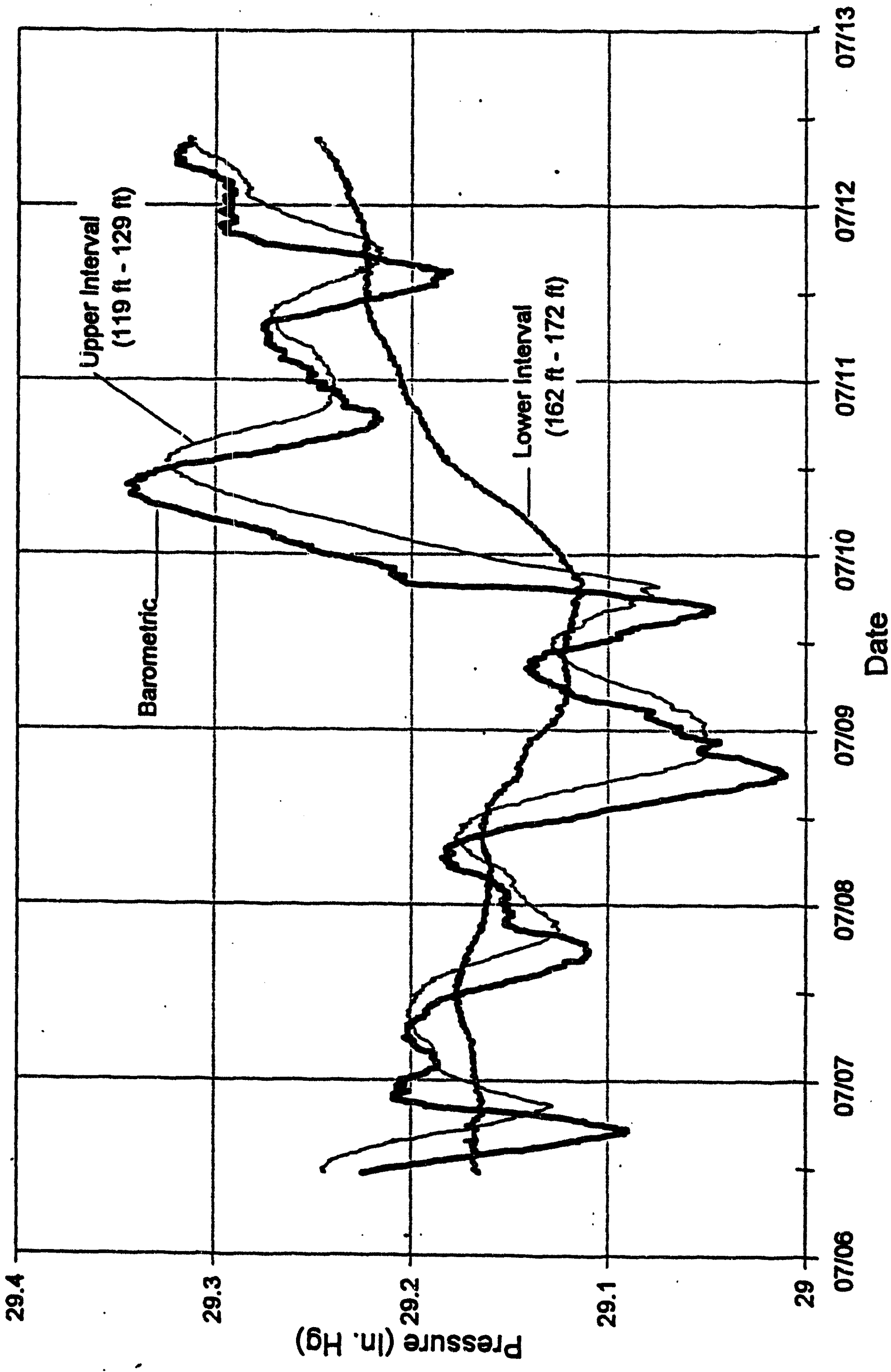


Figure 6. Well Flow Rate and Differential Pressure Above the Caliche.

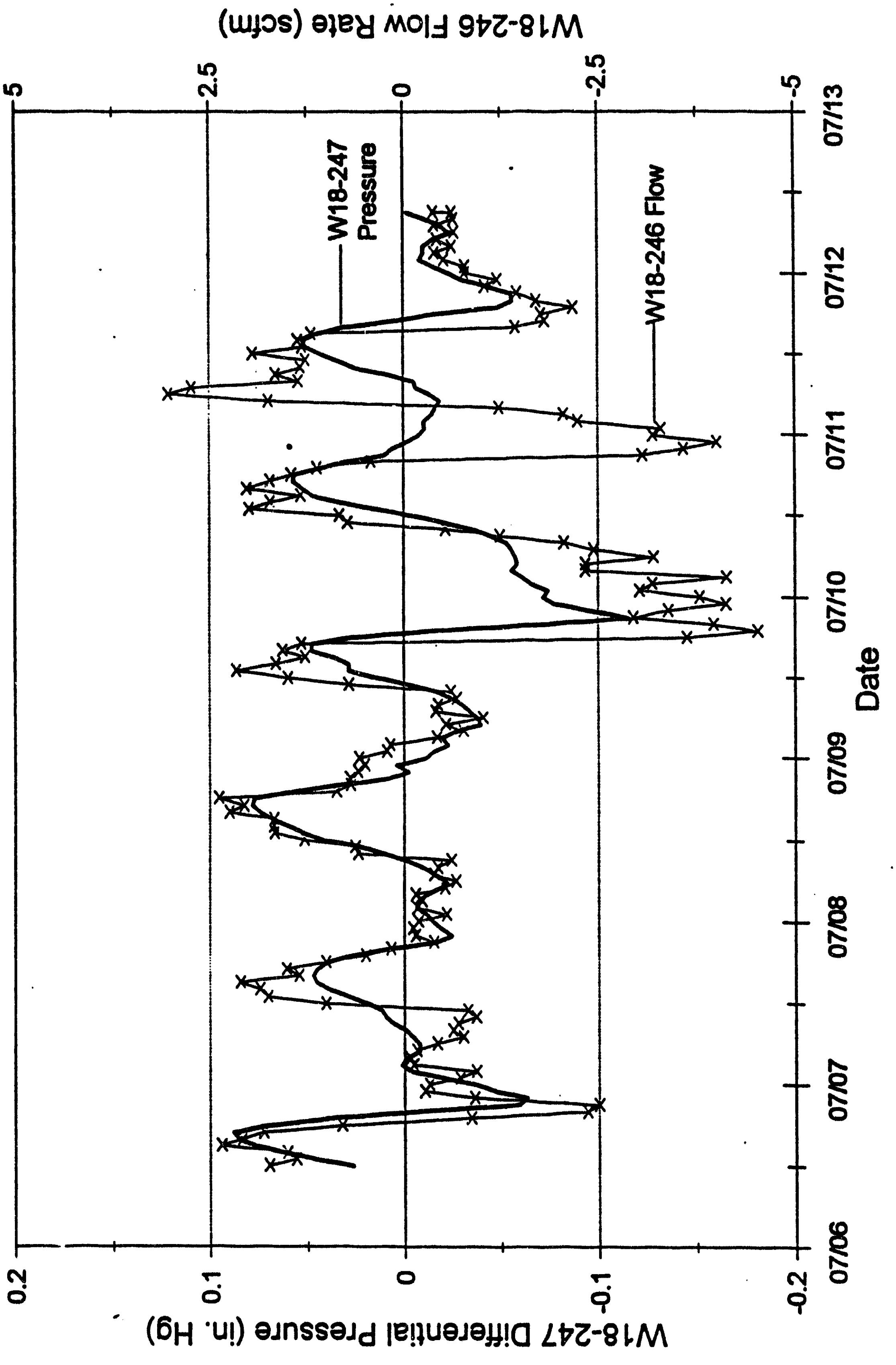
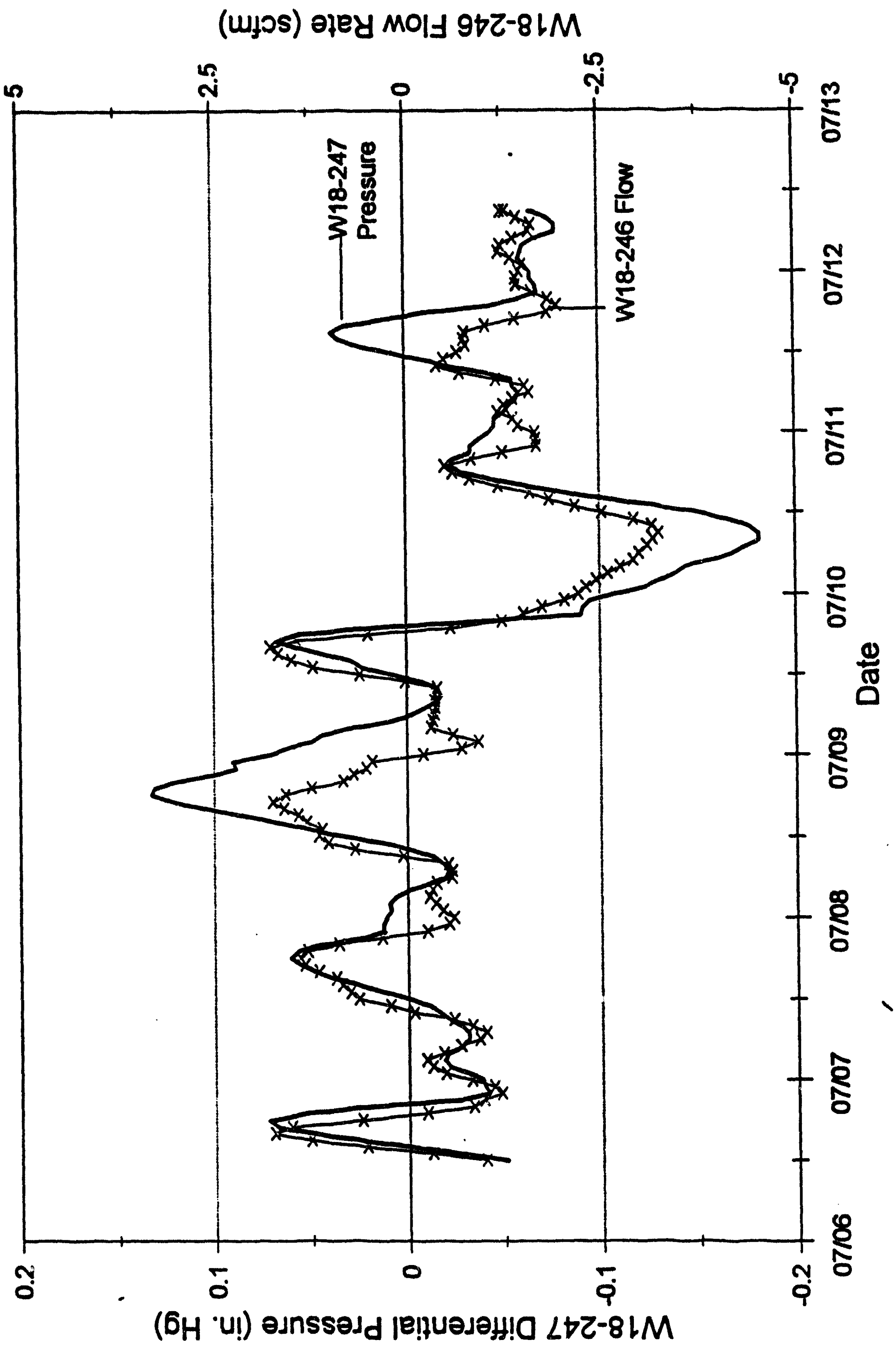


Figure 7. Well Flow Rate and Differential Pressure Below the Caliche.



Figures 6 and 7 show the subsurface differential pressure for well 299-W18-247 overlain on the airflow rates above and below the caliche layer, respectively, for the nearby well 299-W18-246. In both cases there is a strong correlation with the sign and magnitude of the differential pressure and the direction and magnitude of the flow rate. A positive sign indicates flow out of the well, and a negative sign indicates flow into the well.

The subsurface air pressure is a complex function of the barometric pressure and properties of the soils around the well. Modeling of subsurface air flow is being performed to quantify this function and to predict the effectiveness and radius of influence of a passive vapor extraction system. Inputs to the model will include wellhead monitoring data and data obtained from tracer gas testing. When completed, this model will be used as a tool for optimizing the design of and the spacing between passive vapor extraction systems. The tracer gas testing will provide information on airflow pathways and VOC movement in the unsaturated zone.

A summary of the data collected from six of the monitored wells is provided in Table 1. This table includes airflow rates and concentrations. The wellhead monitoring concentrations are in parts per million by volume of carbon tetrachloride, while the baseline monitoring concentrations are in parts per million by volume of organics that are assumed to be carbon tetrachloride.

2.1.2 Passive Vapor Extraction System Conceptual Design

A proposed passive vapor extraction system utilizing a ball valve, a check valve, GAC canister(s), saturation indicator, and wind-powered turbine fan is shown in Figure 8. The ball valve is used to seal the well while working on downstream components; the check valve will prevent flow of ambient air into the well; the GAC will capture carbon tetrachloride vapors; the saturation indicator will change color prior to VOC breakthrough of the GAC; and the turbine will provide additional air flow from the well.

The check valve is required to prevent the inward flow of ambient air that would tend to dilute the soil gas VOC concentration around the well. The use of check valves should increase the average VOC concentration of the extracted soil gas. Additionally, wells located around the passive vapor extraction system could have check valves installed that only let ambient air into the well and the unsaturated zone to which it opens. These wells could be used to selectively direct air flow in the unsaturated zone toward, for example, the passive extraction well.

