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Office of
Emergency and
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EPA/ROD/R10-91/032
September 1991

EPA

Superfund Record of Decision:

American Lake Gardens (McChord AFB - Area D), WA

50272-101

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First Remedial Action - Final

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16. Abstract (Limit: 200 words)

The American Lake Gardens (McChord AFB-Area D) site is an active U.S. Air Force base located at McChord Air Force Base, Pierce County, Washington. The site consists of two areas, Area D and American Lake Garden Tract (ALGT). Area D is located entirely on-base. Area D activities include Air Force Base administration, flight operations support functions, and housing and recreation facilities. Approximately 2,384 people reside in the Area D housing facilities. ALGT is an off-base commercial and residential area with approximately 3,431 residents and various businesses. Hydrogeologic units exist onsite including a series of confined and unconfined aquifers that appear to be hydraulically connected. Various surface water bodies exist near the site and are principally ground water-fed. From the mid-1940's to the present, no known industrial activities have occurred in the ALGT area; however, seven waste disposal sites have operated within the Area D portion of the site. In 1981, the Air Force initiated a multi-phase program to identify past disposal sites and contaminants and to eliminate public health risks. Concurrent with DOD investigations, EPA discovered TCE in ground water monitoring wells installed at the ALGT, and in 1984, concluded that waste disposal sites in Area D were the likely

(See Attached Page)

17. Document Analysis a. Descriptors
Record of Decision - American Lake Gardens (McChord AFB-Area D), WA
First Remedial Action - Final
Contaminated Medium: gw
Key Contaminants: VOCs (benzene, PCE, TCE, toluene, xylenes), other organics, metals (arsenic, chromium, lead)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 102
	20. Security Class (This Page) None	22. Price

EPA/ROD/R10-91/032
American Lake Gardens (McChord AFB-Area D), WA
First Remedial Action - Final

Abstract (Continued)

source of ground water contamination. Modeling studies indicate that most of the soil contamination by VOCs has moved into the ground water, and that DNAPLs may continue to act as a secondary source of ground water contamination. In 1986, the Air Force provided an alternate water source to residents of ALGT, and subsequently connected 80% of the residences to a public water supply. This ROD addresses remediation of the contaminated onsite and offsite ground water plume, as a final remedy. The primary contaminants of concern affecting the ground water are VOCs including benzene, PCE, TCE, toluene, and xylenes; other organics; and metals including arsenic, chromium, and lead.

The selected remedial action for this site includes pumping and treating both the onsite and offsite ground water contaminant plumes in the confined aquifer using an onsite multi-bed carbon adsorption treatment facility, followed by recharging or irrigating the treated ground water onsite; regenerating the spent carbon offsite; monitoring the ground water contaminant plume; and implementing institutional controls such as deed, ground water, and land use restrictions. The estimated present worth cost for this remedial action ranges from $4,445,000 to $6,949,000, for interest rates of 10% and 4% respectively, which includes an annual O&M cost of $341,000 for years 0-2 and $318,000 for years 3-30.

PERFORMANCE STANDARDS OR GOALS: Ground water will be restored to levels consistent with State and Federal MCLs. Chemical-specific goals for ground water include cis-1,2-DCE 70 ug/l (MCL), 1,1-DCE 0.7 ug/l (Model Toxic Control Act), TCE 5 mg/l (MCL), and vinyl chloride 0.04 ug/l (Model Toxic Control Act).

RECORD OF DECISION

McCHORD AIR FORCE BASE, WASHINGTON
American Lake Garden Tract

U.S. E.P.A. Region 10

McChord Air Force Base

Washington State Department of Ecology

September 19, 1991

RECORD OF DECISION

for the

UNITED STATES AIR FORCE
AREA D/AMERICAN LAKE GARDEN TRACT
McCHORD AIR FORCE BASE, WASHINGTON

TABLE OF CONTENTS

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Area D/American Lake Garden Tract
McChord Air Force Base, Pierce County, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected final remedial action for Area D/American Lake Garden Tract (Area D/ALGT) at McChord Air Force Base, Washington, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the administrative record for Area D/ALGT.

The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site to the groundwater, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

Remedial action is not necessary for source control to protect human health or groundwater, surface water, or sediments. It has been determined that contaminant concentrations found in the soil do not pose an unacceptable risk to human health or the environment, as defined by the NCP.

The selected remedy (Alternative 3) for Area D/ALGT addresses remediation of groundwater contamination by eliminating or reducing the risks posed by the site to levels that are protective of human health and the environment.

The major components of the selected remedy include:

- Install groundwater extraction wells capable of capturing the groundwater contaminant plume in the unconfined aquifer. An estimated three extraction systems will be necessary to achieve this goal.

- Install one of the three groundwater extraction systems near areas of highest concentration of contaminants within the contaminant plume.

- Install on-site groundwater treatment facilities to remove contaminants from the extracted groundwater. The preferred treatment is carbon adsorption, with an estimated two treatment facilities necessary to achieve this goal.

- Monitor the groundwater contaminant plume and the extraction/treatment system during groundwater remediation activities to ensure that groundwater remediation goals are achieved and maintained throughout the contaminant plume.

- Implement administrative and institutional controls such as restrictive covenants and McChord Air Force Base command directives, that supplement engineering controls and minimize exposure to releases of hazardous substances during remediation.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy utilizes permanent solutions and alternative or resource recovery treatment technologies, to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element.

Because this remedy will result in hazardous substances remaining on-site in the groundwater above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Signature sheet for the foregoing McChord Air Force Base Record of Decision between the United States Air Force and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Dana A Rasmussen

DANA RASMUSSEN
Regional Administrator, Region 10
U.S. Environmental Protection Agency

Sept 19, 1991
Date

Signature sheet for the foregoing McChord Air Force Base Record of Decision between the United States Air Force and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Howard J. Ingersoll

HOWARD J. INGERSOLL, COLONEL, USAF
Commander, 62d Military Airlift Wing

19 Sept 91
Date

Signature sheet for the foregoing McChord Air Force Base Record of Decision between the United States Air Force and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Carol L. Fleskes

CAROL FLESKES, PROGRAM MANAGER
Toxics Clean-up Program
Washington State Department of Ecology

8/5/91
Date

DECISION SUMMARY

INTRODUCTION

The McChord Air Force Base (AFB) Area D/American Lake Garden Tract (ALGT) was listed on the National Priorities List (NPL) in October 1984, under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Pursuant to Executive Order 12580 (Superfund Implementation) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Air Force performed a Remedial Investigation/Feasibility Study (RI/FS) for Area D/ALGT. The Remedial Investigation (RI) (1991) characterized the nature and extent of contamination in the groundwater, soil, surface water, and sediments. The Human Health Risk Assessment (1990) and the Ecological Risk Assessment (1991) evaluated potential effects of the contamination on human health and the environment. The Feasibility Study (FS) (1991) evaluated alternatives for remediation of the contamination.

I. SITE NAME, LOCATION AND DESCRIPTION

The Area D/ALGT site is located in Pierce County, Washington, approximately one mile south of Tacoma (Figure 1). The site is bounded by: Interstate 5 and Porter Hills to the north; McChord AFB ammunition storage area, "A" Street, and Burlington Northern Railroad (BNRR) to the east; Fort Lewis Logistics Center boundary with ALGT to the south; and ALGT to the west.

A. Area D

Area D is located entirely on-base in the southwest portion of McChord AFB. Activities within Area D include AFB administration, flight operations support functions, and housing and recreation facilities. Area D has had several waste disposal sites in various stages of operation from the mid-1940s to the present. These disposal sites were evaluated as part of the RI.

Hartwood Housing Area, which is situated along the western boundary of Area D, consists of 860 housing units with a population of approximately 2,384. Families reside in the housing area for an estimated 2.5 to 3 years, with some tenants remaining up to 11 years.

B. ALGT

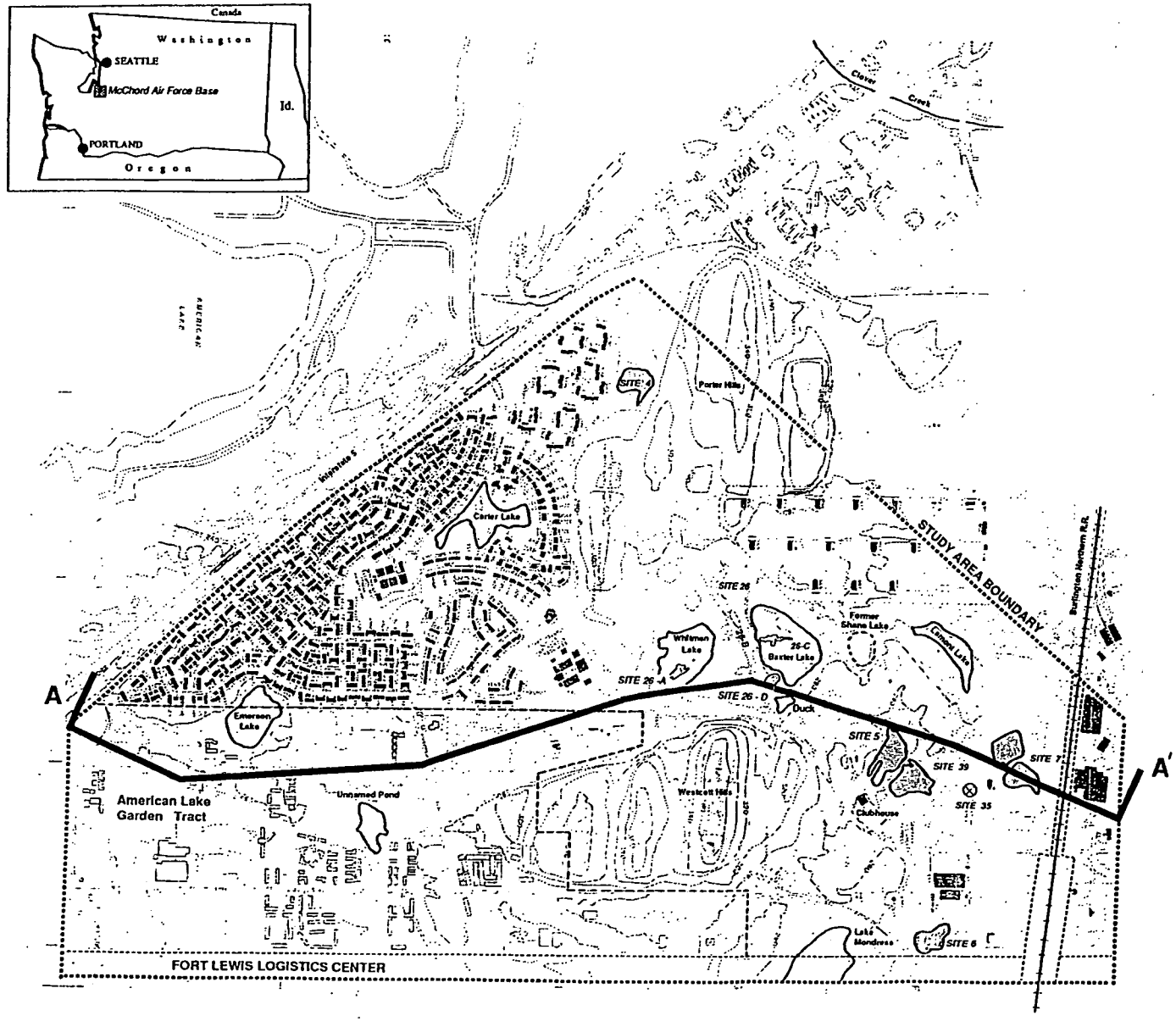
ALGT is an off-base residential tract abutting the southwest boundary of Area D between McChord AFB and Fort Lewis Army Installation. This tract consists of approximately 1,183 housing units. Approximately 3,431 people reside in ALGT. Up to 80 percent of the residents are renters, and over one-half of the residents move each year due to frequent transfers of military personnel.

Commercial activities have been limited to barber shops, equestrian facilities, gasoline service stations, grocery stores, laundromats, restaurants, and vehicle repair shops. No known industrial activities occurred within the ALGT.

C. Surface water and Groundwater Resources

Seven on-base water supply wells are installed in the vicinity of the Area D. With the exception of one family housing well, which was disconnected at the time of sampling, all wells were sampled during the RI. One well, the Whispering Firs Golf Course irrigation well, exhibited contamination that exceeded drinking water standards. This well is used exclusively for irrigation of the golf course during the summer months. The remaining wells are located out of the path of the plume either horizontally or are beneath the contaminated shallow aquifer.

Approximately 86 percent of the drinking water for ALGT residents is supplied by the Lakewood Water District. The remaining residents continue to use private wells that are installed beyond the known contaminant plume boundary. Water supplied by the Lakewood Water District is drawn from three public water supply wells, which are located more than one mile from the Area D/ALGT plume and are screened in the uncontaminated lower aquifer. These wells are sampled on a quarterly basis by the jurisdictional health department, and are not known to be currently affected by the contaminant plume.



LEGEND

- INSTALLATION RESTORATION PROGRAM (IRP) SITES
- SURFACE WATER BODIES
- STUDY AREA BOUNDARY

N

0 500 1000

Scale (feet)

Generalized Subsurface Profile Location

A — A'

McChord Air Force Base-Area D/ALGT

Figure 1
McCHORD AND ALGT STUDY AREA

Record of Decision

The nearest surface water bodies are Lamont Lake, the Duck Pond, Baxter Lake, Whitman Lake, Carter Lake, an unnamed pond in ALGT, Emerson Lake, and Lake Mondress (Figure 1). These surface water sites are principally groundwater-fed.