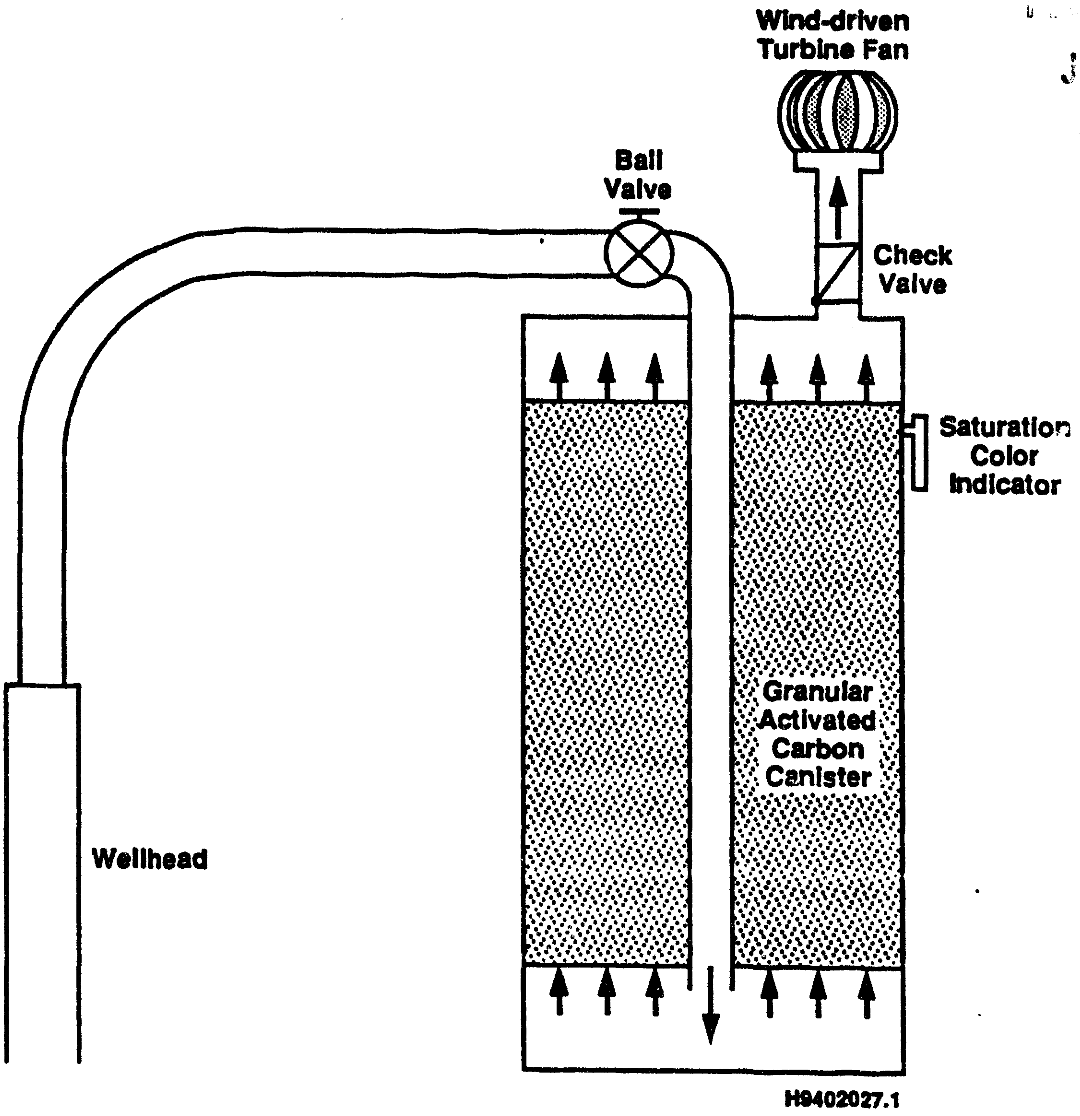
The GAC canister will be a standard 50-gal unit containing a nominal 200 lb of GAC. Alternatively, a low-pressure drop canister of a radial flow design may be used for wells with particularly low natural air flows. Such designs decrease the air pressure drop across the GAC bed. Assuming a 25% loading, a single 200-lb canister can load 50 lb of carbon tetrachloride. Depending on the flow rate and concentrations, this should be adequate for 2 weeks to 1 year of operations. A second GAC canister may be required to ensure that no VOCs are released to the atmosphere when the first canister saturates. An indicator will be placed near the outlet of the GAC canister to signal when this canister is nearly saturated. The indicator changes color with exposure to VOCs.

Table 1. Well Data Summary.

Well	Average outflow (stdft^3/min)	Average inflow (stdft^3/min)	Time of outflow (%)	Time of inflow (%)	Average outflow concentration (ppm$_v$)		Depth open interval (ft)
					Wellhead monitoring	Baseline monitoring	
W15-218[a]	4.7	4.4	52	48	404	137	70-80, 180-195
W15-9	1.3	1.3	62	38	N/A	38	186-189
W18-246 L	1.1	1.3	43	57	N/A	44	165-175
W18-246 U	0.9	1.0	51	49	N/A	30	120-130
W18-6	7.6	6.4	56	44	33	53	190-210
W18-7	2.7	2.3	53	47	N/A	31	196-204

[a] Data given is the combined flow from the upper and lower intervals.
L = lower interval.
U = upper interval.

Figure 8. Passive Vapor Extraction System Conceptual Design.



A wind-powered turbine fan will be placed on the system outlet to provide additional vacuum to increase the natural air flow. A wind-powered device should be particularly effective because the highest winds typically occur when the barometric pressure is falling and passive well air flows are the greatest.

For purposes of this evaluation, it is assumed that a passive vapor extraction system would be implemented outside of any radiation zone and would not require high-efficiency particulate air (HEPA) filtration. Should HEPA filtration be required, an 8- by 8-in. filter and housing could be used.

2.1.3 Passive Vapor Extraction Applications

The application of passive vapor extraction to the carbon tetrachloride plume below the 200 West Area may be especially appropriate because of the presence of the low-permeability caliche zone. As dense nonaqueous phase liquids such as carbon tetrachloride flow through the unsaturated zone, they leave behind residual organics in the interstitial spaces of the soil. The amount of residual liquid tends to increase as permeability decreases. Soil sample results and numerical modeling studies indicate that a majority of the carbon tetrachloride can be found in the early "Palouse" soil and the caliche (Plio-Pleistocene unit) (Last and Rohay 1993).

The presence of carbon tetrachloride in the caliche and early "Palouse" units reduces the effectiveness of vapor extraction because of the low permeability of these layers. Extraction of soil gas from a region containing a low-permeability zone may be impacted by rate of gaseous diffusion through the zone. Soil gas will preferentially flow through high-permeability soils rather than through low-permeability lenses, such as the caliche layer. Carbon tetrachloride vapors must first diffuse through the low-permeability caliche to higher permeability soil where it can be swept away by the flowing soil gas. As extraction proceeds, the carbon tetrachloride is removed from the surface of the low-permeability caliche, thereby increasing the diffusional distance and decreasing the extraction rate. This condition results in a decrease in the soil-gas concentration while a vapor extraction unit is operating and then an increase after vapor extraction has ceased. (This response, in fact, has been noted during operation of the active vapor system at the 216-Z-1A Tile Field.) The decreased removal efficiency observed may be accommodated by cycling the use of active vapor extraction between several wells to allow the soil-gas concentrations in the idle wells to reestablish equilibrium.

The airflow rates achievable by passive vapor extraction will usually be low enough that soil-gas concentrations will be near equilibrium levels, whereas active vapor extraction often will not be at equilibrium, especially at the lower soil vapor concentrations. Thus, the average soil-gas concentrations will often be greater for passive vapor extraction.

The comparative cost/benefit of passive vapor extraction must be measured in terms of a decreased soil-gas extraction rate but achieved, in most cases, at a lower cost per pound extracted. For a given set of extraction wells, it is predicted that a site can typically be remediated by passive vapor extraction at a lower cost but over a longer time period than required by active vapor extraction. Active vapor extraction is more cost-effective where soil-gas concentrations are high. In other words, at increased concentrations, the energy and labor required by active vapor extraction are used more effectively in terms of mass of soil-gas contaminants removed.

Because of its relatively lower capital costs and inherently lower operating costs, passive vapor extraction may be particularly well-suited for use on an extraction well after active vapor extraction has been used to remove a majority of the easily volatilized contaminants. For similar reasons, passive vapor extraction may be more cost-effective on extraction wells located on the edge of an unsaturated soil-gas plume. Active vapor extraction may be more cost-effective for treating the higher concentrations in the center of the plume.

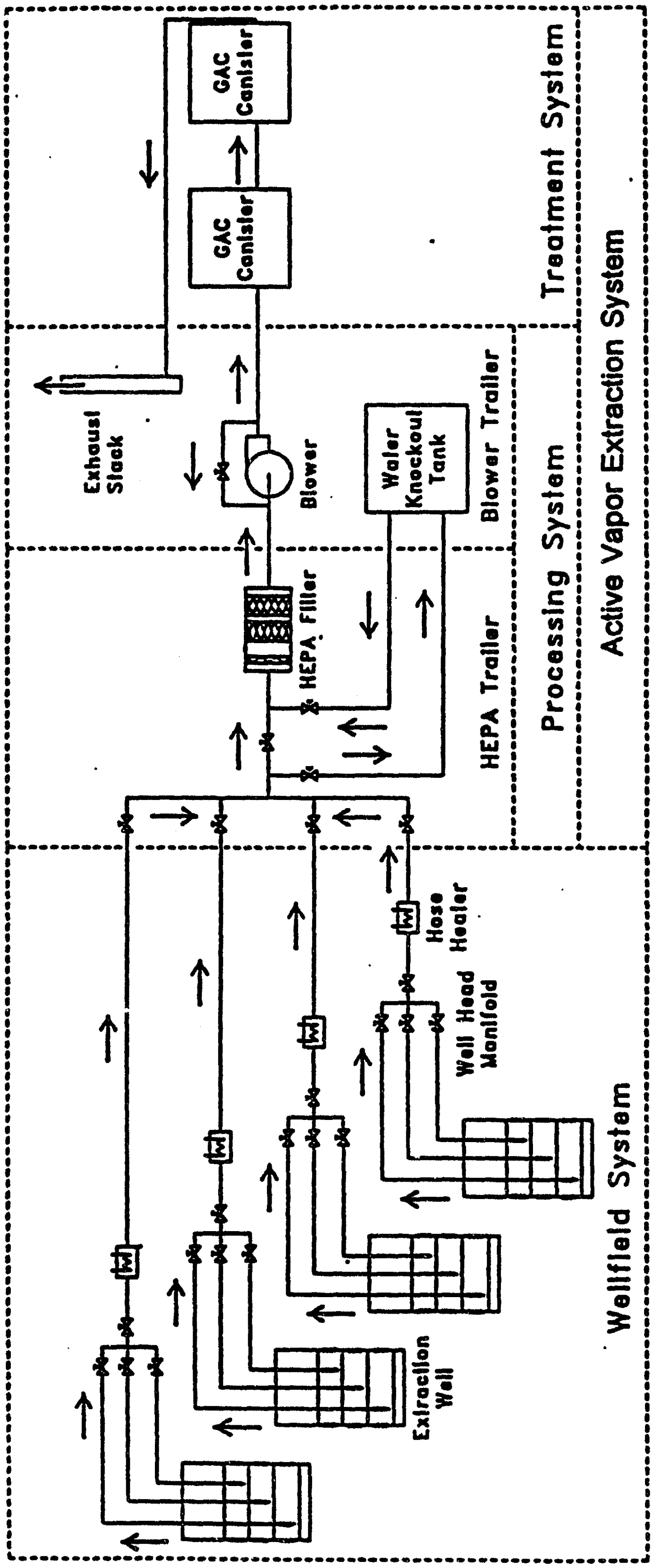
In all of the applications of passive vapor extraction previously discussed, the goal is extraction of soil gas. An alternate application of passive vapor extraction technology is the controlled use of natural air flow to contain or reduce the horizontal migration of a soil-gas plume. This could be accomplished by placing wells around a soil-gas plume and using check valves that allow air flow only into the well and the subsurface. While it seems unlikely that this alone would meet most remedial action goals, it might prove to be a useful component of a containment alternative.

2.2 ACTIVE VAPOR EXTRACTION

The application of active vapor extraction is similar to that of passive vapor extraction in that soil gas is withdrawn from contaminated areas of the unsaturated zone and treated for removal of VOCs. Unlike passive vapor extraction, however, in active vapor extraction a vacuum is applied to the extraction wells using a blower. The typical active vapor extraction system also includes a water knockout tank to remove entrained water, an air cooler to reduce the temperature of the gas stream temperature downstream of the blower and prior to the GAC, GAC canisters for adsorption of VOCs, and a process control system. Due to the use of active vapor extraction on wells located within the carbon tetrachloride disposal sites and the co-contamination of these sites with radionuclides, the active vapor extraction systems also include HEPA filtration. Figure 9 shows these active vapor extraction components.

Passive vapor extraction is compared to two alternative configurations of active vapor extraction systems. The first, active vapor extraction with offsite thermal oxidation of GAC, is the baseline system that is currently operating at the 216-Z-1A Tile Field. A recent engineering study (WHC 1993) identified active vapor extraction with onsite desorption of the GAC and thermal oxidation of the VOCs as the most cost-effective treatment method. Therefore, active vapor extraction with onsite thermal oxidation is also included in the current feasibility study. Offsite and onsite thermal oxidation are discussed in Sections 2.2.1 and 2.2.2, respectively.

Figure 9. Active Vapor Extraction System Design.



2.2.1 Offsite Thermal Oxidation

One of the terms of the existing GAC regeneration contract is that loaded GAC canisters are transported by truck to a reactivation facility.

At this facility, carbon tetrachloride-laden GAC is transferred from the loaded canisters into a high-temperature thermal incinerator. The incinerator is designed and operated to convert carbon tetrachloride to carbon dioxide and hydrogen chloride at high efficiencies. A scrubber contacts incinerator flue gas with an aqueous solution of sodium hydroxide. The scrubbing captures particulates formed by attrition of the GAC during its passage through the incinerator. The scrubber also neutralizes hydrogen chloride produced by oxidation of the carbon tetrachloride. Clean exhaust gas vents from the scrubber to the atmosphere.

The empty canisters are decontaminated, refilled with fresh, reactivated GAC, and transported by truck back to the Hanford Site. The vendor cost for this service is $1.42 per pound of GAC.

2.2.2 Onsite Thermal Oxidation

Onsite thermal oxidation requires that carbon tetrachloride and other VOCs be desorbed from the GAC prior to high-temperature thermal oxidation.

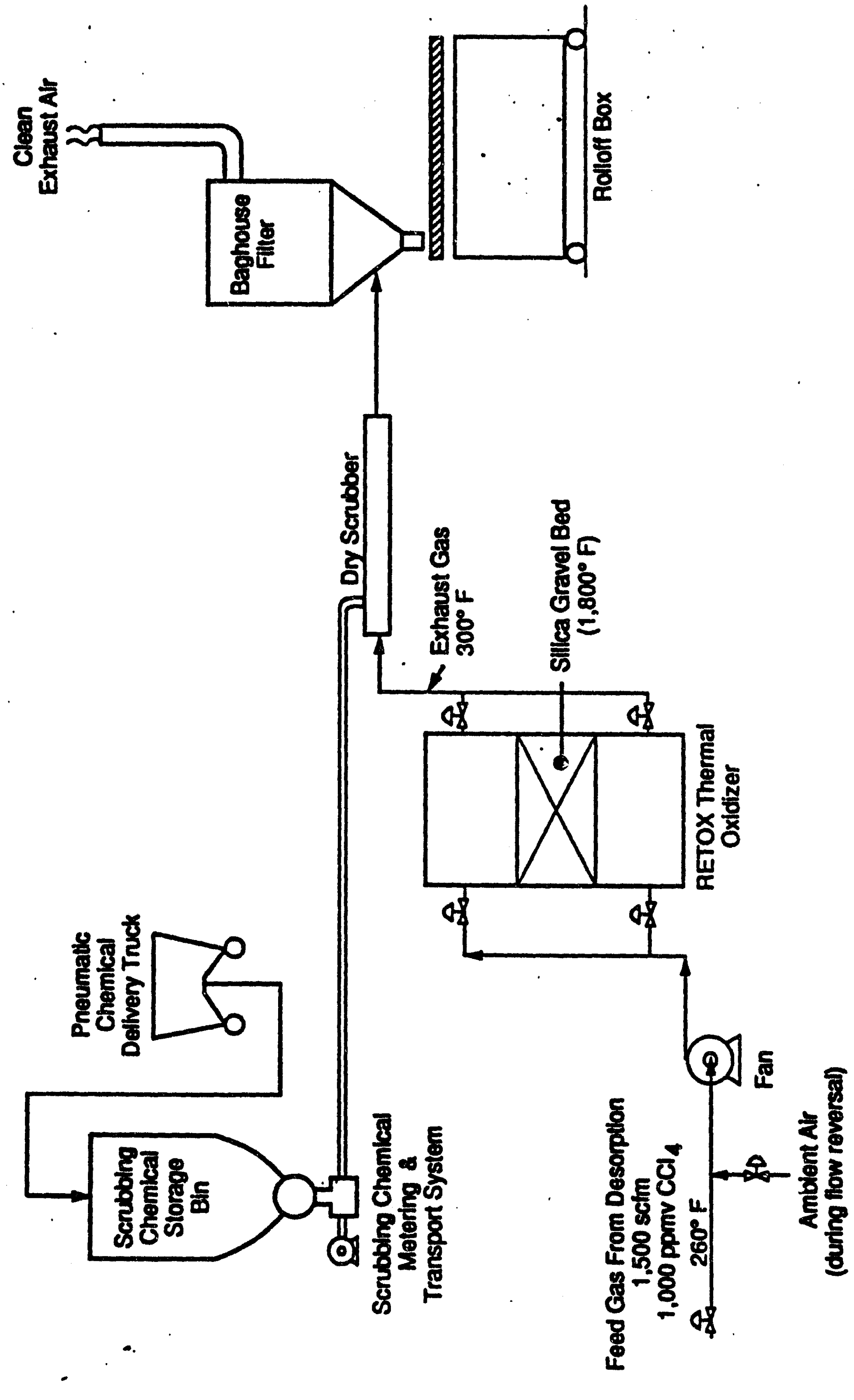
Desorption at a relatively low temperature (121 to 177 °C [250 to 350 °F]) is a process routinely used in industry to remove materials such as VOCs and water vapor that have been adsorbed onto GAC, thus restoring the adsorption capacity of the GAC. Desorption is usually accomplished by passing a low-pressure stream of superheated steam, heated nitrogen, or heated air through the bed of GAC. The elevated temperature of the steam or gas vaporizes the adsorbed materials and sweeps them out of the bed. The desorbed materials are then fed to the thermal oxidation process.

Carbon tetrachloride in the thermal oxidation influent gas stream is oxidized at high temperature to carbon dioxide and hydrogen chloride. Carbon tetrachloride destruction efficiencies of 99% or higher are possible if the oxidation is carried out at 982 to 1,093 °C (1,800 to 2,000 °F) and ample residence time and turbulence are allowed. The hydrogen chloride that is formed must be treated by a neutralization process before the gas stream can be emitted.

Carbon tetrachloride is nonflammable and has a low heating value. Therefore, a supplemental energy source such as propane or electric heating must be used to maintain the operating temperature. The heat in the treated gas stream would be 98% recovered through regenerative heat exchange by means of a silica gravel bed contained within the oxidizer. Figure 10 shows a schematic diagram of the proposed process. The thermal oxidation unit would require only electrical energy.

Warm air carrying desorbed carbon tetrachloride would enter one end of the silica bed and approach the heating elements. The silica gravel, which would be maintained at 1,093 °C (1,800 °F), would rapidly heat the gas. The water in the stream would react with the carbon tetrachloride, oxidizing 99%

Figure 10. Thermal Oxidation Process Flow Diagram.



or more of it to carbon dioxide and hydrogen chloride. The heat released by oxidation of carbon tetrachloride would raise the temperature of the gas stream by 6 to 11 °C (10 to 20 °F). After combustion, the exit portion of the silica bed would be heated by the exhaust gas stream that would rapidly cool to approximately 150 °C (300 °F).

Thermal oxidation of carbon tetrachloride would generate hydrogen chloride at a concentration of approximately 4,000 ppm_v. An acid dry scrubber system for the hydrogen chloride would consist of a chemical receiving and storage system, a chemical metering and transport system, a scrubber where the dry chemical and hydrogen chloride-contaminated exhaust gas from the thermal oxidation unit are brought into contact, a baghouse filter, and a secondary waste chemical transport and temporary storage system.

A more detailed description of onsite thermal oxidation is provided in WHC (1993).

3.0 REGULATORY ANALYSIS

It was assumed that all applicable or relevant and appropriate requirements (ARARs) identified in the ERA Proposal (DOE-RL 1991) for vapor extraction and GAC offgas treatment are ARARs for passive vapor extraction as well. The following discussion draws from both the ERA Proposal (DOE-RL 1991) and from a memo prepared by Battelle Human Affairs Research Center (HARC) for Westinghouse Hanford Company (Appendix A). Sections 3.1 through 3.6 contain a review of the individual ARARs as they relate to passive vapor extraction.

3.1 RADIATION PROTECTION - AIR EMISSIONS

Chapter 246-247 of the Washington Administrative Code (WAC) contains requirements that are implemented by the Washington Department of Health and address monitoring, control, and reporting of airborne radionuclide emissions from specific sources to ensure compliance with applicable standards, including the requirement for best available radionuclide control technology. The requirements specifically apply to DOE facilities. The term "radionuclide" is defined to mean any nuclide that emits radiation. However, the dose-based standards that must be met exclude doses due to ^{220}Rn, ^{222}Rn, and their decay products. Thus, sources of such emissions are completely excluded from these regulations.

Current monitoring and best professional judgment indicate that implementation of passive vapor extraction under the ERA does not represent a new source of radionuclide emissions other than radon, which is excluded from these regulations. Therefore, current compliance with this regulation would continue.

3.2 NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAPS) - RADIONUCLIDE EMISSION FROM DOE FACILITIES

Title 40, Code of Federal Regulations (CFR), Part 61, Subpart H applies to operations at any DOE facility that emit any radionuclide into the air other than ^{220}Rn or ^{222}Rn. The standard requires that radionuclide emissions not cause a member of the public to receive an effective dose equivalent of 10 mrem/yr. There are detailed monitoring, reporting, and record-keeping requirements for all emission points within the facility having the potential to discharge radionuclides in quantities leading to an effective dose equivalent to a member of the public of more than 0.1 mrem/yr. Other emission points would require periodic confirmatory measurement to verify that emissions are below the threshold. In addition to these monitoring and reporting requirements, any fabrication, erection, or installation of a new building or structure, or modification, within a facility that emits radionuclides must be approved if the new construction or modification causes emissions greater than the 0.1 mrem/yr effective dose equivalent.

Current monitoring and best professional judgment indicate that implementation of passive vapor extraction under the ERA does not represent a source of radionuclide emissions other than radon, which is excluded from these regulations. Current compliance with this regulation would continue.

3.3 PREVENTION OF SIGNIFICANT DETERIORATION

Chapter 173-403-080 WAC and 40 CFR Section 52.21 provide that construction of a major stationary source (or a major modification to a source) in an attainment area requires a Prevention of Significant Deterioration (PSD) technology permit and the application of best available control technology. The PSD review is triggered by greater than threshold emissions of "criteria" pollutants such as sulfur dioxide, particulates, and certain VOCs. For the ERA, the "significant net increase" of VOC emissions that would trigger PSD review is 40 tons/yr. The ERA as currently configured and including implementation of passive vapor extraction would result in an estimated maximum carbon tetrachloride emission of only 1.8 tons/yr and thereby is exempt from PSD requirements. Thus, current compliance would continue.

3.4 CONTROLS FOR NEW SOURCES OF TOXIC AIR POLLUTANTS

Chapter 173-460 WAC applies to sources that may emit one or more toxic air pollutants listed in the regulations, including carbon tetrachloride and hydrogen chloride, and that commenced construction after September 18, 1991. Before constructing, installing, or establishing such a source, the owner or operator must seek and obtain approval for a notice of construction. To receive construction approval, the new source must use best available control technology for toxics (T-BACT) and demonstrate that emission levels are sufficiently low to protect human health and safety from potential carcinogenic or other toxic effects. The demonstration regarding emissions is made, in the first instance, through comparison with acceptable source impact levels (ASILs) to unrestricted access areas specified in the regulations. The ASIL for carbon tetrachloride is 0.067 $\mu g/m^3$ (maximum annual average).

The passive vapor extraction system would be subject to the substantive requirements of this ARAR, including the control technology requirement (T-BACT) and the ASIL demonstration. Regarding the T-BACT requirement, the GAC collection system would in itself be T-BACT for emissions from the wellheads, according to the Washington Department of Ecology, so no further technology would be required. Regarding the ASIL demonstration, as detailed in the ERA Proposal (DOE-RL 1991), it was demonstrated that emissions of up to 5 lb/day of carbon tetrachloride from the GAC exhaust resulted in unrestricted access area concentrations that met the ASIL. The maximum emissions from a passive vapor extraction system would be 0.06 lb/day of carbon tetrachloride from each well. The number of wells used for passive vapor extraction would be limited to ensure that the current compliance would continue.

3.5 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) AIR EMISSION STANDARDS FOR PROCESS VENTS AND EQUIPMENT LEAKS

The Resource Conservation and Recovery Act (RCRA) Part 264 Treatment, Storage, and Disposal Requirements provide substantive and procedural requirements for the treatment of hazardous waste. The RCRA Subpart AA process vent standards apply to vents from certain waste management units that manage hazardous waste with an annual average total organics concentration of 10 parts per million by weight or greater. The affected waste management units include distillation, fractionation, thin-film evaporation, solvent extraction, and air or steam stripping operations and associated tanks.

In the preamble to the final rule adopting these requirements, the U.S. Environmental Protection Agency (EPA) discussed their applicability to *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) removal and remedial actions and specifically stated that they would not be ARARs for, among other things, "in situ soil vapor extraction."

The RCRA Subpart BB equipment leak standards apply to emissions from valves, pumps, compressors, pressure-relief devices, sampling connection systems, and open-ended valves or lines where the equipment contains or contacts hazardous waste streams with organic concentrations of 10 wt% or greater. The requirements include identifying, monitoring, maintaining, and keeping records for affected equipment. They also include certain performance requirements. For example, sample connections must have closed-loop purge systems and pressure-relief devices must operate with "no detectable emissions." The EPA has stated that these standards would be considered ARARs for equipment components installed at CERCLA sites that contain or contact such substances.

As a result of the permit exemption available for onsite activities at CERCLA sites, a RCRA treatment, storage, and disposal permit is not required for the ERA, although substantive RCRA treatment standards must be followed. Regarding the Subpart AA requirements, active vapor extraction and passive vapor extraction are specifically exempt. The only equipment affected by Subpart BB would be the canisters, piping, and valving used to contain the loaded GAC that, at design adsorption capacity, contain up to 30 wt% carbon tetrachloride. Applying Subpart BB to a passive vapor extraction system would be a matter of extending the design constraints and operating procedures already in place for equipment and operations associated with loaded GAC canisters within the existing ERA.

3.6 HAZARDOUS SUBSTANCE RELEASE REPORTING

40 CFR Part 302 requires that as soon as a person in charge of a facility has knowledge of a release of a hazardous substance in an amount equal to or exceeding its reportable quantity, the person must immediately notify the National Response Center. Federally permitted releases (i.e., releases under air or water emissions programs) need not be reported. In addition, releases of a continuous nature need be reported only once. The reportable quantity is 4.5 kg/day (10 lb/day) for carbon tetrachloride, 2,270 kg/day (5,000 lb/day) for hydrogen chloride, 0.1 Ci for ^{220}Rn or ^{222}Rn, and 0.01 Ci for ^{210}Pb (a decay product of radon).

Passive vapor extraction will not be utilized on wells with carbon tetrachloride concentrations greater than 500 ppm$_v$. The higher sustained passive air flows measured in wells at the 200 West Area carbon tetrachloride site were in the range of 20 stdft^3/min. This flow and the maximum concentration allowable would result in an extraction rate of 6 lb carbon tetrachloride per 24 h. Thus, even if a well were to vent directly to atmosphere, the reportable quantity would not be exceeded. The use of GAC with an assumed 99% removal efficiency would result in a maximum emission rate of 0.06 lb/day. According to the RCRA Permits Section of EPA Region 10, the CERCLA 302 requirement is specifically a notification requirement, not an enforceable emissions level. For this reason, the CERCLA 302 levels are generally not considered ARARs for CERCLA actions in Region 10. In particular, the actual applicability of the CERCLA 302 reportable quantity level to ongoing treatment emissions was questioned. It was stated that the federally permitted release exemption should be applicable to any CERCLA action and, therefore, any air emissions should be covered by applicable air quality regulations, not CERCLA reportable quantity regulations.

Further discussion with EPA Hanford Site representatives may be necessary to determine whether the CERCLA 302 regulation is in fact an ARAR for the ERA in general and passive vapor extraction in particular. However, such a determination is moot in this case, as passive vapor extraction would not trigger the reportable quantity requirement.

4.0 COST ANALYSIS

This section is divided into two parts, system costs and cost effectiveness. In Section 4.1, assumptions are identified and cost estimates for active vapor extraction with onsite regeneration, active vapor extraction with offsite thermal oxidation, and passive vapor extraction are presented. In Section 4.2, the cost analyses are summarized and the different systems are compared.

4.1 SYSTEM COSTS

This section describes the methods used to estimate costs for the three vapor extraction system alternatives: active vapor extraction with onsite regeneration, active vapor extraction with offsite thermal oxidation, and passive vapor extraction with offsite thermal oxidation.

4.1.1 Basis for Estimated Cost

It was assumed that operation of a 500-stdft^3/min active vapor extraction system extracting from a series of wells can be compared directly to multiple passive vapor extraction systems that generate an equivalent combined flow.

Each vapor extraction system has separate fixed costs that include all of the necessary equipment to deliver soil vapor to the GAC and a stack for discharging the effluent. The capacity of the active vapor extraction system is assumed at 500 stdft^3/min, the same as that of the original active vapor extraction system installed at the 216-Z-1A Tile Field.

Active vapor extraction is assumed to operate 6,000 h/yr, yielding a total operating efficiency (TOE) of 68%. At this TOE, which is based on operation 24 h/day, 5 day/week, and 50 week/yr, 180,000,000 ft^3/yr of air is extracted and treated. The passive vapor extraction units are assumed to operate 4,400 h/yr, yielding a TOE of 50%. This assumes that falling barometric pressure results in outflow of soil gas from the wells 50% of the time. The capital cost for passive vapor extraction is based on the number of units that will extract a combined air flow of 180,000,000 ft^3/yr. This results in 68 passive vapor extraction units at 10 stdft^3/min each, 136 passive vapor extraction units at 5 stdft^3/min each, and 682 units at 1 stdft^3/min each.

Capital costs include equipment purchase costs and installation costs. Active vapor extraction equipment includes a 25-brake horsepower (Bhp) blower, a water knockout tank, a HEPA filter and trailer, 12 GAC canisters, and instrumentation and controls. For onsite regeneration, the cost of a thermal oxidation system is added to the price of the active vapor extraction. The equipment cost of a passive vapor extraction system includes costs associated with two 200-lb GAC canisters, a ball valve, a check valve, and a wind turbine. The total installed equipment cost is estimated by multiplying the equipment costs by 2.5. This factor includes equipment purchase costs plus 7.8% for taxes and 21% for handling, placement, and anchorage. The sum of these costs is further increased by 8% for instrumentation and controls, 10% for outside facilities, 5% for auxiliary equipment, 27% for engineering, 16% for contract administration, and 15% for project management, yielding an overall factor of 2.5 times the purchased equipment costs.

A capital cost item that was not included was that associated with placement of the vapor extraction wells. This may be significant because, due to the lower flows, passive vapor extraction will have a smaller radius of influence and thus impact a smaller volume of soil than active vapor extraction. To remediate a given site, in general more extraction wells would be required for passive vapor extraction than for active vapor extraction.

Information regarding the effective radius of influence for passive versus active vapor extraction is being investigated but is not currently available. Additional methods for increasing the radius of influence (wind-powered vacuum pump, surface seals) and the extracted soil-gas concentrations (check valves) for passive vapor extraction and utilizing low-cost cone penetrometer extraction wells are also being investigated. The results of these studies will be incorporated at a later date.

Operating and maintenance costs include basic operating, maintenance, electricity, and chemical (e.g., GAC) costs. The GAC costs are directly related to the mass flux of carbon tetrachloride (CCl_4) that passes through the carbon canisters. At a flow rate of 500 $\text{stdft}^3/\text{min}$, 1 ppm_v would be equivalent to 0.0128 lb of carbon tetrachloride per hour. Using this flux rate, the total number of pounds of carbon tetrachloride adsorbed at a given concentration per year can be estimated (e.g., for a soil-gas concentration of 50 ppm_v carbon tetrachloride, 0.0128 lb $CCl_4/\text{h}/\text{ppm}_v$ * 50 ppm_v * 6,000 h/yr = 3,840 lb CCl_4/yr).