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Department of Defense (DOD) Installation Restoration Program (IRP) was initiated at McChord AFB in March 1981. The purpose of the multi-phase program was to identify the locations and contents of past disposal sites and to eliminate the hazards to public health in an environmentally responsible manner. The Phase I record search investigation identified past and current potential waste disposal sites. The Phase II investigation measured low level organic contamination at several of these sites across McChord AFB and recommended further studies to confirm contaminant characteristics and distribution.

Concurrent with the United States Air Force's (Air Force) Phase II IRP investigation, the United States Environmental Protection Agency (EPA) discovered TCE in groundwater monitoring wells installed at the ALGT, and in 1984, concluded that the groundwater contamination in the ALGT most likely originated from Area D. The site was subsequently listed on the NPL in October 1984. Upon listing, the IRP investigation was phased into the CERCLA RI/FS process.

A. Source Areas

Seven waste disposal sites within Area D were identified and investigated as potential sources of contamination during the RI. These sites are depicted in Figure 1 and described in Table 1.

B. Groundwater

Once it was determined that Area D was the likely source of groundwater contamination, the Air Force provided an alternate water source to residents of ALGT. Beginning in the summer of 1986, the Air Force offered connection to the Lakewood Water District to residents of ALGT. Approximately 80 percent of the ALGT residents, including all residents directly affected by the contaminant plume, were permanently transferred to the Lakewood Water District water supply. The private drinking water wells were generally not abandoned.

Table 1. Area D Waste Site History - McChord Air Force Base.

Waste Disposal Site	Approximate Time of Operation	General Waste Type Received	Specific Waste Type Received	Land Use Prior To Waste Disposal	Current Land Use
4	1941 - 1958 (sporadic use)	Unknown	Unknown	Gravel pit	Soccer Field
	1958 - 1978	Rubbish, garbage Industrial	Unknown		
5	1951 - 1967(?)	Industrial, domestic, construction	Waste oil, fuel, solvents(?)	Unknown	Golf Course
6	1961(?) - Present	Industrial, domestic, construction	Unknown	Borrow pit	Borrow pit, landfill
7	1967 - 1972	Industrial, domestic, construction	Unknown	Pond	Golf Course
26	1943 - 1956	Ordnance disposal	Grenades, fragmentation bombs, industrial fuels(?), chemicals(?)	Unknown	Undeveloped
	1960? - 1979(?)	Stumps, grass	Stumps, grass		
35	1950? - 1959(?)	Low-level radioactive waste	Rinsate from decontamination of radar components, fluorescent dials; possibly medical waste liquids	Well of undetermined depth	Golf Course
39	1953 - 1960(?)	Waste POL[1/], solvents, fuel	Waste JP-4[2/] solvents, POL	Unknown	Golf Course

1/ POL - petroleum, oil, and lubricant

2/ JP-4 - jet fuel

C. Enforcement

A Federal Facilities Agreement (Agreement), Administrative Docket Nos. 1088-06-17-120 and 1088-06-18-120, between the Air Force, the EPA, and the State of Washington Department of Ecology (Ecology) became effective October 23, 1989. The Agreement establishes a procedural framework for agency coordination and a schedule for all CERCLA activities conducted at McChord AFB.

Under the terms of the Agreement, EPA and Ecology provided oversight of the remainder of the RI/FS activities for Area D/ALGT. In accordance with CERCLA Section 120, the Air Force and the EPA, in collaboration with Ecology, selected the final remedy in this Record of Decision (ROD).

III. COMMUNITY RELATIONS

A. Community Relations During the RI/FS

In accordance with 55 FR 8847, community interviews were conducted with interested residents, local officials, and public interest groups to identify concerns and public information needs, and to solicit involvement in the Superfund process. The information gathered during the interviews provided the basis for development of the site-specific Community Relations Plan (CRP). Under the CRP, the following activities were undertaken to address community concerns and interests.

- Information repositories containing site information and documents on site activities were established at the following four locations:

  - Pierce County Library - Lakewood Branch
  - Pierce County Library - Tillicum Branch
  - McChord AFB - Library
  - McChord AFB - Public Affairs Office

- Three workshops to inform the public of the status and findings of the site investigation were held:

  - April 14, 1989 (announced the beginning of the RI/FS)

- November 9, 1989 (summarized preliminary results of the environmental samples)
- March 20, 1990 (discussed the findings of the remedial investigation)

Three factsheets and three press releases were issued to correspond with the workshops.

Also, in accordance with Section 113 (k)(1) of CERCLA, an administrative record was established to provide the basis for selection of the remedial action. The administrative record was available for public review at the McChord AFB Environmental Engineering Office.

B. Community Relations to Support Selection of a Remedy

In accordance with Sections 113 (k)(2)(B)(i-v) and 117 of CERCLA, the public was given the opportunity to participate in the remedy selection process. The proposed plan, which summarized the alternatives evaluated and presented the preferred alternative, was mailed to approximately 850 interested parties in March 1991. The Air Force provided notice through a display ad in the *Tacoma Morning News Tribune* and the *Lakewood Journal* to explain the proposed plan, list the public comment period, and announce the public meeting. A news release was provided to the local news media which resulted in news coverage by the *Tacoma Morning News Tribune* on March 31, 1991. A meeting of the Citizen Advisory Committee, comprised of local government officials, environmental interest groups, and local residents, was also held to disseminate information on the proposed plan.

A 45-day comment period was held from March 25 to May 8, 1991. There were no requests for extensions. Approximately 30 people attended a public meeting held on April 11, 1991 at Woodbrook Junior High School. The written comments, which were received during the public comment period, are included in the Responsiveness Summary attached to this ROD.

IV. SCOPE AND ROLE OF RESPONSE ACTION WITHIN SITE STRATEGY

The RI evaluated the nature and extent of contamination in all potentially affected media including groundwater, soil, surface water, and sediment. However, with respect to the soil, the objective of the RI was to investigate the soil as potential sources of volatile

organic compound (VOC) groundwater contamination. Thus, the RI is not a complete characterization of the sources; nonetheless, based on available data, the soil does not appear to be a source of continuing contamination for the groundwater.

Results from the RI and the Baseline Risk Assessment indicate that no remedial action is necessary for soil, surface water, or sediments to ensure protection of human health or the environment. Groundwater contamination does exceed health-based levels and/or MCLs and will require remediation as outlined in this ROD. Therefore, the final remedial action selected in this ROD addresses groundwater contamination at the McChord Area D/ALGT site. Groundwater will continue to be monitored biannually for VOCs, (semi-volatile organic compounds (SVOCs), inorganics, and pesticides. If additional contamination is identified, additional investigation and/or remediation of the groundwater or source areas may be required.

The final selected remedy includes: (1) no remedial action for soil, surface water, or sediments; and (2) treatment of contaminated groundwater to permanently and significantly reduce the volume and mobility of the hazardous substances found within the saturated zones.

V. SUMMARY OF SITE CHARACTERISTICS.

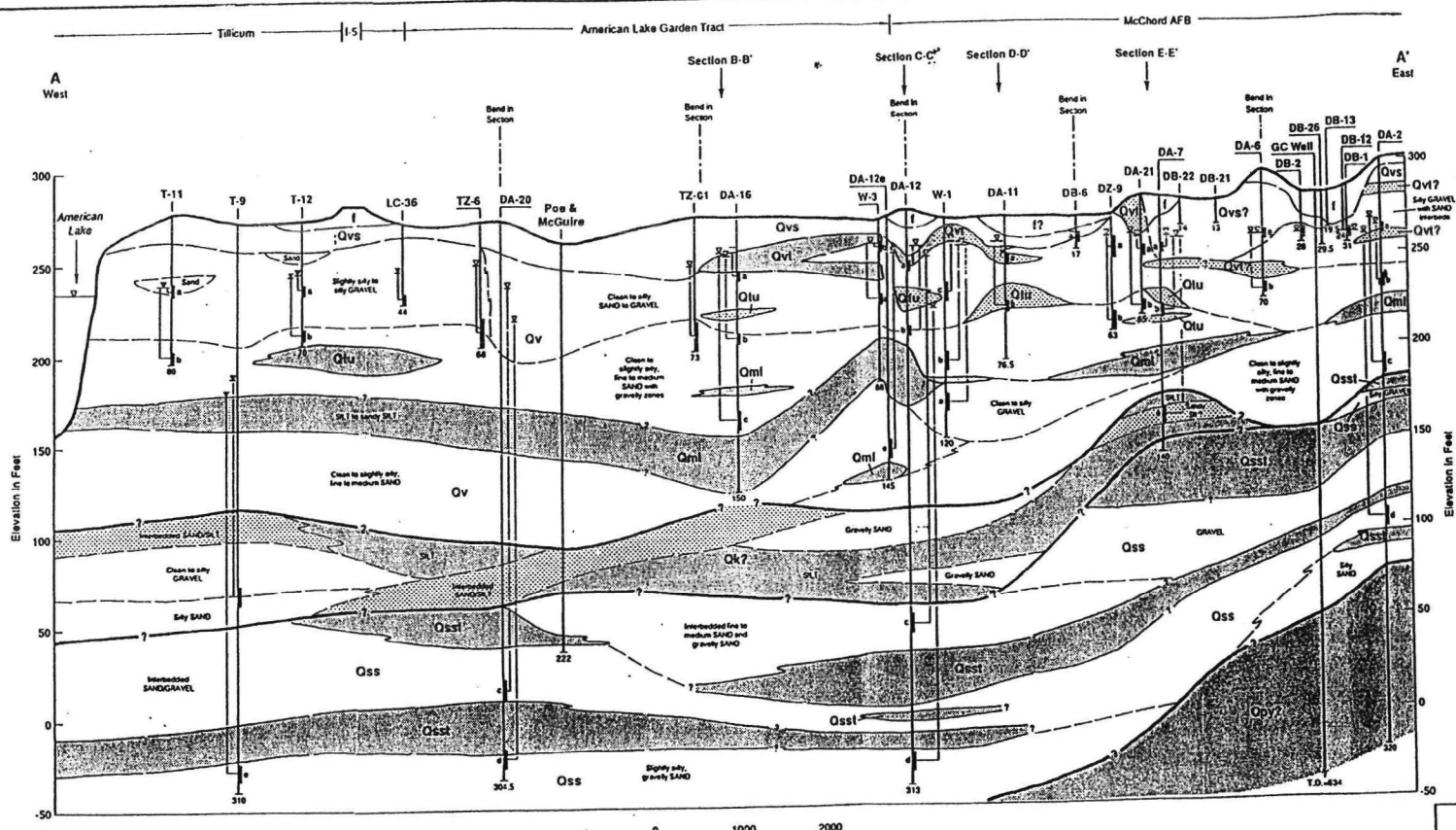
A. Site Geology and Hydrogeology

Area D/ALGT is located on an extensive upland glacial drift plain which occupies much of central Pierce County (Table 2, Figure 2). The site consists of highly permeable sand and gravel glacial outwash materials separated by till layers and interspersed non-glacial units.

The uppermost hydrogeologic unit generally found across the site is the Vashon Drift/Post Kitsap Aquifer, which consists of the Steilacoom Gravel, and recessional outwash, till, and advance outwash units as well as lacustrine silt and undifferentiated outwash and till units. The Steilacoom Gravel and the outwash units contain the unconfined aquifer unit that extends from the water table at about 20 feet below ground to a depth of between 80 and 160 feet. The underlying Kitsap Formation is a non-glacial unit that generally represents a regional aquitard, but locally has been found to be discontinuous and relatively permeable. The Salmon Springs Drift Aquifer underlies the Kitsap and consists of recessional and advance outwash units separated by a till aquitard.

Table 2. Description of Geologic Units.

GEOLOGIC/ STRATIGRAPHIC UNIT	SITE GEOLOGIC UNIT	SYMBOL	LITHOLOGIC DESCRIPTION	SITE THICKNESS FT.	SITE HYDROGEOLOGIC DESIGNATION
	Fill	f	Predominantly silty gravel with varying amounts of garbage.	0->25	Aquifer where saturated
Recent	Recent Deposits	Qr	Predominantly alluvium and colluvium; silt, sand and gravel with lesser amounts of organic depression fillings.	0-10	Aquifer where saturated
Vashon Stade-Fraser Glaciation (Vashon Drift)	Steilacoom Gravel	Qvs	Open-work coarse gravel with abundant cobbles.	20-40 locally absent	Vashon Drift/Post Kitsap Aquifer
	Vashon Recessional Outwash	Qvr	Interbedded gravelly sand and sandy gravel with variable amounts of silt, typically medium dense to dense.	0-50	
	Vashon Till	Qvt	Very dense lodgement till: gravelly, clayey, sandy silt; and loose ablation till: gravelly, clayey, sandy silt.	0-20 locally, up to 100	(Qvt-aquitard)
	Vashon Advance Outwash	Qva	Interbedded uniformly graded sand and sandy gravel with silt lenses, typically dense to very dense, local lenses of gravelly sand.	5-90	
Vashon Drift and Pre-Vashon/ Post-Kitsap	Undifferentiated Outwash	Qv	Alluvium and outwash: interbedded gravelly sand, uniformly graded sand and sandy gravel, with silt lenses.	Variable	
	Lacustrine Silt	Qml	Glacial and non-glacial lacustrine silt, locally with organic debris, locally interbedded with sand and silty sand.	0-30	(Qml-aquitard)
Pre-Vashon/ Post-Kitsap	Undifferentiated Till	Qtu	Lodgement till, and lesser amounts of ablation till: predominantly very dense to hard, sandy silt and clayey silt.	0-20	(Qtu-aquitard)
Olympia Interglacial	Kitsap Formation	Qk	Non-glacial deposits of silt, sand, gravel, and clay; with scattered ash, wood, and peat.	10-60 locally absent	Kitsap Aquitard
Salmon Springs Glaciation	Salmon Springs Outwash	Qss	Interbedded sand and gravel with silt and clay lenses.	60-100	Salmon Springs Aquifer
(Salmon Springs Drift)	Salmon Springs Till	Qsst	Very dense, heterogeneous mixture of gravel, sand, clay, and silt.	2-55	Salmon Springs Till Aquitard
Puyallup Interglacial	Puyallup Formation	Qpy	Alluvial deposits of interbedded silt and coarse-grained sediment with mudflow deposits and ash.	up to 135	Puyallup Aquitard
Stuck Glacial	Stuck Drift	Qst	Till, lacustrine silt and fine sand, glaciofluvial sand and gravel.	50-100	Stuck Drift Aquifer



NOTE: Location of cross-section can be found on Figure 1.