The active vapor extraction is assumed to utilize three full-time equivalent (FTE) operators and support personnel in the case of offsite regeneration of GAC and 4.0 FTE in the case of onsite regeneration. The passive vapor extraction units are assumed to require one FTE operator per 30,000 lb of carbon tetrachloride per year (e.g., at 50 ppm_v, (0.0128 lb $CCl_4/\text{h}/\text{ppm}_v$ * 50 ppm_v * 4,400 h/yr)/(30,000 lb CCl_4/yr/FTE) * \$100,000/FTE = \$9,400. This is based on a requirement of four employee-hours to replace a saturated GAC canister containing 60 lb of carbon tetrachloride. Additionally, passive vapor extraction requires that an operator check each system weekly. It is assumed that this takes 1 h/month per passive vapor extraction unit.

Maintenance is estimated at 7% of the installed capital cost for active vapor extraction and 2% for passive vapor extraction (Peters and Timmerhaus 1980).. Active vapor extraction with offsite regeneration uses a 25-Bhp blower and electricity based on a cost of \$0.04/kWh. Active vapor extraction with onsite regeneration includes a 25-Bhp blower as well as a thermal oxidation system that consumes power at a rate of 2.3 kWh/lb of carbon tetrachloride (WHC 1993). The acid scrubber is estimated to use 3.2 lb of trona per pound of carbon tetrachloride. (Trona is natural mineral containing sodium sesquicarbonate and is used in dry scrubbers.)

Waste disposal costs include those associated with offsite GAC regeneration in the case of active vapor and passive extraction with offsite GAC regeneration or offsite disposal of used trona in the case of onsite regeneration. Costs for the GAC are based on a 25 wt% carbon tetrachloride loading factor. Costs for disposal of spent scrubber slurry are based on the assumption that scrubber slurry is generated at a factor of 1.4 times the rate of trona usage (WHC 1993).

Equivalent uniform annualized costs for each alternative were calculated assuming a 4-year operating life and a 10% discount rate for the installed capital costs plus the annual operating and maintenance and waste disposal costs. The overall cost-effectiveness was determined by dividing the equivalent uniform annualized costs by the pounds of carbon tetrachloride removed from the soil annually.

4.1.2 Cost Estimates

As described in Section 2.1, the rate of passive air flow from wells is a complex function of the well configuration, depth of open intervals, unsaturated zone permeability, and the difference between barometric pressure and soil air pressure. Therefore, a range of passive air flow rates--1, 5, and 10 stdft^3/min--from individual wells were assumed. These values represent average airflow rates. This range is representative of rates measured in most of the wells that have been monitored in the 200 West Area (Table 1). Cost estimates were made for three passive vapor extraction systems, each assumed to consist of passive vapor extraction units placed on wells providing 1, 5, or 10 stdft^3/min of air flow.

System costs were estimated for a range of soil-gas concentrations. This was necessary because operation and waste disposal costs are a function of concentration. Cost estimates were made for soil-gas concentrations of 5, 50, 100, 200, 500, 1,000, and 5,000 ppm$_v$ of carbon tetrachloride and are given in Tables 2 through 8, respectively.

4.2 COST EFFECTIVENESS

This section compares the overall cost of soil vapor removal and treatment for the three vapor extraction system alternatives.

Table 9 and Figure 11 show that the overall costs range from $3 to $4,000 per pound of carbon tetrachloride removed. At concentration levels below 500 ppm$_v$ of carbon tetrachloride, passive vapor extraction units on 10-stdft^3/min wells will treat the soil vapor at the lowest cost. At 5,000 ppm$_v$, active vapor extraction with onsite regeneration will treat the soil vapor at half the cost of any other method. Because of the relatively low cost of onsite regeneration, active vapor extraction is the most cost-effective method at higher concentrations of carbon tetrachloride. Passive vapor extraction units used on 1-stdft^3/min wells have the highest costs of the systems analyzed. At concentrations greater than 500 ppm$_v$, costs are predominantly waste disposal costs for treatment of the GAC.

The unsaturated zone wells in the vicinity of the 200 West Area carbon tetrachloride disposal sites have an average airflow rate of 5 stdft^3/min based on current data. Therefore, active vapor extraction should be used on all of these wells with soil-gas concentrations greater than 100 ppm$_v$ carbon tetrachloride. Passive vapor extraction should be used on wells with concentrations below 100 ppm$_v$.

5.0 SUMMARY AND RECOMMENDATIONS

Natural air flows emanating from wells open to the unsaturated zone in the 200 West Area carbon tetrachloride site have been found to average from 1 to 8 stdft^3/min. These natural air flows can be employed in a passive vapor extraction system to remove contaminated soil gas from the subsurface. Passive vapor extraction can be designed and operated to meet all ARARs.

Table 2. Individual Extraction System Operations 5 ppm$_v$ Costs.

5 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$109,891	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$274,727	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$42,084	$82,884	$410,484
	Maintenance costs:	[4]	$17,500	$19,231	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$4,512	$0	$0	$0
	Chemical costs:	[6]	$0	$136	$0	$0	$0
	Total O&M costs:		$321,976	$423,742	$48,884	$96,484	$478,684
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$2,186	$0	$2,188	$2,188	$2,188
	Acid scrubber waste costs:	[8]	$0	$187	$0	$0	$0
	Total waste disposal costs:		$2,186	$187	$2,188	$2,188	$2,188
4	Equivalent uniform annualized costs (EUAC):	[9]	$403,032	$510,596	$158,333	$313,192	$1,556,625
5	Removal costs, $/lb CCl4:	[10]	$1,046	$1,325	$411	$813	$4,040

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE systems.

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 3. Individual Extraction System Operations 50 ppm$_v$ Costs.

50 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$139,375	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$348,438	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$53,643	$94,443	$422,043
	Maintenance costs:	[4]	$17,500	$24,391	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$4,831	$0	$0	$0
	Chemical costs:	[6]	$0	$1,356	$0	$0	$0
	Total O&M costs:		$321,976	$429,222	$60,443	$108,043	$490,243
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$21,885	$0	$21,885	$21,885	$21,885
	Acid scrubber waste costs:	[8]	$0	$1,873	$0	$0	$0
	Total waste disposal costs:		$21,885	$1,873	$21,885	$21,885	$21,885
4	Equivalent uniform annualized costs (EUAC):	[9]	$422,728	$541,016	$189,588	$344,447	$1,587,881
5	Removal costs, $/lb CCl4:	[10]	$110	$140	$49	$89	$412

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE systems

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 4. Individual Extraction System Operations 100 ppm$_v$ Costs.

100 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$159,682	$136,000	$272,000	$1,384,000
	Total installed costs:	[2]	$250,000	$399,205	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$66,486	$107,286	$434,886
	Maintenance costs:	[4]	$17,500	$27,944	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$5,186	$0	$0	$0
	Chemical costs:	[6]	$0	$2,712	$0	$0	$0
	Total O&M costs:		$321,976	$433,131	$73,286	$120,886	$503,086
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$43,769	$0	$43,769	$43,769	$43,769
	Acid scrubber waste costs:	[8]	$0	$3,746	$0	$0	$0
	Total waste disposal costs:		$43,769	$3,746	$43,769	$43,769	$43,769
4	Equivalent uniform annualized costs (EUAC):	[9]	$444,813	$562,813	$224,315	$379,175	$1,622,608
5	Removal costs, $/lb CCl4:	[10]	$58	$73	$29	$49	$211

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE system

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 5. Individual Extraction System Operations 200 ppm_v Costs.

200 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$190,461	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$476,152	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$92,172	$132,972	$460,572
	Maintenance costs:	[4]	$17,500	$33,331	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$5,896	$0	$0	$0
	Chemical costs:	[6]	$0	$5,425	$0	$0	$0
	Total O&M costs:		$321,976	$439,227	$98,972	$146,572	$528,772
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$87,539	$0	$87,539	$87,539	$87,539
	Acid scrubber waste costs:	[8]	$0	$7,491	$0	$0	$0
	Total waste disposal costs:		$87,539	$7,491	$87,539	$87,539	$87,539
4	Equivalent uniform annualized costs (EUAC):	[9]	$488,382	$596,930	$293,771	$448,631	$1,692,064
5	Removal costs, $/lb CCl4:	[10]	$32	$39	$19	$29	$110

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE systems

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading)

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 6. Individual Extraction System Operations 500 ppm_v Costs.

500 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$256,756	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$641,891	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$169,231	$210,031	$537,631
	Maintenance costs:	[4]	$17,500	$44,932	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$8,027	$0	$0	$0
	Chemical costs:	[6]	$0	$13,562	$0	$0	$0
	Total O&M costs:		$321,976	$452,959	$176,031	$223,631	$605,831
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$218,847	$0	$218,847	$218,847	$218,847
	Acid scrubber waste costs:	[8]	$0	$18,728	$0	$0	$0
	Total waste disposal costs:		$218,847	$18,728	$218,847	$218,847	$218,847
4	Equivalent uniform annualized costs (EUAC):	[9]	$619,690	$674,185	$502,138	$656,998	$1,900,431
5	Removal costs, $/lb CCl4:	[10]	$16	$17	$13	$17	$49

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE systems.

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H_2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 7. Individual Extraction System Operations 1,000 ppm$_v$ Costs.

	1000 ppmv Alternative:		AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$337,598	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$843,995	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$297,662	$338,462	$666,062
	Maintenance costs:	[4]	$17,500	$59,080	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$11,578	$0	$0	$0
	Chemical costs:	[6]	$0	$27,125	$0	$0	$0
	Total O&M costs:		$321,976	$470,657	$304,462	$352,062	$734,262
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$437,694	$0	$437,694	$437,694	$437,694
	Acid scrubber waste costs:	[8]	$0	$37,457	$0	$0	$0
	Total waste disposal costs:		$437,694	$37,457	$437,694	$437,694	$437,694
4	Equivalent uniform annualized costs (EUAC):	[9]	$838,537	$774,369	$849,416	$1,004,276	$2,247,709
5	Removal costs, $/lb CCl4:	[10]	$11	$10	$11	$13	$29

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE system

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 8. Individual Extraction System Operations 5,000 ppm$_v$ Costs.

5000 ppmv Alternative:			AVE 500 scfm GAC, offsite Thermal Oxidation	AVE 500 scfm GAC, onsite Thermal Oxidation	PVE 10 scfm per unit	PVE 5 scfm per unit	PVE 1 scfm per unit
1	Capital costs, $/yr:						
	Equipment costs:	[1]	$100,000	$724,058	$136,000	$272,000	$1,364,000
	Total installed costs:	[2]	$250,000	$1,810,144	$340,000	$680,000	$3,410,000
2	Operating & maintenance (O&M) costs, $/yr:						
	Basic operating costs:	[3]	$300,000	$400,000	$1,325,112	$1,365,912	$1,693,512
	Maintenance costs:	[4]	$17,500	$126,710	$6,800	$13,600	$68,200
	Electricity costs:	[5]	$4,476	$39,985	$0	$0	$0
	Chemical costs:	[6]	$0	$135,623	$0	$0	$0
	Total O&M costs:		$321,976	$566,695	$1,331,912	$1,379,512	$1,761,712
3	Waste disposal costs, $/yr:						
	GAC costs:	[7]	$2,188,468	$0	$2,188,468	$2,188,468	$2,188,468
	Acid scrubber waste costs:	[8]	$0	$187,284	$0	$0	$0
	Total waste disposal costs:		$2,188,468	$187,284	$2,188,468	$2,188,468	$2,188,458
4	Equivalent uniform annualized costs (EUAC):	[9]	$2,589,312	$1,325,025	$3,627,640	$3,782,500	$5,025,933
5	Removal costs, $/lb CCl4:	[10]	$7	$3	$9	$10	$13

NOTES

[1] Capital costs of AVE unit at 216-Z-1A including blower, water knockout tank, HEPA filter & trailer, 12 GAC canisters, and instrumentation and control.
Onsite thermal oxidation costs include AVE equipment plus desorption, oxidation, offgas neutralization, and chemical handling systems.
Onsite thermal oxidation costs estimated from system costs in WHC 1993 using "six-tenths-factor rule".
Costs of PVE include two 200lb GAC canisters, check valve, and wind turbine. Cost per PVE unit is $2,000 each, see text for number of PVE systems

[2] Total installed equipment costs = 2.5*equipment costs.
The 2.5 factor is equipment cost plus 7.8% taxes and 21% handling, placement and anchorage. This sum is increased by 8% instruments/controls, 10% outside facilities, and 5% auxiliary equipment. This sum is increased by 27% engineering, 16% contract administration, and 15% project management.

[3] One FTE = 100,000$/yr, PVE costs are for changing out saturated GAC (4 hr per canister, 60 lb CCl4/canister) and checking PVE systems (1.0 hr/unit per month).

[4] 7% of total equipment costs for AVE and 2% for PVE.

[5] Operating power, 25 Bhp, @ $0.04/kWh for AVE.

[6] Cost for HCl scrubber chemical (trona), 3.2 lb trona per lb CCl4, $220/ton trona.

[7] $5.68 /lb CCl4 (1.42$/lb GAC, 25% CCl4 loading).

[8] Cost to dispose HCl scrubber chemical (trona), assume 40% weight increase (20% NaCl, 20% H2O) over material costed in [6], $217/ton waste trona.

[9] (0.31547 * installed equipment costs) + O&M + waste disposal.

[10] Costs per pound of CCl4 removed from the soil.

Table 9. Individual Extraction System Operation Cost Summary.

ppm CCl_4	Active vapor extraction		Passive vapor extraction		
	500 $stdft^3$/min GAC, offsite thermal oxidation \$/lb CCl_4	500 $stdft^3$/min GAC, onsite thermal oxidation \$/lb CCl_4	10 $stdft^3$/min per unit \$/lb CCl_4	5 $stdft^3$/min per unit \$/lb CCl_4	1 $stdft^3$/min per unit \$/lb CCl_4
5	\$1,046	\$1,325	\$411	\$813	\$4,040
50	\$110	\$140	\$49	\$89	\$412
100	\$58	\$73	\$29	\$49	\$211
200	\$32	\$39	\$19	\$29	\$110
500	\$16	\$17	\$13	\$17	\$49
1,000	\$11	\$10	\$11	\$13	\$29
5,000	\$7	\$3	\$9	\$10	\$13

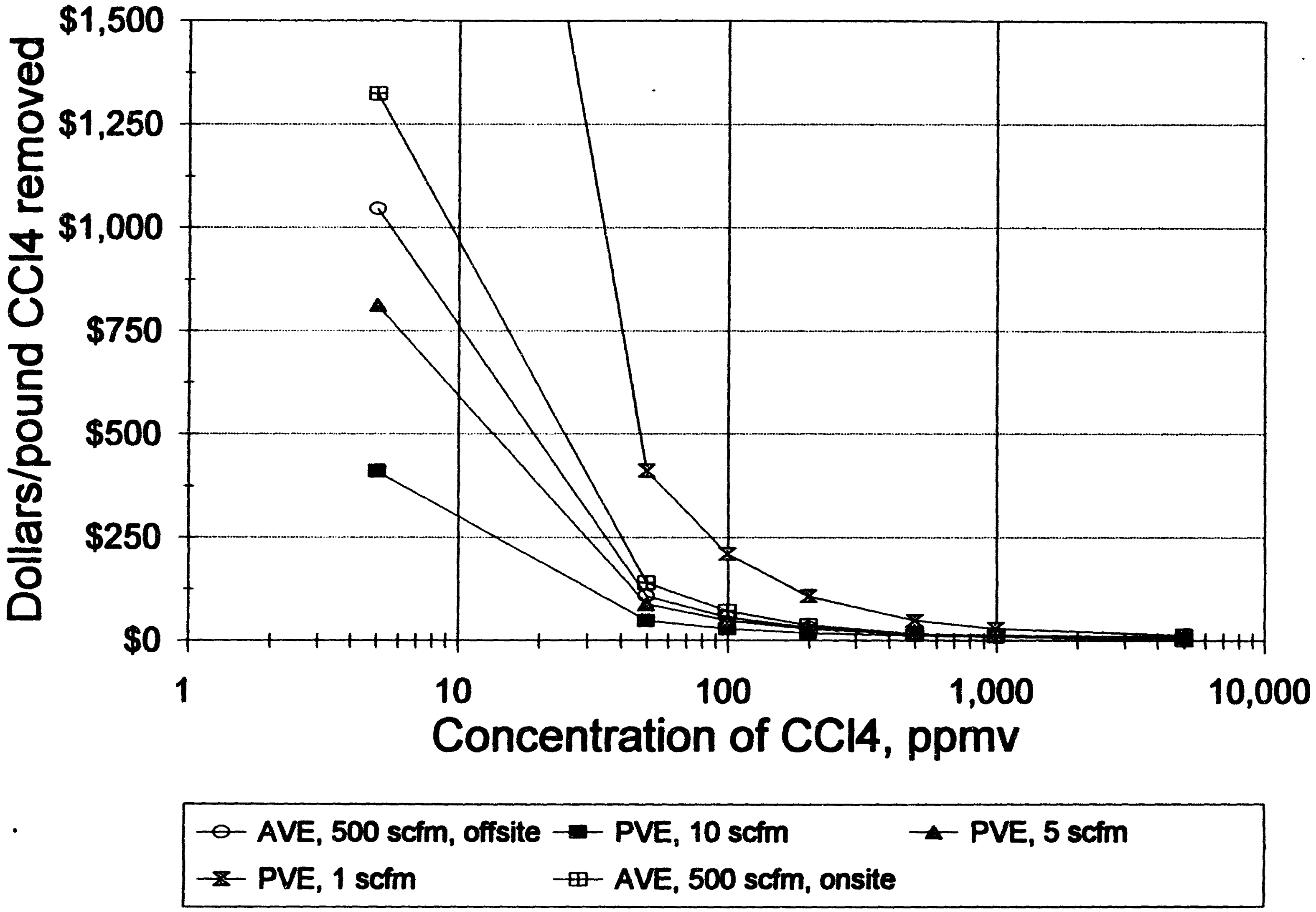


Figure 11. Individual Extraction System Operations Cost Curves.