McChord Air Force Base - Area D/ALGT

Figure 2
SUBSURFACE PROFILE ALONG AN EAST - WEST AXIS

Record of Decision

The deepest unit evaluated during the RI is the Puyallup Formation, which is generally an aquitard.

Unconfined groundwater flow beneath the site is generally from the east or southeast to the west or northwest, with some diversions caused by the drumlins of the Wescott and Porter Hills. The gradient varies, across the site and by season, between 4 to 60 feet per mile. Groundwater flow velocities similarly vary from 0.01 to 1 foot per day, with a median velocity of approximately 0.5 foot per day.

In the underlying Salmon Springs confined aquifer, the flow is in a similar direction to the west or northwest at a gradient of 20 to 60 feet per mile. The groundwater velocity, which is similar to the unconfined aquifer, is 0.1 to 1 foot per day. There appears to be a downward vertical gradient between the upper unconfined aquifer and the lower Salmon Springs Aquifer.

B. Nature and Extent of Contamination

The investigation of Area D/ALGT evaluated the nature and extent of contamination found in groundwater, surface water, sediment, and soil. The investigation also evaluated naturally occurring (i.e., "background") inorganic concentrations found in groundwater and soil. The background samples, which were collected from four upgradient groundwater locations and twenty-seven soil locations, were then compared with inorganic samples collected from within Area D/ALGT.

1. Groundwater

During the RI, 51 previously installed groundwater monitoring wells and 73 new groundwater monitoring wells were sampled and analyzed on a quarterly basis to provide information on the distribution and concentration of contaminants. The new wells were installed using a phased approach that utilized the findings of each previous phase to design and/or modify each subsequent phase. During the first phase, 11 shallow source area wells (approximately 25 feet), 14 shallow well pairs (approximately 35 and 70 feet), and 4 deep well pairs (approximately 200 and 300 feet) were installed. During the second phase, 4 shallow well pairs, 1 intermediate well (approximately 100 feet), and 2 deep well pairs were installed. During the final phase, 4 shallow well pairs, 1 single shallow well, and 4 intermediate wells (approximately 140 feet) were installed.

New and existing wells were sampled for VOCs, SVOCs, pesticides, polychlorinated biphenyls (PCBs), and inorganics. Table 3 summarizes the RI groundwater sampling data.

Pesticides and PCBs were not detected in the groundwater. Elevated levels of inorganic compounds were detected in many of the wells without a discernable pattern or apparent plume. Samples were taken of both filtered and unfiltered metals, and exceedances of MCLs were reported in the total metals samples of lead (one sample), chromium (one sample), barium (one sample), and cadmium (four samples, plus five filtered samples). Based on the upgradient groundwater analytical data, the presence of these inorganic compounds was determined to be attributable to naturally occurring concentrations in the glacial drift, which is generally present in the suspended sediment normally found in monitoring wells screened in silty units.

The primary contaminants found in the groundwater were trichloroethylene (TCE) and cis-1,2-dichloroethylene (DCE). The contaminant plume, which is approximately 3500 feet in length, 500 feet in width, and 40 feet thick, extends from the vicinity of Site 5&39 and travels west in a curving path into the northeast corner ALGT. Figure 3 shows the distribution of TCE across the site and indicates areas that are above and below the MCL of 5 ug/l (micrograms per liter). The maximum average concentration of TCE (76 ug/l) was found at well DA-07b.

Figure 4 shows the distribution of the DCE contaminant plume. The maximum average concentration of DCE (222 ug/l) was similarly found at well DA-07b. The extent of the plume exceeding the MCL is significantly greater for TCE than for DCE. The source of the DCE is not known. Its presence may be attributable to an impurity of TCE solvent or may have been a degradation product of TCE within the aquifer.

The results of the RI investigation were incorporated into a groundwater model for contaminant transport that used the Method of Characteristics (MOC) procedure of Konikow and Bredehoeft. The modeling was performed during the FS to predict the possible future distribution of TCE that could result from any of the various alternative remedial actions, including the no action alternative, which were considered.

Although several sites in Area D were reportedly used for disposal of waste materials, the source of groundwater contamination appears to have been Site 5&39. In the area near Site 5&39, groundwater contamination was generally found to be greater in

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Upgradient	Downgradient				
	Range of Concentration[1] (µg/l)	Frequency of Detection[2]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3] (µg/l)	MCL[4] (µg/l)
Inorganics						
Aluminum	301-38,900	22/29	212-38,600	4,900	<200-<200	
Antimony	BDL	0/29	N/A	N/A	<60-<60	
Arsenic	3.1-10	4/29	12-24	18	<10-<10	50
Barium	27-860	2/29	333-1,280	810	<200-<200	1,000
Beryllium	7-7	0/29	N/A	N/A	<5-<5	
Cadmium	5-39	8/29	5-8	6	<5-<5	5
Calcium	7,610-65,100	29/29	6,620-78,300	18,000	N/A	
Chromium	1.4-67	6/29	22-103	39	<10-<10	100
Cobalt	11-133	1/29	92	92	<50-<50	
Copper	13-244	10/29	25-131	46	<25-<25	
Iron	103-155,000	26/29	107-31,300	5,500	<100-<100	
Lead	1.7-27	12/29	5.9-78	16	<5-<5	50
Magnesium	2,740-27,800	17/29	5,180-20,600	9,000	<5,000-<5,000	
Manganese	10-4,330	23/29	22-5,320	680	<15-<15	
Mercury	1-1	0/29	N/A	N/A	<0.2-<0.4	2
Nickel	38-344	1/29	65	65	<40-<40	
Potassium	480-8,940	2/29	5,400-5,740	5,600	<5,000-<5,000	
Selenium	BDL	0/29	N/A	N/A	<5-<5	50
Silver	BDL	0/29	N/A	N/A	<10-<10	
Sodium	4,220-34,600	22/29	5,040-1,890,000	93,000	<5,000-<5,000	
Thallium	BDL	1/29	11	11	<10-<10	
Vanadium	11-379	1/29	64	64	<50-<50	
Zinc	9-297	9/29	24-152	51	<20-<20	
Cyanide	NA	0/17	N/A	N/A	<10-<10	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Volatiles					
Chloromethane	16/256	0.092-1.3	0.72	<0.10-<50	
Bromomethane	0/256	N/A	N/A	<0.10-<50	
Vinyl Chloride	15/256	0.084-1.8	0.47	<0.18-<40	2
Chloroethane	3/256	0.18-0.7	0.37	<0.10-<50	
Methylene Chloride	82/256	0.19-34	2.95	<0.1-<50	
Acetone	8/81	8-110	39	<10-<50	
Carbon Disulfide	12/81	2-13	4.7	<5-<25	
1,1-Dichloroethylene (DCE)	14/256	0.075-0.80	0.39	<0.1-<5	7
1,1-Dichloroethane (DCA)	35/256	0.06-5.3	1.0	<0.07-<50	
cis-1,2-Dichloroethylene (DCE)	295/657	0.08-350	20.7	<0.1-<5	70
trans-1,2-Dichloroethylene (DCE)	23/657	0.01-0.83	0.18	<0.1-<50	100
Chloroform	34/256	0.03-0.59	0.18	<0.05-<50	100 (THM)
1,2-Dichloroethane (DCA)	27/256	0.011-0.9	0.17	<0.03-<100	5
2-Butanone	0/81	N/A	N/A	<10-<100	
1,1,1-Trichloroethane (TCA)	96/256	0.02-18	0.64	<0.03-<50	200
Carbon Tetrachloride	1/81	0.19	0.19	<5-<25	5
Vinyl Acetate	0/81	N/A	N/A	<10-<50	
Bromodichloromethane	1/256	0.09	0.09	<0.1-<50	100(THM)
1,2-Dichloropropane	0/256	N/A	N/A	<0.1-<25	5
cis-1,3-Dichloropropene	0/256	N/A	N/A	<0.1-<25	
Trichloroethylene (TCE)	354/657	0.08-120	7.8	<0.12-<5	5
Dibromochloromethane	1/256	0.27	0.27	<0.1-<25	100 (THM)
1,1,2-Trichloroethane	19/256	0.02-0.9	0.14	<0.02-<50	
Benzene	25/256	0.02-1.4	0.39	<0.1-<50	5

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Volatiles (Continued)					
trans-1,3-Dichloropropene	0/81	N/A	N/A	<5-<25	
Bromoform	1/256	0.34	0.34	<0.1-<25	100 (THM)
4-Methyl-2-Pentanone	0/81	N/A	N/A	<10-<50	
2-Hexanone	0/81	5	5	<10-<50	
Tetrachloroethylene (PCE)	62/256	0.03-0.52	0.10	<0.03-<50	5
Toluene	4/256	0.02-670	95.7	<0.1-<50	1,000
1,1,2,2-Tetrachloroethane	0/256	N/A	N/A	<0.1-<50	
Chlorobenzene	2/256	0.34-0.36	0.35	<0.1-<25	100
Ethyl benzene	9/256	0.27-100	22.5		700
Styrene	0/256	N/A	N/A	<0.1-<25	100
Xylenes Total	11/102	0.02-400	82	<0.1-<50	10,000
2-Chloroethyl Vinyl Ether	0/81	N/A	N/A	<5-<25	
Semivolatiles					
Phenol	0/17	N/A	N/A	<8-10	
bis(2-Chloroethyl)Ether	0/17	N/A	N/A	<8-10	
2-Chlorophenol	0/17	N/A	N/A	<8-10	
1,3-Dichlorobenzene	30/272	0.13-7.8	2.07	<0.3-50	
1,4-Dichlorobenzene	14/272	0.3-5	1.05	<0.4-50	75
Benzyl Alcohol	0/17	N/A	N/A	<8-10	
1,2-Dichlorobenzene	4/272	0.35-0.79	0.57	<0.4-50	600
2-Methylphenol	0/17	N/A	N/A	<8-10	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[1]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3] (µg/l)	MCL[4] (µg/l)
Semivolatiles (Continued)					
bis(2-Chloroisopropyl)Ether	0/17	N/A	N/A	<8-<10	
4-Methylphenol	0/17	N/A	N/A	<8-<10	
N-Nitroso-Di-n-propylamine	0/17	N/A	N/A	<8-<10	
Hexachloroethane	0/17	N/A	N/A	<8-<10	
Nitrobenzene	0/17	N/A	N/A	<8-<10	
Isophorone	0/17	N/A	N/A	<8-<10	
4-Methylphenol	0/17	N/A	N/A	<8-<10	
2-Nitrophenol	0/17	N/A	N/A	<8-<10	
2,4-Dimethylphenol	0/17	N/A	N/A	<8-<10	
Benzoic Acid	0/17	N/A	N/A	<40-<50	
bis(2-Chloroethoxy)Methane	0/17	N/A	N/A	<40-<50	
2,4-Dichlorophenol	0/17	N/A	N/A	<8-<10	
1,2,3-Trichlorobenzene	2/272	0.68-13	6.84	<0.1-<50	
1,2,4-Trichlorobenzene	3/272	0.51-13	5.41	<0.1-<50	
Naphthalene	4/272	0.53-11	3.79	<0.1-<50	
4-Chloroaniline	0/17	N/A	N/A	<8-<10	
Hexachlorobutadiene	3/272	0.72-11	4.88	<0.1-<50	
4-Chloro-3-Methylphenol	0/17	N/A	N/A	<8-<10	
2-Methylnaphthalene	0/17	N/A	N/A	<8-<10	
Hexachlorocyclopentadiene	0/17	N/A	N/A	<8-<10	
2,4,6-Trichlorophenol	0/17	N/A	N/A	<8-<10	
2,4,5-Trichlorophenol	0/17	N/A	N/A	<40-<50	
2-Chloronaphthalene	0/17	N/A	N/A	<8-<10	
2-Nitroaniline	0/17	N/A	N/A	<40-<50	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Semivolatiles (Continued)					
Dimethyl Phthalate	0/17	N/A	N/A	<8-<10	
Acenaphthylene	0/17	N/A	N/A	<8-<10	
2,6-Dinitrotoluene	0/17	N/A	N/A	<8-<10	
3-Nitroaniline	0/17	N/A	N/A	<40-<50	
Acenaphthene	0/17	N/A	N/A	<8-<10	
2,4-Dinitrophenol	0/17	N/A	N/A	<40-<50	
4-Nitrophenol	0/17	N/A	N/A	<40-<50	
Dibenzofuran	0/17	N/A	N/A	<8-<10	
2,4-Dinitrotoluene	0/17	N/A	N/A	<8-<10	
Diethylphthalate	0/17	N/A	N/A	<8-<10	
4-Chlorophenyl-phenyl Ether	0/17	N/A	N/A	<8-<10	
Fluorene	0/17	N/A	N/A	<8-<10	
4-Nitroaniline	0/17	N/A	N/A	<40-<50	
4,6-Dinitro-2-Methylphenol	0/17	N/A	N/A	<40-<50	
n-Nitrosodiphenylamine	0/17	N/A	N/A	<8-<10	
4-Bromophenyl-phenylether	0/17	N/A	N/A	<8-<10	
Hexachlorobenzene	0/17	N/A	N/A	<8-<10	
Pentachlorophenol	0/17	N/A	N/A	<40-<50	
Phenanthrene	0/17	N/A	N/A	<8-<10	
Anthrene	0/17	N/A	N/A	<8-<10	
Di-n-Butylphthalate	0/17	N/A	N/A	<8-<10	
Fluoranthene	0/17	N/A	N/A	<8-<10	
Pyrene	0/17	N/A	N/A	<8-<10	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Semivolatiles (Continued)					
Butylbenzylphthalate	0/17	N/A	N/A	<8-<10	
3,3'-Dichlorobenzidine	0/17	N/A	N/A	<16-<20	
Benzo(a)Anthracene	0/17	N/A	N/A	<8-<10	
Chrysene	0/17	N/A	N/A	<8-<10	
bis(2-Ethylhexyl)Phthalate	2/17	5-9	7	<8-<10	
Di-n-Octyl Phthalate	1/17	20	20	<8-<10	
Benzo(b)Fluoranthene	0/17	N/A	N/A	<8-<10	
Benzo(k)Fluoranthene	0/17	N/A	N/A	<8-<10	
Benzo(a)Pyrene	0/17	N/A	N/A	<8-<10	
Indeno(1,2,3-cd)Pyrene	0/17	N/A	N/A	<8-<10	
Dibenz(a,h)Anthracene	0/17	N/A	N/A	<8-<10	
Benzo(g,h,i)Perylene	0/17	N/A	N/A	<8-<10	
Pesticides/PCBs					
alpha-BHC	0/20	N/A	N/A	<0.01-<0.05	
beta-BHC	0/20	N/A	N/A	<0.01-<0.05	
delta-BHC	0/20	N/A	N/A	<0.01-<0.05	
gamma-BHC(Lindane)	0/20	N/A	N/A	<0.01-<0.05	
Heptachlor	0/20	N/A	N/A	<0.01-<0.05	0.4
Aldrin	0/20	N/A	N/A	<0.01-<0.05	
Heptachlor Epoxide	0/20	N/A	N/A	<0.01-<0.05	0.2
Endosulfan I	0/20	N/A	N/A	<0.01-<0.05	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Pesticides/PCBs (Continued)					
Dieldrin	0/20	N/A	N/A	<0.02-<0.11	
4,4'-DDE	0/20	N/A	N/A	<0.02-<0.11	
Endrin	0/20	N/A	N/A	<0.02-<0.11	
Endosulfan II	0/20	N/A	N/A	<0.02-<0.11	
4,4'-DDD	0/20	N/A	N/A	<0.02-<0.11	
Endosulfan Sulfate	0/20	N/A	N/A	<0.02-<0.11	
4,4'-DDT	0/20	N/A	N/A	<0.02-<0.11	
Methoxychlor	0/20	N/A	N/A	<0.1-<0.53	40
Endrin Ketone	0/20	N/A	N/A	<0.02-<0.11	
Chlordane	0/20	N/A	N/A	<0.1-<0.53	2
Toxaphene	0/20	N/A	N/A	<0.2-<1.1	3
Aroclor-1016	0/20	N/A	N/A	<0.1-<0.53	0.5
Aroclor-1221	0/20	N/A	N/A	<0.1-<0.53	0.5
Aroclor-1232	0/20	N/A	N/A	<0.2-<0.53	0.5
Aroclor-1242	0/20	N/A	N/A	<0.2-<0.53	0.5
Aroclor-1248	0/20	N/A	N/A	<0.2-<0.53	0.5
Aroclor-1254	0/20	N/A	N/A	<0.2-<1.1	0.5
Aroclor-1260	0/20	N/A	N/A	<0.2-<1.1	0.5
Phorate	0/6	N/A	N/A	<0.20-<0.21	
Disulfoton	0/6	N/A	N/A	<0.20-<0.21	