A passive vapor extraction system capable of meeting the technical and regulatory requirements was found to be a cost-effective method for remediation of soils containing low concentrations of VOCs. For wells that average 5-stdft^3/min natural airflow rates, passive vapor extraction is more cost effective than active vapor extraction at carbon tetrachloride concentrations at or below 100 ppm$_v$.

On the basis of the information gathered to date regarding passive extraction, it is recommended that passive vapor extraction continue to be developed as a remediation method. The following characterization and development tasks will be required.

- Develop and build a prototype passive vapor extraction remediation system.
- Demonstrate the passive vapor extraction prototype at the 200 West Area carbon tetrachloride site.
- Develop a mathematical model of passive extraction. This model will provide refined estimates of passive vapor extraction effectiveness. Additionally it will allow for a sensitivity analysis of the important parameters that will be characterized for each extraction well. It is anticipated that these will include vertical permeability. The model will be verified with site data.
- Perform tracer gas studies to determine site parameters for the mathematical model. These parameters will include permeability, radius of influence, and carbon tetrachloride mass transfer constants.
- Continue wellhead characterization efforts. Data gathered by this task will be used to develop and verify the mathematical model, support demonstration of passive vapor extraction, and provide additional site characterization information to the ERA program.

These tasks were all initiated by FY 1993 and are continuing into FY 1994 as part of the FY 1993 and FY 1994 wellfield task plans (Rohay and Cameron 1993, Rohay 1994).

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APPENDIX A

ERA ARARs MEMO

MEMORANDUM

Date: May 20, 1992

To: Mike Hagood, Rick Cameron

From: Fred Morris, Marina Skumanich

Subject: ERA ARARs

The following is an expanded version of our review of the ARARs and associated air monitoring requirements potentially applicable to the 200 West Area Carbon Tetrachloride ERA previously transmitted by memo dated April 23, 1992.

? In summary, we continue to believe that with minor exceptions the ARARs analysis in the EE/CA & EA is correct. We also believe that the air monitoring presently being conducted meets applicable environmental requirements. We have not performed a "Hanford compliance" (DOE orders) analysis, but can do so if you would like.

Below we discuss two preliminary matters (hazardous waste designation and the CERCLA permit exemption) and then provide our own analysis of the potential ARARs listed on Table 7 of the EE/CA & EA. A discussion of occupational health and safety requirements applicable to the ERA is included as Appendix 1 to this memo. Finally, Appendices 2 and 3 provide additional information on the ARARs analysis: Appendix 2 reviews the criteria for determining if carbon tetrachloride is a Washington State-only dangerous waste; Appendix 3 provides information on the application of Washington state well drilling standards to the ERA.

Hazardous Waste Designation

In connection with the ERA, as with all CERCLA response actions, a threshold issue in analyzing potential ARARs is whether the material being managed is a hazardous waste under EPA's definition (or a dangerous waste under Ecology's broader definition). The determination as to whether a material is a hazardous (or dangerous) waste requires a two-stage inquiry. First, one must determine whether the material is a solid waste. Second, if a material is a solid waste, one must determine whether it is also a hazardous waste (or a dangerous waste) -- by virtue of exhibiting a hazardous waste "characteristic" (ignitability, corrosivity, reactivity, or toxicity), by virtue of having been specifically "listed" by EPA, or by meeting the designation criteria for being a Washington "state-only" dangerous waste.

Under EPA and Ecology definitions, solid waste is essentially, any solid, liquid, semi-solid, or contained gaseous material which is discarded, has served its intended purpose, or is a manufacturing or mining by-product. While this definition is obviously quite broad, there is at least some ambiguity about whether carbon tetrachloride vapor in the soil, which is a gaseous material, but not a contained gaseous material, can be a solid waste. Indeed, we have spoken with two different people in the dangerous waste permits office at Ecology, both of whom insisted that the vapor itself could not be a solid waste, since it is an unconfined gas.

We are somewhat skeptical of Ecology's analysis. The thrust of EPA regulation of hazardous waste (e.g., the mixture, derived-from, and contained-in principles discussed below) is "once a hazardous waste, always a hazardous waste," at least until the material no longer exhibits a hazardous waste characteristic (in the case of characteristic waste) or is de-listed (in the case of listed waste). It seems to us illogical to conclude that a material that was clearly once a solid waste (discarded liquid carbon tetrachloride) could escape regulation as a hazardous waste merely by its vaporization. In addition, EPA policy apparently holds that even if the vapor itself is not strictly a solid waste, if it is coming out of contaminated media that would qualify as hazardous waste (under the contained-in principle, discussed below), then vapor extraction would still be hazardous waste treatment, since the treatment is actually of the contaminated media. Therefore, our assessment is that the ERA should be assumed to be treating "solid waste" under the EPA definition, even though the treatment is of uncontained carbon tetrachloride vapors.

Carbon tetrachloride that is a solid waste can qualify as one of three kinds of hazardous waste: characteristic hazardous waste, listed hazardous waste, or Washington state-only dangerous waste. It is a characteristic hazardous waste if, using the test method known as the "toxicity characteristic leaching procedure" (TCLP), the resulting extract from a representative sample exceeds .5 milligrams carbon tetrachloride per liter. It is a listed hazardous waste (having the waste code F001) if it was used as a solvent in degreasing operations. It is a Washington state-only dangerous waste if it is found to be toxic, persistent, or carcinogenic based on criteria specified in Ecology's dangerous waste regulations.

Media containing carbon tetrachloride waste (e.g., soil) and/or materials otherwise associated with carbon tetrachloride treatment (e.g., treatment residuals), can be considered hazardous waste under a series of EPA rules: the "mixture," "derived-from," and "contained in" principles.

When a hazardous waste is mixed with a non-hazardous solid waste, the entire mixture is potentially subject to regulation as a hazardous waste by virtue of the "mixture rule." The mixture rule differs in its application depending on whether the hazardous waste portion of the mixture is a characteristic hazardous waste or a listed hazardous waste. Specifically, a mixture of a solid waste and a characteristic hazardous waste is a hazardous waste only if the mixture itself exhibits a hazardous waste characteristic. In contrast, a mixture of a solid waste and a listed hazardous waste escapes regulation as a hazardous waste only if it has undergone the long and onerous process of "delisting". (There is a minor exception for certain listed hazardous wastes that were listed solely by virtue of exhibiting a hazardous waste characteristic. As with characteristic wastes, mixtures containing these listed wastes are considered hazardous only if the mixture exhibits the characteristic for which the wastes were listed. None of the listed wastes potentially present at the 200 West ERA fall under this exception).

Similarly to the mixture rule, when a hazardous waste is treated, stored, or disposed of, any solid waste thereby generated can also be a hazardous waste by virtue of the "derived-from rule." Like the mixture rule, however, the derived-from rule differs in its application depending on whether the waste involved is characteristic hazardous waste or listed hazardous waste. Specifically, if the waste being treated, stored, or disposed of is a characteristic waste and the solid waste thereby generated does not exhibit a hazardous waste characteristic, then it is not a hazardous waste. However, if the waste being treated, stored, or disposed of is a listed hazardous waste, then solid waste thereby generated is also a hazardous waste unless it is delisted.

It should be noted that last December, in Shell Oil Co. v. EPA, 950 F.2d 751 (D.C. Cir. 1991), the Court of Appeals remanded the mixture and derived-from rules on the grounds that EPA had failed to give proper notice and opportunity for comment when they were originally promulgated. EPA then re-promulgated the rules on an interim basis and is taking comments on alternative approaches. Thus, although these rules are still in effect, they could change in the near future.

EPA has construed the mixture and derived-from rules to apply to contaminated media. This construction, which was upheld in Chemical Waste Management, Inc. v. EPA, 869 F.2d 1526 (D.C. Cir. 1989), is known as the "contained-in" principle. Under this principle, contaminated media containing hazardous waste are themselves subject to regulation as hazardous waste unless they no longer exhibit a hazardous waste characteristic (in the case of media containing characteristic waste) or they have been delisted (in the case of media containing listed waste). Under evolving EPA policy, it is also possible that contaminated media may escape regulation as a hazardous waste once they have been "decontaminated," presumably to health-based or background levels. EPA has not established such levels and has stated that until it does so, the EPA regions and authorized states may set them on a case-by-case basis.

Applying the preceding concepts to the ERA, one could argue that the carbon tetrachloride in the soil and groundwater beneath the 200 West Area includes listed F001 hazardous waste (spent carbon tetrachloride used in degreasing) because it was reportedly used in Z-plant cleaning operations. That the carbon tetrachloride was apparently discarded before the waste was listed in 1981 would not affect this result. As EPA has repeatedly stated: "Hazardous waste listings under RCRA apply to wastes whose management ceased prior to the effective date of the rule listing or identifying them as hazardous." As EPA has further explained,

no. see next page

> this does not mean that wastes that have been previously disposed must be exhumed for proper management once a rule listing them as hazardous has been promulgated. However, if such wastes are being actively managed (e.g., excavated, stored) after the effective date of a rule identifying them as hazardous, they must be managed in accordance with

all applicable listings and any other requirements under RCRA.

However, according to Jim Green, the carbon tetrachloride found at the 200 West Area was technically used not as a solvent, but as a fire suppressant (plutonium millings can represent a fire hazard) and as a carrier for the actual solvent, tri-butyl phosphate. If this history can be confirmed, it would be consistent with Doug Sherwood's statement to us that EPA and Ecology do not currently consider the carbon tetrachloride in 200 West Area soils to be a listed waste. This issue will continue to require monitoring by the ERA team.

Independent of the listed waste determination, the 200 West Area contamination might still be a characteristic hazardous waste. This determination is based on whether the contaminated media fails the TCLP test. As under the listed waste analysis, however, this possibility would only be relevant once the waste is actively managed, since the TCLP test became effective in 1990--after the end of carbon tetrachloride disposal at the 200 West Area. (Carbon tetrachloride was not a characteristic waste under the former "extraction procedure" (EP) method for determining whether a solid waste exhibits the toxicity characteristic.)

Finally, it is possible that even if the carbon tetrachloride does not qualify as a characteristic waste, it could still be a Washington state-only dangerous waste under Ecology's regulations. The analysis required for making this determination is summarized in Appendix 2 of this memo.

In summary, carbon tetrachloride in the vapor being extracted, in the various stages of treatment, and in treatment residuals should for the time being only be considered hazardous waste if the given mixture exhibits the toxicity characteristic by virtue of failing the TCLP test (or a dangerous waste if it is toxic, persistent, or carcinogenic under Ecology rules).

CERCLA Permit Exemption

Under the CERCLA National Contingency Plan (NCP), no federal, state, or local permits are required for on-site response actions, such as the ERA. "On-site" means the
7 areal extent of contamination and all suitable areas in very close proximity to the contamination necessary to implement the response action. EPA has clarified that "areal" includes the air above the site and also includes situations where the response activity occurs entirely on-site but the effects cannot be strictly limited to the site. As an example, EPA has stated that a direct discharge of CERCLA wastewater would be an on-site activity if the receiving water body is in the area of contamination or in very close proximity to the site, even if the water flows off-site.

On the basis of the above principles, air emissions from onsite ERA response activities do not require federal, state, or local permits.

ARARs Analysis

Our analysis of the specific ARARs listed in Table 7 of the EE/CA & EA is as follows.

1. Ch. 246-247 WAC (Radiation Protection--Air Emissions).

These requirements address monitoring, control, and reporting of airborne radionuclide emissions from specific sources to assure compliance with applicable standards. They specifically apply to DOE facilities. "Radionuclide" is defined to mean any nuclide that emits radiation, but the dose-based standards which must be met exclude doses due to radon-220, radon-222, and their decay products, so arguably sources of such emissions are completely excluded from these regulations. "Source" is defined as the point of release of airborne emissions of radionuclide materials. Existing sources must register with the Department of Health (DOH). New or modified sources may not begin construction until a notice of construction has been approved and must use best available radionuclide control technology (BARCT). DOH has discretion to impose appropriate monitoring requirements and to require compliance demonstration tests at the emissions source. In addition, facility owner/operators are required to submit a semi-annual inventory of radionuclides released to unrestricted areas in airborne emissions during the previous six months. Compliance with applicable standards is determined by using EPA-approved sampling procedures at the source, together with EPA-approved modeling procedures, to calculate the dose to members of the public at the point of maximum annual air concentration in an unrestricted area.

Applying the above requirements to the ERA, we conclude that (1) these requirements do not apply to any emissions of radon-220, radon-222, or their decay products, (2) given current results from the on-site continuous air monitoring equipment as well as professional judgment, there is currently no reason to believe that the ERA is a new source of any other radionuclide emissions, and (3) if it is determined that the ERA is a source of other radionuclide emissions, the CERCLA permit exemption relieves the ERA from the requirement to obtain construction approval, but BARCT and air monitoring requirements would apply. In this case, the existing HEPA filters should satisfy the BARCT requirement. According to Cathy Sowa, DOH has been notified of the ERA activity, and has agreed that these regulations currently do not apply.

2. 40 CFR Part 61, Subpart H (NESHAPS for Radionuclide Emissions from DOE Facilities).

Except for certain radioactive waste disposal activities, these requirements apply to operations at any DOE facility that emits any radionuclide into the air other than radon-220 or radon-222. "Facility" is defined to mean all buildings, structures, and operations at one contiguous site. The overall standard requires that radionuclide emissions should not cause a member of the public to receive an effective dose equivalent of 10 millirems per year. There are detailed monitoring, reporting, and recordkeeping requirements for all emission points within the facility with the potential to discharge radionuclides in quantities leading to an effective dose equivalent to a member of the public of more than 0.1 millirem. (The effective dose equivalent is to be calculated using prescribed modeling procedures.) For other emission points, periodic confirmatory measurement are required to verify that emissions are below the threshold. In addition to these monitoring and reporting requirements, any fabrication, erection, or installation of a new building or structure, or modification, within a facility that emits radionuclides must apply for and obtain approval for the construction or modification. This application and approval process is again exempted if the effective dose equivalent to a member of the public caused by all emissions from the new construction or modification is less than 0.1 millirem per year. The exemption is not available unless the facility is otherwise in compliance with Subpart H.

Applying the above requirements to the ERA, we conclude that (1) these requirements do not apply to any emissions of radon-220, radon-222, or their decay products, (2) given current results from the on-site continuous air monitoring equipment as well as professional judgment, there is currently no reason to believe that the ERA involves construction or modification that emits other radionuclides, and (3) if it is determined that the ERA does involve such a construction or modification, the CERCLA permit exemption relieves the ERA from the requirement to obtain construction or modification approval, but the major substantive standards and air monitoring requirements would apply if emissions lead to an effective dose equivalent to the public of over 0.1 millirem per year. For radionuclide emissions under this threshold, periodic confirmatory monitoring requirements would be required. In either case, the continuous air monitoring devices currently implemented at the site should provide any such monitoring information required.

3. <u>WAC 173-403-080 and 40 CFR § 52.21 (Prevention of Significant Deterioration)</u>. These requirements provide that construction of a major stationary source (or a major modification) in an attainment area requires a PSD permit. "Major stationary source" means a source which has the potential to emit pollutants in excess of specified thresholds. A source's "potential to emit" is determined with reference to its maximum emissions capacity after the imposition of federally enforceable emissions controls. "Major modification" means any physical or operational change that would result in a "significant net emissions" increase. Whether there will be a net emissions increase is determined by comparing the source's potential emissions after modification with its actual emissions before modification, taking into account certain other contemporaneous increases and decreases from the source. The significance of an increase is determined with reference to thresholds set in EPA's regulations on a pollutant-by-pollutant basis.

Until recently, PSD review could be triggered by greater than threshold emissions of any pollutant subject to regulation under the Clean Air Act--i.e., not just "criteria" pollutants such as sulfur dioxide, particulates, and certain VOCs. However, under the 1990 Clean Air Act amendments, and as per interim guidance issued by EPA (March 11,1991), radionuclides and other pollutants regulated under 40 CFR Part 61 (NESHAPs) are exempted from PSD review.

Of relevance to the ERA, the "significant net increase" of VOC emissions that would trigger PSD review is 40 tons per year. To obtain a PSD permit, the source must not violate any Clean Air Act emissions standard and must incorporate "best available control technology" (BACT) for each pollutant emitted that is subject to Clean Air Act regulation other than NESHAPs (i.e., not just the pollutants triggering PSD review).

Applying the above requirements to the ERA, we conclude that (1) there is currently no reason to believe that the ERA results in a significant emissions increase of either carbon tetrachloride (because the estimated maximum emissions are 1.8 tons per year) or other conventional pollutant subject to PSD review and (2) if it is determined that the ERA does result in such an emissions increase, the CERCLA permit exemption relieves the ERA from the requirement to obtain PSD approval, but the ERA would have to employ BACT.

2.74 at 1500 lb/d extracted x 0.01 discharge x 365 d/y operation

4. 40 CFR Part 264 (RCRA Treatment, Storage, and Disposal Requirements, particularly Subpart AA and BB Air Emission Standards for Process Vents and Equipment Leaks).

The RCRA Subpart AA process vent standards apply to vents on certain waste management units that manage hazardous waste with an annual average total organics concentration of 10 parts per million by weight (ppmw) or greater. The affected waste management units include distillation, fractionation, thin-film evaporation, solvent extraction, and air or steam stripping operations and associated tanks. In the preamble to the final rule adopting these requirements EPA discussed their applicability to CERCLA removal and remedial actions and specifically stated that they would not be ARARs for, among other things, "in situ soil vapor extraction." The RCRA Subpart BB equipment leak standards apply to emissions from valves, pumps, compressors, pressure relief devices, sampling connection systems, and open-ended valves or lines where the equipment contains or contacts hazardous waste streams with organic concentrations of 10 percent by weight or greater. EPA has stated that these standards would be considered an ARAR for equipment components installed at CERCLA sites that contain or contact such substances. Both the Subpart AA and the Subpart BB standards were promulgated pursuant to the Hazardous and Solid Waste Amendments of 1984 and are therefore federally enforceable in an "authorized" RCRA state such as Washington in advance of adoption by Ecology.

Applying the above requirements to the ERA, we conclude (1) that if the carbon tetrachloride is a hazardous waste, then the soil vapor extraction/GAC system constitutes RCRA hazardous waste treatment, (2) that such treatment qualifies for the CERCLA permit exemption and therefore a RCRA TSD permit is not required, (3) that the Subpart AA process vent standards do not apply to this type of system, and (4) that the Subpart BB equipment leak standards would apply to any emissions from valves, pumps, compressors, pressure relief devices, sampling connection systems, or open-ended valves or lines if the equipment contains or contacts hazardous waste streams with organic concentrations of 10 percent by weight or greater. (However, given that the ERA vapor extraction design configuration limits withdrawal of VOCs to concentrations below 0.1% by weight, these standards would not under normal operations be triggered by the ERA.) A gray area is what type of hazardous waste treatment unit the soil vapor extraction/GAC system would be considered: container, tank, miscellaneous unit, or some combination appear to be the likeliest possibilities. Depending on the answer, various operating and closure requirements could potentially apply. We recommend raising

$$\frac{1500\ \text{lb/d}}{3000\ \text{scfm} \times 60\ \frac{\text{m}}{\text{h}} \times 24\ \frac{\text{h}}{\text{d}} \times 0.0765\ \frac{\text{lb}}{\text{ft}^3}} = 0.00454 \text{ wt fraction} = 0.454 \text{ w\%}$$

this question directly with Doug Sherwood and Ecology.

5. WAC 173-303-670 and 40 CFR Part 264, Subpart O (RCRA Incinerator Standards).

These requirements establish standards for facilities that incinerate hazardous waste. Among other things, these standards specify a destruction and removal efficiency of 99.99% for each principal organic hazardous constituent in the waste feed. Also, an incinerator that produces stack emissions of more than 1.8 kilograms (4 pounds) per hour of hydrogen chloride must limit emissions to the larger of 1.8 kilograms per hour or 1% of the hydrogen chloride in the stack gas prior to entering any pollution control equipment. These standards apply only to units meeting the RCRA definition of incinerator, which are essentially limited to devices employing controlled flame combustion, infrared, or plasma arc.

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Applying the above requirements to the ERA, we conclude that the standards are not technically "applicable" to any current or contemplated on-site ERA treatment unit, because none falls within the definition of a RCRA incinerator. Of course, even if not "applicable," EPA and Ecology can determine that the incinerator standards are nonetheless "relevant and appropriate." According to Cathy Sowa, these standards are being considered ARARs for ERA treatment units to partially address EPA's concern about air emissions from the site. In particular, she indicates that these standards are viewed as providing some means of orienting the ERA toward the forthcoming regulations governing carbon tetrachloride emissions under the new federal Clean Air Act air toxics provisions.

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6. Ch. 173-460 WAC (Controls for New Sources of Toxic Air Pollutants).
These requirements apply to sources that may emit one or more toxic air pollutants listed in the regulations, including carbon tetrachloride and hydrogen chloride, and which commenced construction after September 18, 1991. Before construction, installation, or establishment of such a source, the owner or operator must file and obtain approval for a notice of construction. To receive construction approval, the new source must use best available control technology for toxics (T-BACT) and demonstrate that emissions levels are sufficiently low to protect human health and safety from potential carcinogenic or other toxic effects. The appropriate T-BACT is not specified in regulation, but is to be determined in consultation with the Department of Ecology on a case by case basis. The demonstration regarding emissions is in the first instance made through comparison with acceptable source impact levels (ASILs) to unrestricted access areas specified in the regulations. The ASIL for carbon tetrachloride is .067 micrograms per cubic meter (annual average) and the ASIL for hydrogen chloride is 23.3 micrograms per cubic meter (24-hour average). If ASILs cannot be met, the source can ask Ecology to perform a site-specific risk assessment known as a second tier analysis. Once an ASIL demonstration is made and T-BACT controls installed, these regulations do not otherwise impose ongoing air monitoring requirements.

Applying the above requirements to the ERA, we conclude that (1) the ERA does involve carbon tetrachloride and hydrogen chloride emissions subject to these requirements, (2) the CERCLA permit exemption relieves the ERA from the requirement to obtain construction approval, and (3) an ASIL demonstration and T-BACT are required. The ASIL demonstration was conducted as part of the EE/CA, and demonstration was made that emissions were below the relevant standards for both carbon tetrachloride and hydrogen chloride. Furthermore, according to Cathy Sowa, the ERA treatment system was implicitly deemed to be T-BACT by Ecology during its review of the ASIL demonstration.

by 99% eff

7. 40 CFR Part 302 (Hazardous Substance Release Reporting).
As soon as a person in charge of a facility has knowledge of a release of a hazardous substance in an amount equal to or exceeding its reportable quantity, the person must immediately notify the National Response Center. Federally permitted releases (i.e., releases under air or water emissions programs) need not be reported. In addition, releases of a continuous nature need be reported only once to the Response Center. The reportable quantity is 4.5 kilograms (10 pounds) for carbon tetrachloride, 2270 kilograms (5000 pounds) for hydrogen chloride, 0.1 curie for radon-220 or radon-222, and .01 curie for lead-210.

there are still but E/CA is 10 lb/d

Applying the above requirements to the ERA, we conclude that (1) according to Cathy Sowa, the federally-permitted release reporting exemption is not presently considered to be applicable to the ERA, (2) the most likely contaminant release triggering this requirement would be carbon tetrachloride and ERA process specifications have been established to avoid release of carbon tetrachloride greater than the 4.5 kilograms threshold, (3) releases of hydrogen chloride and lead-210 are anticipated to be well below the threshold, (3) that releases of radon-220 and radon-222 may need to be monitored to ensure that the threshold is not exceeded and reported if it is.

ew
1500 lb/d = 15 lb/day

8. Ch. 173-160 WAC (Well Construction and Maintenance).
These requirements establish minimum standards for the construction, maintenance, and abandonment of "resource protection wells," which include monitoring wells, extraction wells for the remediation of contaminated groundwater, and certain geotechnical borings.

Applying the above requirements to the ERA, we conclude that well drilling conducted in connection with the ERA must meet these requirements. WHC and KEH staff are in regular contact with Ecology and EPA personnel to ensure that well standards are met. A summary of understandings gleaned from a recent meeting with Ecology staff is attached as Appendix 3 to this memo.

Appendix 1
OSHA Regulation Relevant to ERA Operations at Hanford

OSHA regulates the exposure of workers to physical or health hazards. The purpose of the act is to assure that "no employee will suffer material impairment of health or functional capacity" from a lifetime of occupational exposure. The federal OSHA regulations are codified at 29 CFR Part 1910. Washington state has an approved state-level program for occupational safety and health enforcement, codified at Chapter

296 - 62 WAC. The Washington state program parallels the federal program, and Washington regulation citations will be used as reference in this discussion.

By statute, federal and state employees are excluded from OSHA coverage, although Executive Order 12196 requires federal agency heads to meet the basic OSHA program elements and comply with OSHA standards promulgated for the private sector unless they can justify alternatives. Further, DOE Order 5480.4 requires adherence by DOE employees and contractors to the requirements of 20 CFR Part 1910 (OSHA standards) if they would otherwise have been exempt. As a result, it would appear that OSHA standards are fully applicable to all activities at Hanford.

OSHA regulates both safety and health hazards. Safety hazards are defined as those hazards which cause immediate harm in a direct physical manner, such as burns, electrical shock, cuts, loss of limbs, or death. Health hazards are defined as those hazards which cause health problems for employees. Health hazards are generally identified with exposure to chemical and biological agents, although some physical affects are also included (e.g., noise, radiation).

OSHA Standards Covering Exposure to Hazardous Constituents

OSHA requirements relating specifically to exposure to hazardous constituents (both chemical and radiological) fall into 6 major categories:

(1) A general duty requirement to provide a workplace free from recognized hazards (OSH Act Section 5(a)(1); WAC 296-24-073). This requirement is independent of whether specific standards have been established. It has in fact been used to find a violation when a company was otherwise in full compliance with specific numerical standards on the point in question. International Union. UAW v. General Dynamics Land System Division. 815 F.2d 1570, 13 OSHC 12-1 (D.C. Cir. 1988). This finding reflects the recognition by OSHA and at least some courts that many of the existing OSHA standards (many of which were incorporated by reference into OSHA regulation) are out of date, and that bare compliance with the standards does not necessarily represent responsible management.

Chapter 296-62 WAC Part D elaborates on the general duty requirement by requiring specifically that "in those cases where no acceptable standards have been derived for the control of hazardous conditions, every reasonable precaution shall be taken to safeguard the health of the worker" whether provided in the regulations or not.

This standard would clearly be relevant to ERA activities at the 200W Area.

(2) Hazard Communication requirements (WAC 296-62-054). These procedural requirements represent the backbone of the OSHA chemical hazard regulatory system. They require employers to asses the toxicity of the hazardous chemicals

they make, distribute, or use. Chemicals covered include all hazardous chemicals to which workers may be exposed under normal conditions or in a foreseeable emergency. (In addition, for chemical producers and importers, all chemicals produced or imported are covered.) WAC 296-62-05421 Appendices A and B provide criteria for determining if a chemical is "hazardous", and therefore subject to these requirements. Criteria include being: listed as a carcinogen by IARC or certain other sources; classified as a corrosive by DOT; having certain threshold LD50 values; etc. Employers must develop a Hazard Communication Program to provide information on these hazards to employees (as well as to downstream purchasers). The Communication Program must include: a written program statement; a list of the hazardous chemicals in the workplace; labels, color codes, or signs for identification of all hazardous chemicals; preparation and distribution of Material Safety Data Sheets (MSDSs) (a document summarizing relevant physical and hazard information about the chemical); and training and education programs on the proper procedures to avoid or minimize exposure to hazardous chemicals.

These standards would also generally be relevant to ERA activities at the 200W Area.

(3) Permanent Health standards (OSH Act Section 6(b)). For a small number of compounds, OSHA has promulgated specific permanent health standards, including (generally) both exposure limits and operational requirements (medical monitoring, handling and use requirements, etc.). These permanent standards are developed following formal rulemaking procedures, including opportunities for public hearings, etc. Criteria documents prepared by the National Institute of Occupational Safety and Health (NIOSH) are generally used as the starting point for these standards, but other information may also be used to trigger a criteria-setting process. The compounds covered to date by permanent standards include: asbestos; vinyl chloride; inorganic arsenic; lead; coke oven emissions; cotton dust; 1,2-dibromo-3-chloropropane; acrylonitrile; ethylene oxide; benzene; formaldehyde; and 13 relatively obscure carcinogens (e.g., bis-chloromethyl ether; beta-naphthylamine; benzidine; etc.). (Chapter 296-62 WAC Parts F, G, I, I-1, N and O.) In addition, it appears that Washington code regulates one other specific compound under permanent standards - the pesticide Thiram - although only operational standards are provided (Chapter 296-62 WAC Part I, 07519).

These standards would not appear to be relevant to ERA activities at the 200W Area.