Table 3. McChord AFB Area D/American Lake Garden Tract Groundwater Sampling Results Total (Unfiltered).

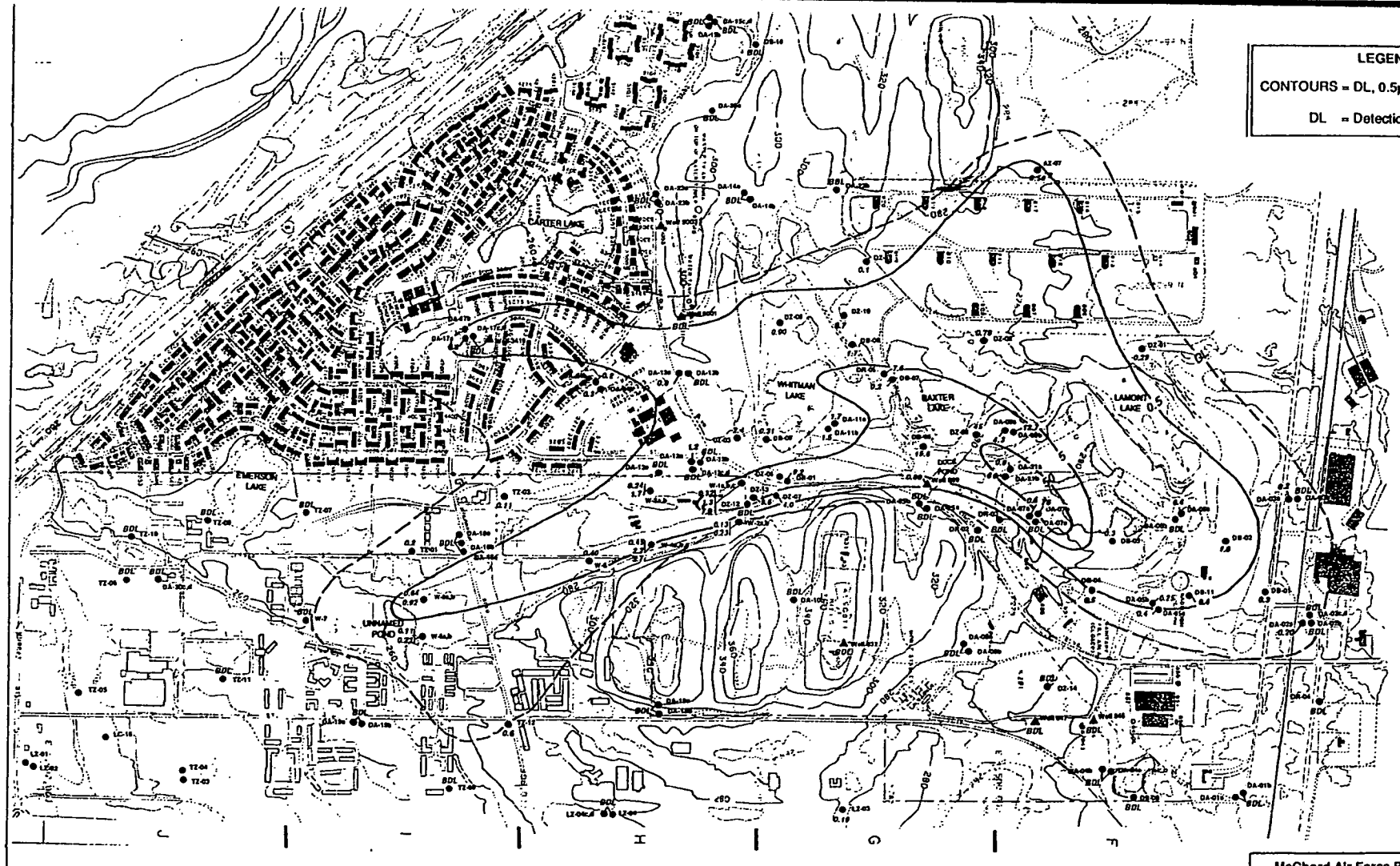
Parameter	Frequency of Detection[2/]	Range of Concentration (µg/l)	Mean of Concentration (µg/l)	Range of DLs[3/] (µg/l)	MCL[4/] (µg/l)
Pesticides/PCBs (Continued)					
Fenthion	0/6	N/A	N/A	<0.50-<0.53	
Sulprofos(bolstar)	0/6	N/A	N/A	<0.50-<0.53	
EPN	0/6	N/A	N/A	<0.50-<0.53	
TEPP	0/6	N/A	N/A	<0.50-<0.53	
Parathion	0/6	N/A	N/A	<0.50-<0.53	
Sulfotepp	0/6	N/A	N/A	<0.50-<0.53	
Malathion	0/6	N/A	N/A	<1.0-<1.1	
Ethoprop	0/6	N/A	N/A	<0.30-<0.32	
Parathion Methyl	0/6	N/A	N/A	<0.30-<0.32	
Ronnel	0/6	N/A	N/A	<0.30-<0.32	
Chlorpyrifos Methyl	0/6	N/A	N/A	<0.30-<0.32	
Diazinon	0/6	N/A	N/A	<0.50-<0.53	
Thionazin	0/6	N/A	N/A	<0.30-<0.32	
Famphur	0/6	N/A	N/A	<1.0-<1.1	

1/ Range of Concentration

2/ Frequency of Detection = number of detections/number of samples analyzed.

3/ Range of DLs = range of detection limits.

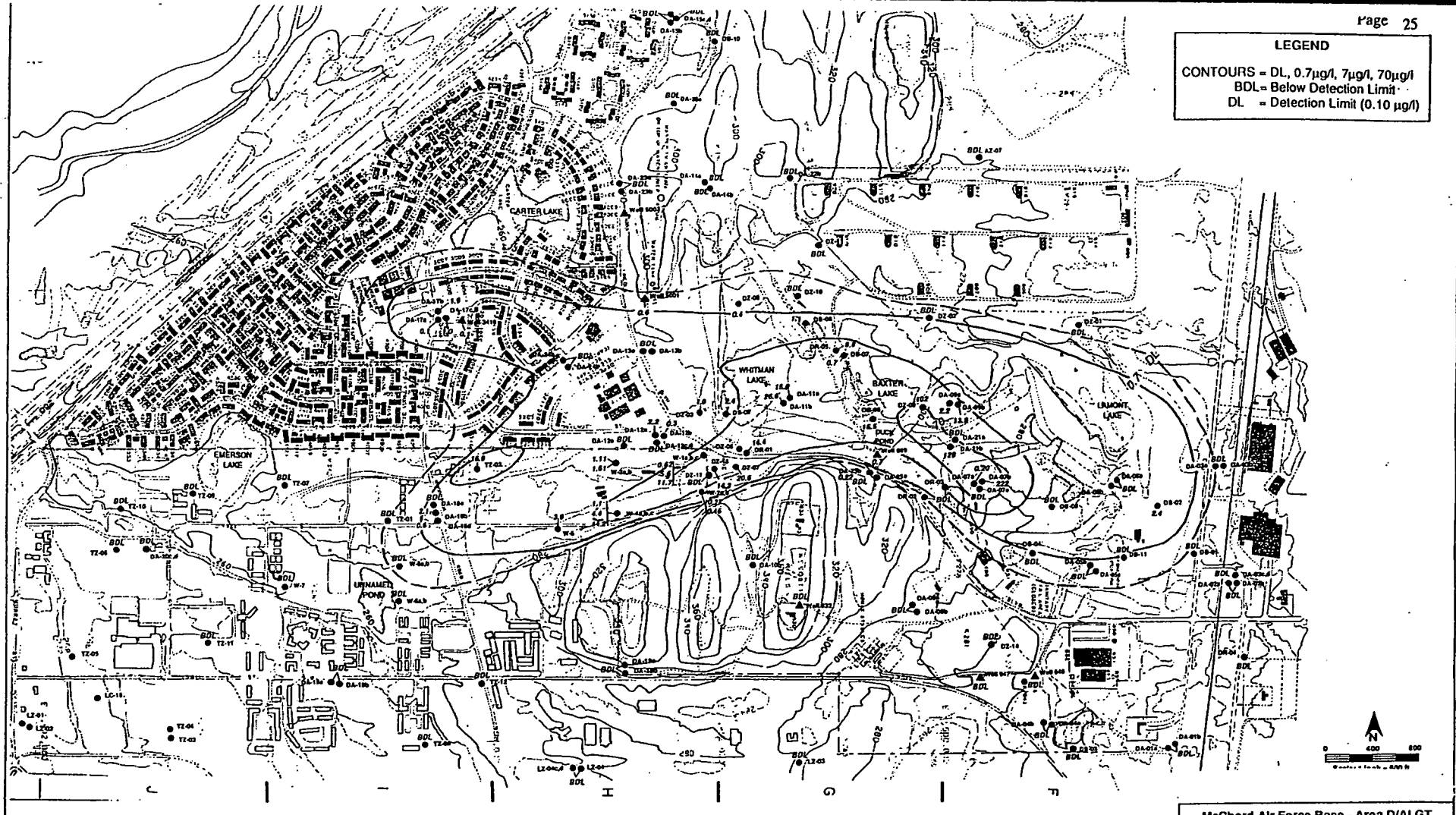
4/ THM = Trihalomethanes (total)



McChord Air Force Base - Area D/ALGT

Figure 3
TCE CONCENTRATIONS IN UNCONFINED AQUIFER

Record of Decision



McChord Air Force Base - Area D/ALGT

Figure 4
DCE CONCENTRATIONS IN UNCONFINED AQUIFER

Record of Decision

concentration in the deeper aquifer zones, rather than in the vadose zone. This phenomenon indicates that the waste material may have infiltrated through the vadose zone and groundwater as separate phase material (dense, non-aqueous phase liquids or DNAPLs) to lodge on top of relatively impermeable zones. Such DNAPLs are difficult to confirm, however, even through an extensive sampling program. The vertical extent of contamination is limited, however, by the till separating the shallow and deeper units of the aquifer. Samples from wells screened in the deeper Salmon Springs Aquifer exhibit contamination at or below detection limits (1.3 ug/l DCE in well DA-17c), and the analytical results were not reproducible during successive sampling events.

2. Surface Water and Sediment

There are a number of lakes or wetlands which are described geologically as glacial "kettle" depressions that appear to be hydraulically connected by groundwater. Surface water and sediment samples were obtained from these water bodies (Figure 1): Duck Pond; Unnamed pond in ALGT; Baxter Lake; Carter Lake; Emerson Lake; Lamont Lake; and Whitman Lake.

Surface water and sediment samples were analyzed for VOCs, inorganics, pesticides, and PCBs. TCE and DCE were both detected in several surface water samples, along with arsenic, chromium, copper, lead, selenium, and zinc, and the pesticides dieldrin and endrin ketone. The sediment samples showed detections of TCE and DCE, arsenic, cadmium, chromium, copper, lead, nickel, selenium, and zinc, and the pesticides chlordane, DDT, DDD, DDE, and dieldrin. Tables 4A and 4B present the frequency of detection of these contaminants in surface water and sediment, respectively.

Direct surface water runoff pathways for transport of soil are not known to have existed between the potential source areas and the surface water bodies. Recharge by groundwater appears to be the sole potential pathway between source areas and surface water. Consequently, the elevated levels of inorganics within the surface waters/sediments were determined to be caused by naturally occurring inorganics both in the groundwater and local geologic formations. Similarly, as pesticides were not found in the groundwater, the low levels of pesticides found in the sediments were attributed to past use of pesticides at the golf course or nearby residential areas.

Table 4A. McChord AFB Area D/American Lake Garden Tract. Surface Water Sampling Results.

Parameter	Frequency[1/] of Detection	Range of Concentration (ug/l)	Mean of Concentration (ug/l)	Range of DLs[2/] (ug/l)	Ambient Water Quality Criteria (ug/l)	
					Acute	Chronic
Volatiles (ug/Kg)						
Trichloroethylene (TCE)	7/12	0.06-1.2	0.41	<0.12-<0.12	45,660*	21,900*
cis-1,2-dichloroethylene	4/21	0.07-1.8	0.80	<0.1-<0.1	11,600[3/]*	-
trans-1,2-dichloroethylene	0/21	N/A	N/A	<0.1-<0.1	11,600[3/]*	-
Dissolved Metals (ug/kg)						
antimony	0/17	N/A	N/A	<3.4-<3.4	9,000*	1,600*
arsenic	7/17	3.4-6.3	4.6	<3.3-<3.3	360 (tri)	190 (tri)
beryllium	0/17	N/A	N/A	<1.6-<1.6	130*	5.3*
cadmium	0/17	N/A	N/A	<2.8-<2.8	3.9+	1.1+
chromium (hex)	0/17	N/A	N/A	<10-<50	16 (hex)	11 (hex)
chromium (total)	8/17	2.4-4.3	3.2	<2.2-<2.2	1700+(tri)	210+ (tri)
copper	1/17	29	29	<10-<11	18+	12+
lead	8/17	2.6-6.2	3.8	<1.5-<1.5	83+	3.2+
mercury	0/17	N/A	N/A	<0.08-<0.08	2.4	0.012
nickel	0/17	N/A	N/A	<22-<22	1,400+	160+
selenium	1/17	3.9	3.9	<2.6-<2.6	20	5.0
silver	0/17	N/A	N/A	<2.5-<2.5	4.1+	0.12
thallium	0/17	N/A	N/A	<3.5-<3.5	1,460*	40*
zinc	16/17	24-220	75	<4.6	120+	110+

Table 4A. McChord AFB Area D/American Lake Garden Tract. Surface Water Sampling Results.

Parameter	Frequency[1/] of Detection	Range of Concentration (ug/l)	Mean of Concentration (ug/l)	Range of DLs[2/] (ug/l)	Ambient Water Quality Criteria (ug/l)	
					Acute	Chronic
Pesticides (ug/kg)						
aldrin	0/14	N/A	N/A	<0.002-<0.03	3.0	-
chlordane	0/14	N/A	N/A	<0.025-<0.35	2.4	0.0043
4,4'-DDT	0/14	N/A	N/A	<0.004-<0.06	1.1	0.001
4,4'-DDD	0/14	N/A	N/A	<0.004-<0.06	-	-
4,4'-DDE	0/14	N/A	N/A	<0.004-<0.06	1,050*	-
dieldrin	4/14	0.006-0.007	0.006	<0.004-<0.06	2.5	0.0019
endosulfan I	0/14	N/A	N/A	<0.004-<0.06	0.22	0.056
endosulfan II	0/14	N/A	N/A	<0.004-<0.06	0.22	0.056
endosulfan sulfate	0/14	N/A	N/A	<0.01-<0.14	-	-
endrin	0/14	N/A	N/A	<0.004-<0.06	0.18	0.0023
endrin ketone	1/14	0.004	0.004	<0.004-<0.06	-	-
alpha-BHC	0/14	N/A	N/A	<0.002-<0.03	-	-
beta-BHC	0/14	N/A	N/A	<0.002-<0.03	-	-
delta-BHC	0/14	N/A	N/A	<0.002-<0.03	-	-
gamma-BHC (lindane)	0/14	N/A	N/A	<0.002-<0.03	2.0	0.08
heptachlor	0/14	N/A	N/A	<0.002-<0.03	0.52	0.0038
heptachlor epoxide	0/14	N/A	N/A	<0.002-<0.03	0.52	0.0038
methoxychlor	0/14	N/A	N/A	<0.05-<0.070	-	0.03
toxaphene	0/14	N/A	N/A	<0.05-<0.070	0.73	0.0002

Table 4A. McChord AFB Area D/American Lake Garden Tract. Surface Water Sampling Results.

Parameter	Frequency[1/] of Detection	Range of Concentration (ug/l)	Mean of Concentration (ug/l)	Range of DLs[2/] (ug/l)	Ambient Water Quality Criteria (ug/l)	
					Acute	Chronic
PCBs (kg/l)					2.0	0.014
arcolor-1016	0/14	N/A	N/A	<0.05-<0.70	-	-
aroclor-1221	0/14	N/A	N/A	<0.05-<0.70	-	-
aroclor-1232	0/14	N/A	N/A	<0.05-<0.70	-	-
aroclor-1242	0/14	N/A	N/A	<0.05-<0.70	-	-
aroclor-1248	0/14	N/A	N/A	<0.05-<0.70	-	-
aroclor-1254	0/14	N/A	N/A	<0.1-<1.4	-	-
aroclor-1260	0/14	N/A	N/A	<0.1-<1.4	-	-

1/ Frequency of Detection = number of detections/number of samples analyzed

2/ Range of DLs = range of detection limits

3/ Criteria is not isomer specific. Value given for unspecified dichloroethylenes.

* Insufficient data to develop criteria. Value presented is LOEL (Lowest Observed Effect Level)

\+ Hardness Dependent Criteria (100 ug/l $CaCO_3$ used)

Table 4B. McChord AFB Area D/American Lake Garden Tract. Sediment Sampling Results.

Parameter	Frequency[1/] of Detection	Range of Concentration	Mean of Concentration	Range of DLs[2/]
Volatiles (ug/kg)				
Trichloroethylene (TCE)	12/12	0.77-40	12	N/A
cis-1,2-dichloroethylene	1/12	2.3	2.3	<0.1-<2.27
trans-1,2-dichloroethylene	0/12	N/A	N/A	<0.1-<2.27
Dissolved Metals (ug/kg)				
antimony	0/17	N/A	N/A	<1.2-<4.8
arsenic	14/17	2.7-8.5	5.3	<2.5-<4.1
beryllium	0/17	N/A	N/A	<0.7-<2.3
cadmium	1/17	3.1	3.1	<1.0-<4.0
chromium (total)	17/17	7.7-48	25	N/A
copper	4/17	16-170	66	<4.5-<16
lead	15/17	2.5-318	77	<1.2-<1.9
mercury	0/17	N/A	N/A	<0.1-<0.7
nickel	2/17	55-86	70	<7.8-<31
selenium	5/17	2.6-4.4	3.3	<0.9-<3.7
silver	0/17	N/A	N/A	<0.9-<3.5
thallium	0/17	N/A	N/A	<1.2-<5.0
zinc	8/17	9-124	60	<3.4-<6.5
Pesticides (ug/kg)				
aldrin	0/17	N/A	N/A	<3.1-<14
chlordane	1/17	650	650	<31-<140
4,4'-DDT	3/17	49-150	100	<6.1-<24
4,4'-DDD	1/17	380	380	<6.1-<24
4,4'-DDE	1/17	61	61	<6.1-<24
dieldrin	1/17	15	15	<61-<28
endosulfan I	0/17	N/A	N/A	<4.1-<14
endosulfan II	0/17	N/A	N/A	<6.1-<28
endosulfan sulfate	0/17	N/A	N/A	<6.1-<28
endrin	0/17	N/A	N/A	<6.1-<28
endrin ketone	0/17	N/A	N/A	<6.1-<28
alpha-BHC	0/17	N/A	N/A	<3.1-<14
beta-BHC	0/17	N/A	N/A	<3.1-<14
delta-BHC	0/17	N/A	N/A	<3.1-<14
gamma-BHC (lindane)	0/17	N/A	N/A	<3.1-<14
heptachlor	0/17	N/A	N/A	<3.1-<14
heptachlor epoxide	0/17	N/A	N/A	<3.1-<14

Table 4B. McChord AFB Area D/American Lake Garden Tract. Sediment Sampling Results.

Parameter	Frequency[1/] of Detection	Range of Concentration	Mean of Concentration	Range of DLs[2/]
methoxychlor	0/17	N/A	N/A	<31-<140
toxaphene	0/17	N/A	N/A	<61-<280
PCBs (ug/kg)				
arcolor-1016	0/17	N/A	N/A	<34-<140
aroclor-1221	0/17	N/A	N/A	<34-<140
aroclor-1232	0/17	N/A	N/A	<34-<140
aroclor-1242	0/17	N/A	N/A	<34-<140
aroclor-1248	0/17	N/A	N/A	<34-<140
aroclor-1254	0/17	N/A	N/A	<61-<280
aroclor-1260	0/17	N/A	N/A	<61-<280

1/ Frequency of Detection = number of detections/number of samples analyzed

2/ Range of DLs = range of detection limits

N/A Denotes not applicable

3. Soil

Soil contamination was investigated in suspected source areas through a successive process of soil gas surveys followed by borings and soil sampling and analyses. Soil gas samples were taken at 350 locations in Sites 4, 5&39, 6, and 7, and several subareas of Site 26. Survey results were used on a qualitative basis to locate 29 soil boring locations in the areas exhibiting the highest levels of soil gas. The source-area soil borings were drilled to depths between 7.5 and 37.5 feet in the seven waste disposal sites. The soil samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and inorganics. In addition, the soil boring taken at Site 35 was analyzed for radioactive parameters. Table 5 summarizes the RI soil sampling data.

a. Organic and Inorganic Compounds

The primary contaminants, TCE and DCE, were found at concentrations up to 881 ug/kg (micrograms per kilogram) and 81 ug/kg respectively, in samples of waste materials obtained from Site 5&39 and Site 7. Several other VOCs were also detected, including PCE, 1,1,2,2-Tetrachloroethane, benzene, ethylbenzene, toluene, and xylenes (the BETX compounds characteristic of fuel products), 1,1-DCE, and 1,4-Dichlorobenzene. Seven pesticides (beta and delta BHCs, DDD, DDE, and DDT, dieldrin, and chlordane) and six inorganics (arsenic, barium, cadmium, lead, mercury, and vanadium) were also detected. The levels of contamination were evaluated in the baseline risk assessment for both protection of human health (e.g., direct contact under the residential scenario) and the environment (e.g., groundwater protection).

Twenty-seven area background soil samples were collected within the boundaries of McChord AFB in areas with: (1) similar geomorphology; and (2) no known or suspected waste disposal activities. Inorganic results for background soils are found in Table 6. All samples were analyzed for the 23 Target Compound List metals. Based on a statistical comparison, the inorganic concentrations found within Area D were found to be consistent with the area background inorganic concentrations.