(4) General "consensus" standards (OSH Act Section 6(a)). In addition to the permanent standards, OSHA has promulgated less detailed "consensus" standards for a larger number of compounds (WAC 296-62 Part H). Part H contains general requirements for controlling airborne exposure to contaminants, as well as a list of "permissible exposure limits" (PELs), in ppm or mg/m3, for about 420 specific compounds. The PELs are provided mostly in terms of 8-hour time weighted

average exposure limits (TWAs), but in some cases 15-minute average short term exposure limits (STELs), and/or instantaneous ceiling exposure limits (Ceilings) are also provided. Most of these standards were incorporated by reference from pre-existing sources, such as the American Conference of Governmental Industrial Hygienists "Threshold Limit Values" document or other industry or association publications. As a result, in many cases they represent standards that are considered to be out of date and/or not based on firm scientific evidence. Unlike permanent health standard requirements, there are no required labeling, monitoring, or medical recordkeeping requirements for compounds covered by consensus standards. Under WAC 297-62-07501, compliance with the standards includes: (1) determining and implementing feasible administrative or engineering controls that have been approved by a competent industrial hygienists or other technically qualified person; and (2) upon request, preparing and submitting a written compliance plan to the state agency. While the state regulation implicitly assumes that sampling will be performed to determine compliance with the standards, no explicit sampling requirement is provided (WAC 296-62-07501, 07503).

The consensus standards for carbon tetrachloride, and perhaps other potential airborne contaminants (e.g., chloro-methane) would be applicable to the ERA activities at the 200W Area.

(5) Standards for exposure to radionuclides. Radionuclides are covered indirectly as sources of ionizing radiation under the general biological and physical hazards provisions of the OSH Act (WAC 296-62-09004). Two sets of exposure standards are provided. First, limits for direct occupational exposure to ionizing radiation are provided in terms of a dosage of rems per calendar quarter to the whole body, to appendages, and to the skin. In addition, exposure to airborne radioactive materials is restricted to the limits specified at WAC 246-221-290, Appendix A, which is part of the radiation protection standards established by the Washington Department of Health. Exposure limits for radon-220 and radon-222 are included. Procedural requirements for exposure to radionuclides under OSHA include: conducting "surveys" of the workplace as necessary to insure compliance with the provisions of the section, including physical surveys of radioactive materials present and measurements of the levels of radiation present; providing personnel monitoring to measure dosage exposure of employees; signing and labeling areas and containers of radioactive materials; providing control equipment to maintain ambient radiation levels below certain limits; and providing signaling equipment to alert employees to ambient radiation level exceedances.

The applicability of these requirements to the 200W Area ERA is complicated. Although somewhat ambiguous, the Washington OSHA regulations appear to exempt DOE and its contractors from compliance with the radiation protection standards to the extent they possess or use source, byproduct, or special nuclear materials in compliance with the Atomic Energy Act. This exemption does not appear to extend to other sources of radiation, such as naturally occurring radioactive materials other than source material. However, the cross-referenced radiation protection standards themselves do grant a broader exemption at WAC 246-220-050 that appears to extend to all sources of radiation. Given that DOE Order 5480.4 requires adherence by DOE contractors to OSHA standards, it appears most reasonable to assume that only the more narrow Washington OSHA exemption applies and that therefore 200 W Area ERA activities are subject to the state radiation protection standards to the extent these standards apply to radiation exposure originating from sources other than source, byproduct, or special nuclear material, such as naturally occurring radioactive materials. DOE's own radiation protection standards, which we have not reviewed for this memo, would apply to 200 W Area ERA activities involving any exposure from radiation orginating from source, byproduct, and special nuclear material .

Other OSHA Standards Applicable to 200W ERA

Finally, in addition to the preceding compound-based standards, under OSHA regulation, there also exist activity-based occupational health standards directly applicable to "Hazardous Waste Operations and Emergency Response" (HAZWOPER) activities, such as the ERA activity at the 200W Area (29 CFR § 1910.120, WAC 296-62-300). These regulations cover three major groups of activities:

(1) Clean up operations, including: (a) clean-ups required by governmental bodies of hazardous substances at uncontrolled sites, (b) corrective actions under RCRA, and (c) voluntary clean-up operations at sites recognized by governmental bodies as uncontrolled hazardous waste sites;

(2) Operations at TSD facilities under RCRA Parts 264 and 265; and

(3) Emergency response operations for releases of, or substantial threats of releases of, hazardous substances.

The requirements for clean-up operations are found in WAC 296-62-3010 to 3130, and include: developing a written Safety and Health Program, including a site-specific plan for each clean-up site; performing a safety/health risk or hazard analysis for each activity at the site ; conducting monitoring at the site; providing employee training; performing medical surveillance (under certain conditions); implementing site control procedures (engineering controls, work practices, and personal protection equipment); and developing an emergency response plan. Monitoring of the site entails initial ambient monitoring of site conditions prior to start-up to clearly identify site hazards for selection of appropriate employee protection methods. In addition, periodic ongoing monitoring of the site (e.g., ambient air monitoring) is required when the possibility exists of "Immediate Danger to Life or Health"; when a flammable atmosphere may exist; or when there is an indication that exposure to contaminants at the site may exceed PELs. The regulations list several events that would trigger periodic monitoring, such as: (a) working on a different part of the site; (b) the startup of different operations; or (c) when sufficient time has passed so that exposure may have significantly increased (WAC 296-62-3070(3)). Direct monitoring of high-risk employees is also required after actual clean-up activities commence.

Requirements for TSD facilities (WAC 296-62-3140 only) are similar to those for clean-up operations, and include: a safety/health program; a hazard communication program; medical surveillance; decontamination procedures; procedures for implementing new technology; material handling requirements; training requirements; and emergency response plans.

Requirements for emergency responses (WAC 296-62-3112 only) primarily include: an emergency response plan; procedures for handling emergency response; and training requirements.

The requirements for clean-up operations found at WAC 296-62-300 would be applicable to the ERA activities at the 200W Area. In particular, ambient and direct monitoring to meet the requirements of WAC 296-62-3070 would be required.

Appendix 2
Carbon Tetrachloride as a Washington State-only Hazardous Waste

A solid waste may be designated Washington state-only hazardous waste (termed "dangerous" waste) under one of three criteria:

- the toxic dangerous waste standard;
- the persistent dangerous waste standard; or
- the carcinogenic dangerous waste standard.

Toxic Dangerous Waste:

One must: (1) determine if the constituent of concern (CCl_4) is toxic, and then
(2) determine if the solid waste is toxic.

(1) To determine if CCl_4 is a toxic constituent, one needs to compare the ranges of values for each category in the WAC 173-303-101 table with the following corresponding values for CCl_4 from the RTECs database:

Fish LC50 = Not Available
Oral Rat LD50 = 2350 mg/kg
Inhalation Rat LC50 = 8000 ppm
Dermal Rabbit LD50 = Not Available

With an Oral Rat LD50 of 2,350 mg/kg, CCl_4 would qualify as a Category D Toxic

Constituent, since the high end of the Category D range in WAC 173-303-101 is 5,000 mg/kg. (The Inhalation Rat LC50 of 8,000 ppm is above the threshold in WAC 173-303-101, and so would not trigger a category assignment.)

(2) To determine if solid waste containing the CCl_4 is hazardous ("toxic dangerous waste"), one needs to look at the concentration of CCl4 in the waste as well as the amount of waste. Given that the CCl_4 is a Category D toxic constituent, the waste would need to have a CCl_4 concentration of over 10% and a waste generation rate of over 220 lbs/month to be considered a dangerous waste.

For the ERA, the design configuration of the VES system will limit CCl_4 concentration in the extracted vapors to no more than 0.1%; therefore, the vapors would not qualify as toxic dangerous waste. However, since the CCl_4 concentration in the GAC canisters is projected to be 30% by weight when filled, and since each canister is on the order of 2,000 lbs, the GAC canisters would qualify as toxic dangerous waste.

Persistent Dangerous Waste:

One must: (1) determine if the constituent of concern (CCl_4) is persistent, and
(2) determine if the solid waste is persistent.

(1) To determine if CCl_4 is a persistent constituent, one needs to assess whether it is either a halogenated hydrocarbon (i.e., it contains halogens such as fluorine, chlorine, or bromine) or it is a polycyclic aromatic hydrocarbon (i.e., it contains ring structure) with more than three rings or less than seven rings.

Given that CCl_4 contains chlorine, it qualifies as a persistent constituent.

(2) To determine if solid waste containing the CCl_4 is hazardous ("persistent dangerous waste"), one needs to look at the concentration of CCl_4 in the waste as well as the amount of waste. If the waste quantity is over 220 lbs/month, the waste will qualify as hazardous as follows:

- With a concentration of CCl_4 between 0.01% and 1.0%, the waste would be dangerous waste.
- With a CCl_4 concentration of greater than 1.0%, the waste would be extremely hazardous waste (a dangerous waste subject to additional management requirements).

For the ERA, given that the CCl_4 concentration in the extracted vapors could be as much as 0.1%, it is possible the vapors would qualify as persistent dangerous waste, if the quantity of vapors extracted was more than 220 lbs/month. In addition, it is likely the GAC canisters would qualify as persistent extremely hazardous waste, since the CCl_4 concentration in the GAC canisters is projected to be 30% by weight when filled, and since each canister is on the order of 2,000 lbs.

Carcinogenic Dangerous Waste:

One must: (1) determine if the constituent of concern (CCl_4) is carcinogenic, and
(2) determine if the solid waste is carcinogenic.

(1) To determine if CCl_4 is a carcinogenic constituent, one needs to determine if it has been listed as an International Agency for Research on Cancer (IARC) positive or suspected carcinogen. This listing can be found in the RTECS database.

Given that CCl_4 is listed in RTECS as a positive carcinogen, it qualifies as a carcinogenic constituent.

(2) To determine if solid waste containing the CCl_4 is hazardous ("carcinogenic dangerous"), one needs to look at the concentration of CCl_4 in the waste as well as the amount of waste. If the waste quantity is over 220 lbs/month, the waste will qualify as hazardous as follows:

- With a concentration of CCl_4 between 0.01% and 1.0%, the waste would be dangerous waste.

- With a CCl_4 concentration of greater than 1.0%, the waste would be extremely hazardous waste (a dangerous waste subject to additional management requirements).

For the ERA, given that the CCl_4 concentration in the extracted vapors could be as much as 0.1%, it is possible the vapors would qualify as a carcinogenic dangerous waste, if the quantity of vapors extracted were more than 220 lbs/month. In addition, it is likely the GAC canisters would qualify as carcinogenic extremely hazardous waste, since the CCl_4 concentration in the GAC canisters is projected to be 30% by weight when filled, and since each canister is on the order of 2,000 lbs.

Appendix 3
Application of Well Drilling Standards

May 1, 1992

Richard Szymarek
Hydrogeologist
Water Resources Well Drilling Unit

Department of Ecology
Mail Stop PV-11
Olympia, WA 98504

Dear Dick:

Don Moak, Greg McLellan, and I appreciated having the opportunity to meet with you, your staff, and colleagues concerning the application of Chapter 173-160 WAC to drilling undertaken in connection with the VOC-Arid Integrated Demonstration and related projects at Hanford. We found these discussions very helpful and look forward to continuing this dialogue.

To this end, we thought that it might be useful to summarize our understanding of some of the major points that emerged from the meeting. They include the following.

1. Drilling activities on the Hanford site conducted for the purpose of characterization, monitoring, geotechnical testing, technology testing, or remediation would generally be considered to involve "resource protection" wells rather than "water supply" wells under Chapter 173-160.

2. By virtue of WAC 173-160-010(3)(a), Ecology considers drilling solely in the vadose zone (i.e., without penetrating an aquifer or perched groundwater) to be generally excluded from the regulations in Chapter 173-160. However, per WAC 173-160-010(4), such excavations must be constructed and abandoned to ensure protection and prevent contamination of the groundwater resource. Ecology also requests that start cards be filed for such drilling.

3. Point 2 applies to horizontal drilling in the vadose zone. Horizontal wells in the groundwater or vadose section both should have surface seals and surface protection. Annular seals have not been demonstrated and variances would be evaluated on a case by case basis.

4. Point 2 also applies to use of the cone penetrometer in the vadose zone. However, to meet the resource protection requirement, Ecology believes that particular attention should be paid to sealing to minimize potential pathways.

5. The cone penetrometer would be considered an uncased geotechnical test boring per WAC 173-160-010(3)(g); accordingly, only WAC 173-160-055, -010(4), and -420 would apply.

6. Ecology envisions three types of interaction regarding drilling and technology development activities: (1) "information exchange" (advance notice of planned drilling activity and distribution of test plans for information), (2) filing of start cards, and (3) discussions regarding variances. We suggest the following, pending issuance of the delegation letter discussed at the meeting. (1) Richard Hibbard will be our point of contact for information exchange on technology programs. We will provide him with

advance notice of drilling activity and test plans for information, and he will distribute to other Ecology staff. (2) Start cards will continue to be filed with the Ecology Central Region office, as is done currently. (3) Richard Hibbard will be our point of contact regarding variances for work not related to RCRA programs or CERCLA programs with no assigned unit manager and he will involve other Ecology staff as appropriate.

7. Variances to Chapter 173-160 will be considered on a case-by-case basis. Wells such as those with a "Webster completion" or old wells in the Rattlesnake gas field are good candidates for variances to allow the well to be plugged back with cement that has been tremied into place. This approach ~~would~~ both be cost-effective and allow a seal to be emplaced without causing other preferential pathways that could result by overdrilling or fishing and perforating.

8. A principal criterion for the granting of a variance is that the intent of Chapter 173-160 will be met: e.g., backfilling a well across the aquifer with sand then placing a cement/bentonite plug is acceptable for decommissioning a well to prevent cement contamination in the aquifer.

9. In Ecology's view, Revert mud should not be used. The use of drilling muds should be carefully considered for each well prior to drilling the well; however mud is not preferable. The use of muds and other approaches used at other locations in the industry may not necessarily be prudent for use at Hanford.

We would appreciate your reviewing the above information and providing us with any additions or corrections that you believe are needed. We would like to issue this information with joint concurrence.

Sincerely,

Frederic A. Morris

cc:Don Moak
Greg McLellan
Paul Carter
Julie Erickson

MEMO

Date: November 25, 1992

From: Marina Skumanich, Fred Morris

To: Mike Hagood, Jim Green

RE: CATOX ARARs Analysis

Catalytic Oxidation (CATOX) was evaluated as one of the possible treatment response options for the 200 West Area ERA in the ERA's EE/CA & EA document (hereafter EE/CA). Four configurations of CATOX treatment were examined:

- High-efficiency CATOX;
- High-efficiency CATOX with acid scrubbing;
- Ultra-high-efficiency CATOX; and
- Ultra-high-efficiency CATOX with acid scrubbing.

Along with other treatment systems, these CATOX options were evaluated in the EE/CA for their ability to meet ARARs. As per the EE/CA ARARs analysis , and as verified by Battelle HARC in our memo of May 20, 1992 (hereafter "ARARs Memo," attached), the relevant ARARs for treatment under the 200 West Area ERA were - and are - as follows:

1. Ch. 246-247 WAC (Radiation Protection--Air Emissions).
2. 40 CFR Part 61, Subpart H (NESHAPS for Radionuclide Emissions from DOE Facilities).
3. WAC 173-403-080 and 40 CFR § 52.21 (Prevention of Significant Deterioration).
4. 40 CFR Part 264, RCRA Treatment Storage and Disposal Requirements, including Subparts AA and BB (RCRA Air Emission Standards for Process Vents and for Equipment Leaks).
5. A&B WAC 173-303-670 and 40 CFR Part 264, Subpart O (RCRA Incinerator Standards).
6. C&D Ch. 173-460 WAC (Controls for New Sources of Toxic Air Pollutants).
7. E&F 40 CFR Part 302 (Hazardous Substance Release Reporting).
8. Ch. 173-160 WAC (Well Construction and Maintenance).

The EE/CA analysis concluded that CATOX, if configured as an ultra-high efficiency system with associated acid scrubbing, could meet all potential ARARs except one: the RCRA Subpart O Incinerator Standard for a destruction removal efficiency (DRE) of 99.99%.