Six groundwater monitoring wells installed upgradient of Area D were sampled for inorganic contaminants. The contaminant concentrations, with the exception of Thallium, were determined to be consistent with the area background concentrations. Thallium was noted in a split sample at a concentration above the detection limit. The quality assurance samples analyzed along with this sample indicate that the detection was

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Inorganics				
Aluminum	8/8	8,090-23,500	13,761	N/A
Antimony	0/8	N/A	N/A	<12-<17
Arsenic	8/8	2.9-8.6	4.8	N/A
Barium	7/8	4.4-128	66.3	<55
Beryllium	0/8	N/A	N/A	<1-<1.4
Cadmium	2/8	1.2-4.7	3.0	<1-<1.4
Calcium	8/8	1,990-3,590	3,049	N/A
Chromium	8/8	15-21	18.1	N/A
Cobalt	0/8	N/A	N/A	<10-<14
Copper	7/8	14-31	22	<16
Iron	8/8	8,270-19,700	15,971	N/A
Lead	8/8	3.4-86	17.4	N/A
Magnesium	8/8	2,230-5,520	4,096	N/A
Manganese	7/8	199-584	299	<3.4
Mercury	4/8	0.15-1.9	1.2	<0.1-<0.11
Nickel	8/8	16-32	27.8	N/A
Potassium	0/8	N/A	N/A	<1,040-<1,380
Selenium	0/8	N/A	N/A	<1-<1.4
Silver	0/8	N/A	N/A	<2.1-<2.8
Sodium	0/8	N/A	N/A	<1,040-<1,380
Thallium	0/8	N/A	N/A	<2.1-<2.8
Vanadium	8/8	23-41	34	N/A
Zinc	8/8	27-64	40.5	N/A
Cyanide	0/8	N/A	N/A	<1-<1.4
Volatiles				
Chloromethane	0/55	N/A	N/A	<0.083-2,889
Bromomethane	0/55	N/A	N/A	<0.1-2,889
Vinyl Chloride	0/55	N/A	N/A	<0.19-2,889
Chloroethane	0/55	N/A	N/A	<0.54-2,889
Methylene Chloride	50/54	1.3-490	37.8	<6-<1,445

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Volatiles (Continued)				
Acetone	17/21	16-1,100	489	<11-<2,889
Carbon Disulfide	0/55	N/A	N/A	<6-<1,445
1,1-Dichloroethylene (DCE)	11/55	0.11-11	2.7	<0.1-<1,445
1,1-Dichloroethane (DCA)	2/55	0.49-0.78	0.64	<0.073-<1,445
cis-1,2-Dichloroethylene (DCE)	34/105	0.06-81	9.18	<0.01-<149
trans-1,2-Dichloroethylene (DCE)	1/55	0.66	0.66	<0.1-<1,445
Chloroform	3/55	0.047-0.24	0.135	<0.052-<1,445
1,2-Dichloroethane (DCA)	5/55	0.041-4.4	1.1	<0.031-1,445
2-Butanone	4/18	110-210	148	<11-<2,889
1,1,1-Trichloroethane (TCA)	27/55	0.05-2	0.36	<0.1-<1,445
Carbon Tetrachloride	0/55	N/A	N/A	<0.12-1,445
Vinyl Acetate	0/55	N/A	N/A	<0.1-<2,889
Bromodichloromethane	1/55	0.1	0.1	<0.10-<1,445
1,2-Dichloropropane	4/55	0.07-2.2	0.74	<0.042-<1,445
Trichloroethylene (TCE)	94/105	0.09-881	34.1	<0.12-<1,445
Dibromochloromethane	2/55	0.11-0.16	0.135	<0.094-<1,445
1,1,2-Trichloroethane	0/55	N/A	N/A	<0.021-<1,445
Benzene	10/55	0.15-22	4.68	<0.20-<1,445
trans-1,3-Dichloropropene	0/55	N/A	N/A	<0.37-<1,445
Bromoform	0/55	N/A	N/A	<0.1-<1,445
4-Methyl-2-Pentanone	5/21	6.6-1,900	847	<0.1-<2,889
2-Hexanone	4/21	18-1,400	508	<0.1-<2,889
Tetrachloroethylene (PCE)	25/55	0.026-130	12.6	<0.031-<1,445
Toluene	19/50	0.24-11,000	1,062	<0.21-<1,445
1,1,2,2-Tetrachloroethane	5/55	3.0-240	92.2	<0.03-<1,445
Chlorobenzene	9/55	0.1-660	4.8	<0.21-<1,445
Ethyl benzene	15/53	0.2-3,500	394.8	<0.21-<1,445
Styrene	2/35	4-9.3	6.6	<0.1-<1,445
Xylenes Total	11/23	0.2-17,000	2,452	<5-<6
2-Chloroethyl Vinyl ether	1/55	0.16	0.16	<0.14-<1,445
Trichlorofluoromethane	2/20	6-9	7.5	<0.1-<1,445
1,2-Pentanone	0/3	N/A	N/A	<0.1
Isopropylbenzene	3/5	0.3-4.1	2.8	<0.1

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Volatiles (Continued)				
1,2,3-Trichloropropane	0/3	N/A	N/A	<0.1
n-Propylbenzene	3/5	1-7.7	4.4	<0.1
1,3,5-Trimethylbenzene	4/5	6.5-209	87.6	<0.1
1,2,4-Trimethylbenzene	5/5	0.7-355	107.5	<0.1
sec-Butylbenzene	3/5	0.6-4.4	2.1	<0.1
p-Isopropyltoluene	4/5	1.3-647	187.1	<0.1
n-Butylbenzene	0/5	N/A	N/A	<0.1
Bromochloromethane	0/2	N/A	N/A	<0.1
tert-Butylbenzene	1/5	1.2	1.2	<0.1
Semivolatiles				
Phenol	0/8	N/A	N/A	<364-<1,800
bis(2-Chloroethyl)Ether	0/8	N/A	N/A	<364-<1,800
2-Chlorophenol	0/8	N/A	N/A	<364-<1,800
1,3-Dichlorobenzene	2/63	0.1-0.61	0.36	<0.1-<1,800
1,4-Dichlorobenzene	17/63	0.1-969	101.5	<0.1-<1,800
Benzyl Alcohol	0/8	N/A	N/A	<364-<1,800
1,2-Dichlorobenzene	10/63	0.1-24	5.98	<0.42-<1,800
2-Methylphenol	0/8	N/A	N/A	<364-<1,800
bis(2-Chloroisopropyl)Ether	0/8	N/A	N/A	<364-<1,800
4-Methylphenol	1/8	250	250	<364-<1,800
N-Nitroso-Di-n-propylamine	0/8	N/A	N/A	<364-<1,800
Hexachloroethane	0/8	N/A	N/A	<364-<1,800
Nitrobenzene	0/8	N/A	N/A	<364-<1,800
Isophorone	0/8	N/A	N/A	<364-<1,800
2-Nitrophenol	0/8	N/A	N/A	<364-<1,800
2,4-Dimethylphenol	0/8	N/A	N/A	<364-<1,800
Benzoic Acid	1/8	480	480	<1,822-<9,200
bis(2-Chloroethoxy)Methane	0/8	N/A	N/A	<364-<1,800
2,4-Dichlorophenol	0/8	N/A	N/A	<364-<1,800
1,2,4-Trichlorobenzene	0/8	N/A	N/A	<364-<1,800
Naphthalene	6/13	6.1-155	89	<364-<1,800

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Semivolatiles (Continued)				
4-Chloroaniline	0/8	N/A	N/A	<364-<1,800
Hexachlorobutadiene	0/8	N/A	N/A	<364-<1,800
4-Chloro-3-Methylphenol	0/8	N/A	N/A	<364-<1,800
2-Methylnaphthalene	1/8	825	825	<364-<1,800
Hexachlorocyclopentadiene	0/8	N/A	N/A	<364-<1,800
2,4,6-Trichlorophenol	0/8	N/A	N/A	<364-<1,800
2,4,5-Trichlorophenol	0/8	N/A	N/A	<1,822-<9,200
2-Chloronaphthalene	0/8	N/A	N/A	<364-<1,800
2-Nitroaniline	0/8	N/A	N/A	<1,822-<9,200
Dimethyl Phthalate	0/8	N/A	N/A	<364-<1,800
Acenaphthylene	0/8	N/A	N/A	<364-<1,800
2,6-Dinitrotoluene	0/8	N/A	N/A	<1,822-<9,200
3-Nitroaniline	0/8	N/A	N/A	<364-<957
Acenaphthene	1/8	91	91	<1,822-<9,200
2,4-Dinitrophenol	0/8	N/A	N/A	<1,822-<9,200
4-Nitrophenol	0/8	N/A	N/A	<364-<1,800
Dibenzofuran	0/8	N/A	N/A	<364-<1,800
2,4-Dinitrotoluene	0/8	N/A	N/A	<364-<1,800
Diethylphthalate	0/8	N/A	N/A	<364-<1,800
4-Chlorophenyl-phenyl Ether	0/8	N/A	N/A	<364-<1,800
Fluorene	1/8	125	125	<364-<957
4-Nitroaniline	0/8	N/A	N/A	<1,822-<9,200
4,6-Dinitro-2-Methylphenol	0/8	N/A	N/A	<1,822-<9,200
n-Nitrosodiphenylamine	0/8	N/A	N/A	<364-<1,800
4-Bromophenyl-phenylether	0/8	N/A	N/A	<364-<1,800
Hexachlorobenzene	0/8	N/A	N/A	<364-<1,800
Pentachlorophenol	0/8	N/A	N/A	<1,822-<9,200
Phenanthrene	1/8	305	305	<364-<957
Anthrene	0/8	N/A	N/A	<364-<1,800
Di-n-Butylphthalate	1/8	805	805	<364-<957
Fluoranthene	0/8	N/A	N/A	<364-<1,800
Pyrene	0/8	N/A	N/A	<364-<1,800
Butylbenzylphthalate	0/8	N/A	N/A	<364-<1,800

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Semivolatiles (Continued)				
3,3'-Dichlorobenzidine	0/8	N/A	N/A	<729-<3,700
Benzo(a)Anthracene	0/8	N/A	N/A	<364-<1,800
Chrysene	0/8	N/A	N/A	<364-<1,800
bis(2-Ethylhexyl)Phthalate	3/8	88-340	246	<364-<1,800
Di-n-Octyl Phthalate	1/8	200	200	<364-<957
Benzo(b)Fluoranthene	0/8	N/A	N/A	<364-<1,800
Benzo(k)Fluoranthene	0/8	N/A	N/A	<364-<1,800
Benzo(a)Pyrene	0/8	N/A	N/A	<364-<1,800
Indeno(1,2,3-cd)Pyrene	0/8	N/A	N/A	<364-<1,800
Dibenz(a,h)Anthracene	0/8	N/A	N/A	<364-<1,800
Benzo(g,h,i)Perylene	0/8	N/A	N/A	<364-<1,800
n-Nitroso-di-methylamine	0/8	N/A	N/A	<364-<1,800
Aniline	0/8	N/A	N/A	<364-<1,800
1,2-Diphenyl Hydrazine	0/8	N/A	N/A	<364-<1,800
Benzidene	0/8	N/A	N/A	<364-<1,800
Pesticides/PCBs				
alpha-BHC	0/8	N/A	N/A	<8.3-<11
beta-BHC	3/8	9.2-19	13	<8.3-<11
delta-BHC	1/8	13	13	<8.3-<11
gamma-BHC(Lindane)	0/8	N/A	N/A	<8.3-<11
Heptachlor	0/8	N/A	N/A	<8.3-<11
Aldrin	0/8	N/A	N/A	<8.3-<11
Heptachlor Epoxide	0/8	N/A	N/A	<8.3-<11
Endosulfan I	0/8	N/A	N/A	<8.3-<11
Dieldrin	1/8	49	49	<17-<22
4,4'-DDE	1/8	79	79	<17-<22
Endrin	0/8	N/A	N/A	<17-<22
Endosulfan II	0/8	N/A	N/A	<17-<22
4,4'-DDD	2/8	32-42	37	<17-<22
Endosulfan Sulfate	0/8	N/A	N/A	<17-<22
4,4'-DDT	1/8	37	37	<17-<22

Table 5. McChord AFB Area D/American Lake Garden Tract Soil Sampling Results.

Parameter	Frequency of Detection[1/]	Range of Concentration (µg/kg)	Mean of Concentration (µg/kg)	Range of DLs[2/] (µg/kg)
Pesticides/PCBs (Continued)				
Methoxychlor	0/8	N/A	N/A	<83-<110
Endrin Ketone	0/8	N/A	N/A	<17-<22
Chlordane	1/8	1/60	1/60	<83-<110
Toxaphene	0/8	N/A	N/A	<170-<220
Aroclor-1016	0/8	N/A	N/A	<83-<110
Aroclor-1221	0/8	N/A	N/A	<83-<110
Aroclor-1232	0/8	N/A	N/A	<83-<110
Aroclor-1242	0/8	N/A	N/A	<83-<110
Aroclor-1248	0/8	N/A	N/A	<83-<110
Aroclor-1254	0/8	N/A	N/A	<170-<220
Aroclor-1260	0/8	N/A	N/A	<170-<220

1/ Frequency of Detection = number of detections/number of samples analyzed.

2/ Range of DLs = range of detection limits.

TABLE 6
INORGANIC RESULTS FOR BACKGROUND SOILS
(mg/kg)

Location	Date Sampled	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
BKG 1	11/29/90	26900	<2.0	3.3	83	<0.4	<1.3	1800	31	6.3	14	17600	5.3	4160	464	<0.13	27	365	<0.69	<0.66	307	<0.93	36	40
BKG 2	11/29/90	33700	<1.9	3.5	48	<0.4	<1.2	1500	20	8.1	16	18000	7.1	4520	255	<0.12	34	420	<0.64	<0.62	299	<0.86	40	27
BKG 3	11/29/90	21200	<1.8	5.2	58	<0.4	<1.2	2060	18	6.7	18	17300	8.4	3870	353	<0.11	22	452	<0.62	<0.6	326	<0.83	38	43
dup(=BKG 26)	11/29/90	23900	<1.9	4.3	37	<0.4	1.8	1400	24	8.3	17	19800	8	4880	341	<0.12	28	285	<0.65	<0.63	498	<0.9	47	42
BKG 4	11/29/90	23200	<2.3	16	188	<0.5	<1.5	5840	16	9.3	68	16000	45	3180	1040	<0.14	19	364	<0.78	<0.75	310	<1.0	29	52
BKG 5	11/29/90	28200	<2.2	6.6	79	<0.5	<1.4	2140	22	4.9	20	28100	14	3790	600	<0.14	19	414	<0.74	<0.71	466	<1.0	37	47
BKG 6	11/29/90	32800	<2.3	4.6	117	<0.5	<1.5	1630	15	9.3	17	19300	5.4	3470	833	<0.14	19	373	<0.78	<0.75	460	<1.0	35	43
BKG 7	11/29/90	26400	<2.1	5.6	83	0.5	<1.4	1630	20	5.4	18	16500	9.9	3630	608	<0.13	25	457	<0.7	<0.68	268	<1.0	33	36
BKG 8	11/29/90	21300	<1.9	8.3	80	<0.4	<1.3	2430	25	7.6	19	19200	14	4340	473	<0.12	21	367	<0.66	<0.63	519	<0.9	39	54
BKG 9	11/29/90	23100	<1.8	8	79	0.5	<1.2	2100	17	8	16	18200	12	4140	475	<0.11	28	480	<0.61	<0.59	419	<0.8	39	41
BKG 10	11/29/90	32000	2.2	6.4	103	<0.4	<1.4	3030	21	7.2	16	16700	14	3310	635	<0.13	19	314	<0.72	<0.69	350	<1.0	31	39
BKG 11	11/30/90	18600	<1.7	2.9	68	<0.4	<1.1	2930	19	5.7	17	17700	3.1	3630	258	<0.11	14	899	<0.6	<0.57	326	<0.8	36	29
dup(=BKG 27)	11/30/90	18900	<1.7	2.6	60	<0.4	1.3	3500	22	5.8	14	19100	6	3550	286	<0.11	18	842	<0.58	<0.56	580	<0.8	46	32
BKG 12	11/30/90	19100	<2.0	7.1	93	<0.4	<1.3	2800	19	5.7	7	14600	11	2330	400	0.13	14	485	<0.67	<0.65	606	<0.9	29	28
BKG 13	11/30/90	26100	<1.9	3.4	100	0.5	<1.2	2820	18	7.7	15	25300	4.1	3830	470	<0.12	20	521	<0.63	<0.62	472	<0.9	39	37
BKG 14	11/30/90	23800	<1.9	5.8	113	<0.4	<1.3	2590	18	5.9	11	16600	6.5	2960	388	0.12	17	546	<0.67	<0.64	344	<0.9	35	31
BKG 15	11/30/90	21700	<1.9	5.5	124	<0.4	<1.3	2650	18	6	8.5	16400	5.6	2540	409	<0.12	16	350	<0.65	<0.63	390	<0.9	33	28
BKG 16	11/30/90	22600	<2.0	6	187	0.5	<1.3	3540	16	6.8	14	18300	8.2	3570	643	<0.12	21	457	<0.68	<0.65	475	<0.9	43	39
BKG 17	11/30/90	26300	<2.0	3.6	102	<0.4	<1.3	2240	20	8.9	15	19000	4.7	3730	595	<0.13	48	382	<0.68	<0.66	334	<0.9	38	38
BKG 18	11/30/90	20400	<2.2	4.9	71	<0.5	<1.4	3630	18	6.6	14	18000	7.4	4380	521	<0.14	13	840	<0.74	<0.71	456	<1.0	29	56
BKG 19	11/30/90	21500	<2.1	4.1	175	<0.4	<1.4	3300	27	7.7	13	19900	7.3	3720	603	<0.13	20	482	<0.71	<0.68	373	<1.0	36	45
dup(=BKG 28)	11/30/90	25000	<2.0	3.5	139	0.5	1.6	3170	25	8.5	13	19100	5.5	4000	647	<0.13	20	763	<0.69	<0.67	493	<0.9	50	43
BKG 20	11/30/90	28700	<2.2	5.2	78	<0.5	<1.4	1280	19	7.5	15	21900	4.6	3600	571	<0.14	16	357	<0.75	<0.72	394	<1.0	34	37
BKG 21	11/30/90	13100	<1.7	2.3	36	<0.4	1.1	2490	12	6.1	16	16700	2.3	3600	225	<0.11	23	439	<0.59	<0.57	459	<0.8	35	28
BKG 22	11/30/90	34800	<2.1	4.4	136	0.6	2.8	1980	15	8.5	18	21000	5.1	4190	705	<0.13	23	800	<0.73	<0.7	608	<1.0	50	41
BKG 23	11/30/90	27700	<2.0	3.9	82	0.5	2.1	2030	15	5.1	17	21200	4	4140	621	<0.13	21	403	<0.69	<0.67	552	<0.9	42	43
BKG 24	11/30/90	17900	<1.7	4.9	76	<0.4	1.1	2100	24	8.5	22	16000	214	4160	311	<0.11	23	544	<0.58	<0.56	452	<0.8	36	43
BKG 25	11/30/90	19500	<2.3	18	244	<0.5	2.4	8130	19	6.1	29	20000	53	3350	535	0.38	21	470	<0.79	<0.76	630	<1.1	42	58
Number of detections:		28	1	28	28	7	8	28	28	28	28	28	28	28	28	3	28	28	0	0	28	0	28	28
Mean of detections:		24229	2.2	5.7	101.5	0.5	1.8	2741	19.8	7.1	17.8	18839	17.7	3735	509.5	0.2	21.8	495	BDL	BDL	431	BDL	37.8	40.0
Minimum:		13100	BDL	2.3	36.0	BDL	BDL	1280	12.0	4.9	7.0	14600	2.3	2330	225.0	BDL	13.0	285	NA	NA	268	NA	29.0	27.0
Maximum:		34800	2.2	18.0	244.0	0.6	2.8	8130	31.0	9.3	68.0	28100	214	4880	1040.0	0.4	48.0	899	NA	NA	630	NA	50.0	58.0
Mean (includes 1/2 D.L.)		24229	1.04	5.0	101.5	0.28	1.01	2741	19.8	7.08	17.8	18839	8.6	3735	509.5	0.07	21.8	495	0.3	0.3	431	0.46	37.8	40.0
Standard deviation		5191	0.25	1.6	48.9	0.13	0.60	1405	4.14	1.31	10.65	2842	2.5	562	185	1.49	6.94	172	0.03	0.03	99	0.04	5.76	8.50
95% confidence limit		15690	0.63	2.3	20.95	0.07	0.02	430	12.9	4.92	0.251	14165	1.9	2810	205.49	0.04	10.3	213	0.28	0.28	269	0.39	28.3	26

Notes: BDL = Below Detection Limit; NA = Not applicable;
Dup = Duplicate of the preceding sample.
95% confidence limit based on use of half the detection limit for non-detections and normal distribution of concentrations.

inaccurate. This determination is further supported by the ubiquitous presence of the contaminants throughout the Area D/ALGT groundwater.

A modeling approach was used to evaluate the likely contaminant fate and transport from the unsaturated to the saturated zone. For example, using the maximum concentrations of TCE found in soil borings, along with a soil organic carbon of 30 percent and the partitioning coefficient (K_{oc}) for TCE of 112 liters per kilogram, a conservative leachate concentration of 4 ug/l was calculated. This concentration, which does not exceed the MCL of 5 ug/l for TCE, assumes conservatively that: (1) the infiltrating water is in contact with the unsaturated zone long enough to obtain equilibrium; (2) this leachate seeps directly into the groundwater; and (3) is not diluted once it reaches the groundwater.

Based on modelling results, and soil and groundwater analytical data, it appears that most VOC soil contamination has moved to the groundwater. Residual VOC soil contamination has likely volatilized out of the soil (where it would have been rapidly photooxidized) and contaminants are not continuing to leach out of the soils. This assumption is supported by the fate and transport analysis and the fact that the highest plume concentrations are found at a depth of 40 to 50 feet within the aquifer. The organics may have percolated through the unsaturated and saturated zones as a separate phase material (DNAPLs) to eventually locate on top of the relatively impermeable zones (e.g., till units) within the aquifer. The DNAPLs may continue to act as "secondary sources" of groundwater contamination, slowly releasing contamination into the groundwater through dissolution.

b. Ordnance

Historically, McChord AFB ordnance has been transferred to Fort Lewis for disposal. However, limited ordnance disposal occurred sporadically at Site 26 between the mid-1940s to the mid-1960s.

Most of the material disposed of at Site 26 was detonated with a surplus charge sufficient to completely oxidize the following ordnance explosives and propellants and their casings: nitrocellulose (gunpowder), 2,4,6-trinitrotoluene (TNT), and hexahydro-1,3,5-trinitro-5-trialine (RDX). The ordnance disposal method (i.e., open detonation) used generally ensured complete destruction of the explosive materials. Ordnance was stacked in a containing hole and covered with high explosive. Detonation from the top using an

excess charge would convert the explosive compounds in the resulting fireball into primary oxides of hydrogen, nitrogen, and carbon.

A geophysical survey was conducted for residual debris remaining from ordnance disposal. Ordnance material found included .30 and .50 caliber blank ammunition, nose fuses for 2.75 high explosive MK-1 warheads, spent .50 caliber bullets, one 30 mm cannon casing, several grams of explosive material loose in the soil, and other metal debris such as small cans and drums. The small quantity of material recovered appears to confirm the assumption of complete destruction, and the impact of any residues is presumed to be insignificant.

c. Radionuclides

Soil and groundwater samples collected in vicinity of Site 35 were analyzed for residual contamination resulting from well disposal of low-level radioactive wastewater. Samples were analyzed for the following radioactive parameters: gross alpha, gross beta, and gamma ray scan. Results of the soil and groundwater analyses are presented in Table 7.

Each of the radioactive isotopes identified is a naturally occurring link in the degradation chains: Potassium 40, Thorium (Th) 228 and 232, and Radium (Ra) 226. The reported levels of Ra 226, which along with Krypton (Kr) 85 and Strontium (St) 90, were reported as possibly disposed at Site 35, could not be compared to any readily available background level. However, the levels are below the EPA cleanup standard of 5 picocuries per gram for inactive uranium processing sites (40 CFR 192.12).

VI. SUMMARY OF SITE RISKS

The baseline risk assessment considered both human health and ecological risks. The risk evaluations were prepared in accordance with EPA's Risk Assessment Guidance for Superfund (RAGS) and EPA Region 10 Exposure Parameters (dated January 31, 1990). The results of the human health risk assessment are discussed below.

A. Human Health Risks

Adverse effects resulting from exposure to chemical contaminants are identified as either carcinogenic (i.e., causing the development of cancer in one or more tissues or organ systems) or noncarcinogenic (i.e., direct toxic effects on organ systems, reproductive and

Table 7. Results of Radiological Analyses

Sample	Depth (ft)	Gross Alpha	Gross Beta	Radionuclide (gamma scan): Cs 137	Ra 226	K 40	Th 228	Th 232
WATER (pCi/l)								
DB-11-1		0 +/- 1	0 +/- 2	<14				
DB-11-2		0 +/- 1	0 +/- 3	<9				
SOIL (pCi/g)								
DB-11-1-1	2.5-4	5 +/- 3	16 +/- 3	<0.1	0.29 +/- 0.06	5.2 +/- 0.6	0.38 +/- 0.03	0.32 +/- 0.02
DB-11-1-2	(dup)	3 +/- 2	12 +/- 4	<0.1	0.4 +/- 0.1	8.2 +/- 0.1	0.6 +/- 0.1	0.3 +/- 0.2
DB-11-2	7.5-8.5	0 +/- 5	11 +/- 4	<0.1	0.44 +/- 0.06	8.2 +/- 0.7	0.42 +/- 0.04	0.4 +/- 0.2
DB-11-3	12.5-14.5	0 +/- 4	15 +/- 5	<0.1	0.5 +/- 0.1	9.4 +/- 1	0.57 +/- 0.06	0.55 +/- 0.02
DB-11-4	17.5-18	7 +/- 2	12 +/- 5	<0.1	0.5 +/- 0.1	11 +/- 1	0.64 +/- 0.07	0.5 +/- 0.2
DB-11-5	27.5-29.5	0 +/- 3	10 +/- 2	<0.1	0.32 +/- 0.06	7.4 +/- 0.7	0.41 +/- 0.04	0.4 +/- 0.1
	Mean:	2.5 +/- 6.0	12.7 +/- 4.7	<0.1	0.41 +/- 0.18	8.2 +/- 3.9	0.50 +/- 0.23	0.41 +/- 0.20
RINSATE BLANK (pCi/l)								
RB-11-1		9 +/- 4	0 +/- 4	<53				

Note: Range shown is plus or minus (+/-) two standard deviations.

developmental effects). In the baseline risk assessment, risks have been estimated for both current use and future residential land use at Area D and the ALGT. The human receptors considered were off-site and on-site residents, on-site workers, and on-site visitors. Exposure conditions for these receptors were assumed to correspond to a wide range of activities including residential, recreational, and industrial work associated with Area D and the ALGT.

1. Chemicals of Concern

Data collected during the RI were used to identify chemicals present at the site. Media sampled included groundwater, soils, surface water, and sediments. All chemicals were included in the assessment unless a) they were not detected in any of the above media; b) toxicity reference values (i.e., Reference dose [RfDs] or cancer slope factors) have not been developed for a chemical; or c) the chemical was identified as an essential nutrient. The exception to the above criteria was chemicals that were detected in at least one medium for at least one site allowing for the possibility of migration between media. These chemicals were included in the risk assessment at a concentration equal to half of their respective detection limits (RAGS guidance, 1990).