This memo provides an update on the ARARs analysis for CATOX systems. Each of the eight ARAR regulations will be reviewed in turn, with a discussion of 1) how the ERA as currently configured is meeting the regulation and 2) how deployment of CATOX systems would affect the ability to meet the regulation. The discussion will draw from both the EE/CA and the ARARs Memo, as appropriate, as well as from discussions with state and federal officials.

1. Ch. 246-247 WAC (Radiation Protection--Air Emissions).

These requirements are implemented by the Washington Department of Health (DOH) and address monitoring, control, and reporting of airborne radionuclide emissions from specific sources to assure compliance with applicable standards, including the "BARCT" control technology requirement. They specifically apply to DOE facilities. The term "radionuclide" is defined to mean any nuclide that emits radiation, but the dose-based standards which must be met exclude doses due to radon-220, radon-222, and their decay products, so it would appear that sources of such emissions are completely excluded from these regulations.

As concluded in the ARARs Memo, current monitoring and best professional judgment indicate that the ERA as currently configured (a Vapor Extraction System (VES) feeding into Granular Activated Carbon canisters (GAC)) does not represent a new source of radionuclide emissions other than radon (which is assumed to be excluded from these regulations). Furthermore, it was concluded that even if the ERA were determined to be a source of such radionuclide emissions, the existing HEPA filters should satisfy the applicable BARCT requirement.

The deployment of any of the four CATOX systems in place of - or in addition to - the existing GAC canister system would not affect the amount or type of radioactive emissions occurring under the ERA. Therefore, current compliance with this regulation would continue.

2. 40 CFR Part 61, Subpart H (NESHAPS for Radionuclide Emissions from DOE Facilities).

Except for certain radioactive waste disposal activities, these requirements apply to operations at any DOE facility that emits any radionuclide into the air other than radon-220 or radon-222. The overall standard requires that radionuclide emissions should not cause a member of the public to receive an effective dose equivalent of 10 millirems per year. There are detailed monitoring, reporting, and recordkeeping requirements for all emission points within the facility with the potential to discharge radionuclides in quantities leading to an effective dose equivalent to a member of the public of more than 0.1 millirem per year. Other emission points would require periodic confirmatory measurement to verify that emissions are below the threshold. In addition to these monitoring and reporting requirements, any fabrication, erection, or installation of a new building or structure, or modification, within a facility that emits radionuclides must apply for and obtain approval for the construction or modification, if the new construction or modification causes emissions over the 0.1 millirem per year effective dose equivalent.

As concluded in the ARARs Memo, current monitoring and best professional judgment indicate that the ERA as currently configured (Vapor Extraction System (VES) feeding into Granular Activated Carbon canisters (GAC)) does not represent a source of radionuclide emissions other than radon (which is excluded from these regulations). If the ERA were determined to be a source of such radionuclide emissions, then both substantive standards and air monitoring requirements would apply if emissions lead to an effective dose equivalent to the public of over 0.1 millirem per year. For radionuclide emissions under this threshold, periodic confirmatory monitoring requirements would be required. In either case, the ARARs Memo concluded that the continuous air monitoring devices currently implemented at the site should provide any such monitoring information required.

The deployment of any of the four CATOX systems in place of - or in addition to - the existing GAC canister system should not affect the amount or type of radioactive emissions from the ERA. Therefore, absent any independent increase in radioactive emissions, the construction or modification activities required by the installation of a CATOX system would not trigger any new requirements under this regulation. Instead, current compliance with this regulation would continue.

3. WAC 173-403-080 and 40 CFR § 52.21 (Prevention of Significant Deterioration).

These requirements provide that construction of a major stationary source (or a major modification of a source) in an attainment area requires a PSD permit and the application of "best available control technology". PSD review is triggered by greater than threshold emissions of "criteria" pollutants such as sulfur dioxide, particulates, and certain VOCs. Of relevance to the ERA, the "significant net increase" of VOC emissions that would trigger PSD review is 40 tons per year.

As concluded in the ARARs Memo, the ERA as currently configured would result in an estimated maximum emission of carbon tetrachloride of 1.8 tons per year, which is below the PSD threshold of 40 tons per year. Therefore the ERA is exempt from PSD requirements.

The deployment of certain of the four CATOX systems in place of - or in addition to - the existing GAC canister system could possibly affect the amount of carbon tetrachloride emitted. The EE/CA estimated that while ultra-high-efficiency CATOX systems (with or without scrubbing) would lead to a similar emissions level of carbon tetrachloride of 1.8 tons per year, the high-efficiency CATOX systems (with or without scrubbing) would lead to emissions of 3.6 tons per year. However, emissions of carbon tetrachloride from all CATOX systems would still not exceed the PSD threshold of 40 tons per year. Therefore, current compliance with this regulation would continue under all four of the proposed CATOX systems.

4. 40 CFR Part 264, RCRA Treatment Storage and Disposal Requirements, including Subparts AA and BB (RCRA Air Emission Standards for Process Vents and Equipment Leaks).

RCRA Part 264 provides substantive and procedural requirements for the treatment of hazardous waste. The RCRA Subpart AA process vent standards apply to vents on certain waste management units that manage hazardous waste with an annual average total organics concentration of 10 parts per million by weight (ppmw) or greater. The affected waste management units include distillation, fractionation, thin-film evaporation, solvent extraction, and air or steam stripping operations and associated tanks. In the preamble to the final rule adopting these requirements EPA discussed their applicability to CERCLA removal and remedial actions and specifically stated that they would not be ARARs for, among other things, "in situ soil vapor extraction." The RCRA Subpart BB equipment leak standards apply to emissions from valves, pumps, compressors, pressure relief devices, sampling connection systems, and open-ended valves or lines where the equipment contains or contacts hazardous waste streams with organic concentrations of 10 percent by weight or greater. EPA has stated that these standards would be considered an ARAR for equipment components installed at CERCLA sites that contain or contact such substances.

As concluded by the ARARs Memo, if the carbon tetrachloride at the 200 West Area is a hazardous waste, then the current VES/GAC system constitutes RCRA hazardous waste treatment. Due to the permit exemption available for on-site activities at CERCLA sites, a RCRA TSD permit would not be required for the ERA, although substantive RCRA treatment standards would need to be followed. Regarding the Subpart AA and BB requirements, the ARARs Memo concluded that: 1) the VES system was specifically exempt from Subpart AA, and 2) given that the ERA vapor extraction design configuration limits withdrawal of VOCs to concentrations below 0.1% by weight, the Subpart BB standards would not under normal operations be triggered by the ERA.

The deployment of any of the four CATOX systems under the ERA would affect the applicability of the RCRA TSD regulations to the ERA. In particular, according to Dave Bardis (RCRA Permits Section, EPA Region 10), CATOX systems are regulated as Subpart X units (Miscellaneous Units), and are subject to performance and procedural requirements under that Subpart, as well as to the requirements of both Subparts AA and BB if concentrations exceed the relevant thresholds. Because Subpart X requirements are not explicitly specified, EPA has the authority to set performance and procedural requirements for CATOX systems based on other Subparts. This issue is addressed under #5 below.

5. WAC 173-303-670 and 40 CFR Part 264, Subpart O (RCRA Incinerator Standards).

These requirements establish standards for facilities that incinerate hazardous waste. Among other things, these standards specify a destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent in the waste feed. Also, an incinerator that produces stack emissions of more than 1.8 kilograms (4 pounds) per hour of hydrogen chloride must limit emissions to the larger of 1.8 kilograms per hour or 1% of the hydrogen chloride in the stack gas prior to entering any pollution control equipment. These standards technically apply only to units meeting the RCRA definition of incinerator, which are essentially limited to devices employing controlled flame combustion, infrared, or plasma arc.

As concluded in the ARARs Memo, as currently configured, the ERA system is not affected by the Subpart O standards. However, according to Cathy Sowa, these standards were specified by EPA as ARARs for ERA treatment units to partially address EPA's concern about air emissions from the site.

The deployment of any of the four CATOX systems under the ERA would clearly be affected by the Subpart O standards. According to Dave Bardis (RCRA Permits section, EPA Region 10), CATOX systems are regulated as Subpart X units (Miscellaneous Units). However, the Subpart X regulations do not contain specific standards and instead require application of appropriate provisions from other subparts, including Subpart O Incinerator Standards. According to Bardis, Subpart O would generally be used as a baseline starting point for regulating CATOX systems, including both emissions limits and the 99.99% DRE standard. However, Bardis stated that there is room for EPA to determine that the particular system in question should be governed by standards other than the Subpart O standards. In particular, EPA has the discretion to determine that the fundamental standard of "protection of the environment" will be met by standards other than those specified in Subpart O.

An example of how EPA regulates thermal treatment systems such as CATOX can be seen at a removal action that is currently in progress in Region 10. This removal action (Drexler Ramcor) involves the thermal (non-incinerator) treatment of materials contaminated with PAHs and small amounts of solvents. According to Chris Field, the RPM for the site, the incinerator regulations were used as a starting point for requirements for the unit - but the regulations were only applied "to the extent practicable" (the standard provided in CERCLA for removal actions). According to Field, the incinerator DRE standard was not invoked at all for this unit, and the emissions standard for at least one of the emitted pollutants (particulate matter) was based not on the incinerator standard, but on a level that was as close to that standard as possible (while still being significantly below the health-based standard). As for the State's perspective on this decision, state air quality officials determined that since the removal action did not require an air quality permit, they would not become specifically involved in the EPA decision on the relevant emissions levels.

It is possible that EPA might pursue a similar approach with any proposal for the deployment of CATOX systems under the ERA. Further discussions with EPA will be necessary to determine the degree to which the Subpart O standards are applicable to the ERA.

Assuming the Subpart O standards are applied to the ERA, the two key standards that would directly affect the feasibility of CATOX systems are the hydrogen chloride emissions limit and the DRE standard. According to the EE/CA, in order to meet the Subpart O hydrogen chloride emissions limit, a CATOX system would require an acid scrubber. This would eliminate the two CATOX options without scrubbers. This conclusion is reinforced by the fact that the State had stated that independent of any EPA standard for this pollutant, they would require a scrubber for *any CATOX unit deployed at the ERA (according to Bob King, Department of Ecology). Therefore, only CATOX systems with scrubbers would be acceptable for the ERA.*

Regarding the DRE standard, the EE/CA indicated that neither high-efficiency nor ultra-high-efficiency CATOX system could meet the DRE standard of 99.99%: the high-efficiency system would meet a DRE of 98%, and the ultra-high-efficiency system would meet a DRE of 99%. Therefore, unless EPA is willing to establish a lower DRE standard, the CATOX systems proposed would not be acceptable, based on their removal efficiency.

6. Ch. 173-460 WAC (Controls for New Sources of Toxic Air Pollutants).

These requirements apply to sources that may emit one or more toxic air pollutants listed in the regulations, including carbon tetrachloride and hydrogen chloride, and which commenced construction after September 18, 1991. Before construction, installation, or establishment of such a source, the owner or operator must file and obtain approval for a notice of construction. To receive construction approval, the new source must use best available control technology for toxics (T-BACT) and demonstrate that emissions levels are sufficiently low to protect human health and safety from potential carcinogenic or other toxic effects. The demonstration regarding emissions is in the first instance made through comparison with acceptable source impact levels (ASILs) to unrestricted access areas specified in the regulations. The ASIL for carbon tetrachloride is .067 micrograms per cubic meter (annual average) and the ASIL for hydrogen chloride is 23.3 micrograms per cubic meter (24-hour average).

As detailed in the EE/CA, a demonstration was made that emissions were below the relevant standards for both carbon tetrachloride and hydrogen chloride.

The deployment of any of the four CATOX systems would not affect compliance with this regulation. According to the EE/CA, all CATOX systems examined would meet the relevant standards for both carbon tetrachloride and hydrogen chloride:

7. 40 CFR Part 302 (Hazardous Substance Release Reporting).

As soon as a person in charge of a facility has knowledge of a release of a hazardous substance in an amount equal to or exceeding its reportable quantity, the person must immediately notify the National Response Center. Federally permitted releases (i.e., releases under air or water emissions programs) need not be reported. In addition, releases of a continuous nature need be reported only once to the Response Center. The reportable quantity is 4.5 kilograms (10 pounds) for carbon tetrachloride, 2270 kilograms (5000 pounds) for hydrogen chloride, 0.1 curie for radon-220 or radon-222, and .01 curie for lead-210.

According to the ARARs Memo, 1) ERA process specifications have been established to avoid release of carbon tetrachloride greater than the 4.5 kilograms threshold, 2) monitoring is in place to verify that radon emissions are below threshold, and 3) release of other compounds are anticipated to be well below threshold.

The deployment of certain of the four CATOX system might affect applicability with this regulation. The EE/CA estimated that while ultra-high-efficiency CATOX systems would lead to an emissions level of carbon tetrachloride of less than 10 pounds per day, the high-efficiency CATOX systems would lead to emissions of up to 20 pounds per day. (Both CATOX systems would not otherwise exceed the threshold for hydrogen chloride and would not change the emissions levels of the other compounds.) Therefore, high-efficiency systems would trigger the CERCLA 302 reporting requirement.

It is unclear whether this implies that only ultra-high-efficiency systems would therefore be acceptable under the ERA. While the EE/CA listed the CERCLA 302 reporting requirement as an ARAR for the ERA, according to Judy Schwartz (RCRA Permits Section, EPA Region 10), the CERCLA 302 requirement is specifically a notification requirement - not an enforceable emissions level. For this reason, the CERCLA 302 levels are generally not considered ARARs for CERCLA actions in Region 10. In particular, Schwartz questioned the actual applicability of the 302 reportable quantity level to ongoing treatment emissions. She stated that the federally permitted release exemption should be applicable to any CERCLA action, and that therefore any air emissions should instead be covered by applicable air quality regulations, not CERCLA reportable quantity regulations.

Further discussion with EPA Hanford representatives may be necessary to determine whether the CERCLA 302 regulation is in fact an ARAR for the ERA. Assuming that it is, this would imply that only ultra-high-efficiency CATOX systems would be acceptable.

8. Ch. 173-160 WAC (Well Construction and Maintenance).

These requirements establish minimum standards for the construction, maintenance, and abandonment of "resource protection wells," which include monitoring wells, extraction wells for the remediation of contaminated groundwater, and certain geotechnical borings.

According to the ARARs Memo, these requirements must be met by activities under the ERA.

The deployment of any of the four CATOX systems would not involve well construction and would therefore not affect compliance with these regulations.

Conclusion

Based on the above analysis, the most feasible CATOX system option for the ERA is the ultra-high efficiency system with associated acid scrubbing. This option could meet all potential ARARs except one: the RCRA Subpart O Incinerator DRE Standard of 99.99%. Again, however, according to Dave Bardis of EPA, the applicability of this standard is not based on direct regulatory language, but on the discretion of EPA in setting performance standards for CATOX units. If DOE can provide evidence to EPA that a lower DRE (i.e., the 99% DRE of the ultra-high-efficiency system) would provide "protection of the environment, " there is the possibility that EPA will agree to such a performance standard for the ERA.

As for the State's position, Bob King of the Washington Department of Ecology has stated that the State would have no objection to a CATOX system at the ERA site, as long as it included a scrubber system. In addition, the State favors on-site treatment of the waste. This position should support any DOE efforts to negotiate with EPA for an on-site ultra-high-efficiency CATOX system with acid scrubbing for the 200 West ERA.

As a final point, however, Cathy Sowa has suggested that the deployment of a CATOX system with acid scrubbing at the ERA would trigger a set of new regulatory issues related to the management of scrubber-generated wastewaters. For example, injection of the wastewaters may not be allowed by state regulation, while containment and transport of wastewaters to alternate treatment sites may be infeasible. This issue will require further investigation, if it appears that CATOX systems would be acceptable to EPA and the State based on the ARARs reviewed in this memo.

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