Out of 129 contaminants for which analysis was conducted in Area D exposure media, 77 chemicals were measured above their respective detection limits. Of these 77 chemicals, 18 were determined in the risk assessment to be contaminants of concern (COCs) for the receptors listed above (See Tables 8 and 9). In this case, COCs are defined as those with potential exposures presenting a carcinogenic risk of greater than 1 x 10-6 (one chance of excess cancer in a population of one million) or a noncarcinogenic hazard index greater than a value of one. Table 8 lists chemicals included in the baseline risk assessment based on the RI data and above screening data.

Four of the COCs are known human carcinogens (benzene, vinyl chloride, arsenic, and chromium), eight are probable human carcinogens (dieldrin, methylene chloride, trichloroethylene, styrene, 1,2-dichloroethane, 4,4-DDT, chlordane, and bis(2-ethylhexyl)phthalate) and three are possible human carcinogens (1,1-dichloroethylene, 1,1-dichloroethane, and beta-BHC).

Table 8. Chemicals included in the Baseline Risk Assessment.

	Soil	Groundwater	Surface Water	Sediment	Air
Inorganics					
Aluminum	X	X	N/A	N/A	N/A
Arsenic	X	X	N/A	N/A	N/A
Barium	X	---	N/A	N/A	N/A
Cadmium	X	X	N/A	N/A	N/A
Calcium	X	X	N/A	N/A	N/A
Chromium	X	X	N/A	N/A	N/A
Cobalt	---[1/]	---	N/A	N/A	N/A
Copper	X	---	N/A	N/A	N/A
Iron	X	X	N/A	N/A	N/A
Lead	X	X	N/A	N/A	N/A
Magnesium	X	X	N/A	N/A	N/A
Manganese	X	X	N/A	N/A	N/A
Mercury	X	---	N/A	N/A	N/A
Nickel	X	---	N/A	N/A	N/A
Potassium	---	---	N/A	N/A	N/A
Sodium	---	X	N/A	N/A	N/A
Thallium[2/]	---	---	N/A	N/A	N/A
Vanadium	X	---	N/A	N/A	N/A
Zinc	X	X	N/A	N/A	N/A
Organics					
Tetrachloroethylene (PCE)	X	X	N/A	N/A	X
1,1,2,2-Tetrachloroethane	X	---	N/A	N/A	X
Trichloroethylene (TCE)	X	X	X	X	X
1,1,1-Trichloroethane (TCA)	X	X	N/A	N/A	X
1,1,2-Trichloroethane (TCA)	---	X	N/A	N/A	X
1,1-Dichloroethane (DCA)	X	X	N/A	N/A	X
1,2-Dichloroethane (DCA)	X	X	N/A	N/A	X

Table 8. Chemicals included in the Baseline Risk Assessment.

	Soil	Groundwater	Surface Water	Sediment	Air
1,1-Dichloroethylene (DCE)	X	X	N/A	N/A	X
cis-1,2-Dichloroethylene (cDCE)	X	X	X	X	X
trans-1,2-DCE (tDCE)	X	X	N/A	N/A	X
Vinyl chloride (chloroethylene)	—	X	N/A	N/A	X
Chloromethane (methyl chloride)	—	X	N/A	N/A	X
Methylene Chloride (dichloromethane)	X	X	N/A	N/A	X
Chloroform (trichloromethane)	X	X	N/A	N/A	X
Dibromochloromethane	X	—	N/A	N/A	X
Bromochloromethane	X	—	N/A	N/A	X
Trichlorofluoromethane	X	—	N/A	N/A	X
1,2-Dichloropropane	X	—	N/A	N/A	X
1,2,3-Trichloropropane	X	—	N/A	N/A	X
Benezene	X	X	N/A	N/A	X
Ethylbenzene	X	X	N/A	N/A	X
Toluene	X	X	N/A	N/A	X
Xylenes (total)	X	X	N/A	N/A	X
Chlorobenzene	X	X	N/A	N/A	X
1,2-Dichlorobenzene	X	X	N/A	N/A	X
1,3-Dichlorobenzene	X	X	N/A	N/A	X
1,4-Dichlorobenezene	X	X	N/A	N/A	X
1,3,5-Trimethylbenzene	X	—	N/A	N/A	X
1,2,4-Trimethylbenzene	X	—	N/A	N/A	X
Styrene	X	—	N/A	N/A	X
Isopropylbenzene	X	—	N/A	N/A	X
n-propylbenzene	X	—	N/A	N/A	X
sec-Butylbenzene	X	—	N/A	N/A	X
tert-Butylbenzene	X	—	N/A	N/A	X
n-Butylbenzene	X	—	N/A	N/A	X
p-isopropyltoluene	X	X	N/A	N/A	—

Table 8. Chemicals included in the Baseline Risk Assessment.

	Soil	Groundwater	Surface Water	Sediment	Air
Carbon disulfinde	---	X	N/A	N/A	X
Acetone	X	X	N/A	N/A	X
2-Butanone (Methylethylketone, MEK)	X	---	N/A	N/A	X
4-Methyl-2-penthanone (MIBK)	X	---	N/A	N/A	X
2-Hexanone (butylmethylketone)	X	---	N/A	N/A	X
Naphthalene	X	---	N/A	N/A	X
2-Methylnaphthalene	X	---	N/A	N/A	X
Acenaphthene	X	---	N/A	N/A	X
Fluorene	X	---	N/A	N/A	X
Phenanthrene	X	---	N/A	N/A	X
2-chloroethyl-vinyl-ether	X	---	N/A	N/A	X
Di-n-butylphthalate	X	---	N/A	N/A	X
bis (2-ethylhexyl) phthalate	X	---	N/A	N/A	X
Di-n-Octylphthalate	X	---	N/A	N/A	X
4-Methylphenol	X	---	N/A	N/A	X
Benzoic Acid	X	---	N/A	N/A	X
Beta BHC	X	---	N/A	N/A	X
Delta BHC	X	---	N/A	N/A	X
Chlorodane	X	---	N/A	N/A	X
Dieldrin	X	---	N/A	N/A	X
4,4' DDT	X	---	N/A	N/A	X
4,4' DDD	X	---	N/A	N/A	X
4,4' DDE	X	---	N/A	N/A	X

1/ This chemical was analyzed for, but was not found above detection levels for this medium.
2/ Thallium was not detected in groundwater wells used for computing exposure point concentrations; however, it was detected in a single sample (out of 28) from another well.
N/A Denotes not applicable.
--- Denotes that chemical was analyzed for but not found above detection limit.
X Denotes the chemicals included in the Baseline Risk Assessment.

Table 9. Pathways Evaluated for the Reasonable Maximum Exposure Scenario.

Medium/Exposure Pathway	Population										
	Resident			Worker[1/]		Worker[2/]		Visitor[3/]		Visitor[4/]	
	Current (off-site)	Future (off-site)	Future (on-site)	Current (on-site)	Future (on-site)	Current (on-site)	Future (on-site)	Current (on-site)	Future (on-site)	Current (on-site)	Future (on-site)
AIR											
Volatile Inhalation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
SOIL											
Particulate Inhalation	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No
Ingestion	No	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No
GROUNDWATER											
Volatile Inhalation	Yes	Yes	Yes	No	No	No	No	No	No	No	No
Ingestion	Yes	Yes	Yes	No	Yes	No	No	No	No	No	No
SURFACE WATER											
Volatile Inhalation	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No
Ingestion	Yes	Yes	Yes	No	No	No	No	No	No	No	No
SEDIMENT											
Ingestion	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No

1/ Chronic long-term exposures were evaluated for this population.
2/ Subchronic exposures were evaluated for this population.
3/ Visitor represents golfers (adults).
4/ Visitor represents soccer playing children.

2. Exposure Assessment

a. Exposed Populations: For this assessment, exposure pathways were evaluated for five receptors: residents, long-term workers, short-term workers, adult recreational visitors, and child recreational visitors. The exposure pathways evaluated for each population are presented in Table 9.

Potentially exposed populations include ALGT residents who continue to utilize their drinking water wells or chose to install new wells. Although most of these residents have been transferred to the Lakewood Water District water supply system, their wells have generally not been abandoned. If the contamination were to migrate laterally or to deeper aquifers, additional residents of ALGT or McChord AFB would be similarly exposed if water supply wells screened in the shallow or deeper aquifers became contaminated.

b. Exposure Point Concentrations: Exposure point concentrations, including averages and maxima, were derived for each medium of exposure (soils, groundwater, surface water, and sediments) for as many contaminants as were detected in each (See Tables 10 through 12). Generally, a reasonable maximum exposure concentration (RME, based on a 95 percent upper confidence limit on the arithmetic mean contaminant concentration) could not be accurately computed because with the limited number of data the RME was often found to be greater than the maximum value. In these cases, the RME concentration was set equal to the highest (or in some cases, the only) measured value.

The analytical results for soil were averaged for all the samples in a boring. The highest average concentration, for all the borings in the source area, was then selected as the exposure point concentration for that source area. As there were a limited number of samples analyzed in each area, the RME and average values could not be accurately calculated. For these compounds, only the single analytical result was used.

For groundwater, individual wells were chosen to be representative for each source area, generally on the basis of proximity to the site and having the highest concentrations among the wells in the vicinity. For volatile organic compounds, the concentrations for each sampling round were used to derive a maximum as well as an average value. For other contaminants (semivolatiles, metals, and pesticides), where only one sampling round was analyzed for these analytes, the maximum concentration detected was used.

Table 10. Soil Exposure Concentrations Used in the McChord Area D Risk Assessment.

	Site 4[1/]	Site 5 and 39[2/]	Site 6[3/]	Site 7[4/]
	RME	RME	RME	RME
Inorganics (ug/kg):				
Aluminum	2.35E+07	1.41E+07	8.09E+06	1.51E+07
Arsenic	8.60E+03	3.40E+03	5.80E+03	6.00E+03
Barium	1.28E+05	5.30E+04	<5.50E+04	7.30E+04
Cadium	<1.40E+03	4.70E+03	<1.40E+03	1.20E+03
Calcium	1.99E+06	3.42E+06	3.59E+06	3.22E+06
Chromium	1.60E+04	2.00E+04	1.80E+04	2.10E+04
Cobalt	<1.40E+04	<1.10E+04	<1.40E+03	<1.10E+04
Copper	2.30E+04	3.10E+04	1.40E+04	3.00E+04
Iron	1.50E+07	1.95E+07	8.27E+06	1.97E+07
Lead	2.40E+04	5.90E+03	8.60E+04	7.90E+03
Magnesium	3.40E+06	5.52E+06	2.23E+06	4.66E+06
Manganese	5.84E+05	3.03E+05	2.02E+05	2.77E+05
Mercury	1.90E+03	<1.10E+02	1.20E+03	1.60E+03
Nickel	2.80E+02	3.00E+04	1.60E+04	3.20E+04
Potassium	<1.36E +06	<1.07E+06	<1.38E+06	<1.12E+06
Sodium	<1.36E+06	<1.07E+06	<1.38E+06	<1.12E+06
Thallium	<2.70E+03	<2.10E+03	<2.80E+03	<2.20E+03
Vanadium	3.90E+04	3.50E+04	2.30E+04	4.10E+04
Zinc	5.40E+04	3.70E+04	6.40E+04	4.10E+04
Organics (ug/kg):				
Halogenated Aliphatics:				
Tetrachloroethylene (PCE)	0.14	0.08	0.05	48
1,1,2,2-Tetrachloroethane	0.14	114	<0.031	4.7

Table 10. Soil Exposure Concentrations Used in the McChord Area D Risk Assessment.

	Site 4[1/]	Site 5 and 39[2/]	Site 6[3/]	Site 7[4/]
	RME	RME	RME	RME
Trichloroethylene (TCE)	0.31	138	0.91	311
1,1,1-Trichloroethane (TCA)	0.55	0.24	2	0.44
1,1,2-Trichloroethane (TCA)	<0.03	<0.02	<0.021	<0.03
1,1-Dichloroethane (DCA)	<0.10	<0.07	<0.073	0.3
1,2-Dichloroethane (DCA)	<0.04	<0.03	0.04	2.5
1,1-Dichloroethylene (DCE)	<0.18	0.9	11	5.2
cis-1,2, Dichloroethylene (cDCE)	<0.13	34	<0.12	27
trans-1,2,-DCE (tDCE)	<0.14	10	<0.10	1.1
Vinyl chloride (chloroethylene)	<0.25	<0.19	<0.19	<0.24
Chloromethane (methyl chloride)	<0.11	<0.09	<0.083	<0.11
Methylene Chloride (dichloromethane)	18	148	320	53
Chloroform (trichloromethane)	<0.07	<0.05	<0.052	0.09
Dibromochloromethane	<0.12	<0.10	<0.094	0.11
Bromodichloromethane	<0.14	<0.11	<0.10	0.09
Trichlorofluoromethane	<6	6	<31	9
1,2-Dichloropropane	<0.06	<0.04	<0.042	0.63
1,2,3-Trichloropropane	NA	<0.1	NA	3.6
Hexachlorobutadiene	398	<0.1	<957	<0.1
Aromatic Compounds:				
Benzene	0.97	2.4	1.9	13
Ethylbenzene	<0.28	100	0.34	1,268
Toluene	4.6	9	1.2	4,190
Xylenes (total)	<6	210	<6	6,230

Table 10. Soil Exposure Concentrations Used in the McChord Area D Risk Assessment.

	Site 4[1]	Site 5 and 39[2]	Site 6[3]	Site 7[4]
	RME	RME	RME	RME
Chlorobenzene	<0.28	298	<0.21	1.2
1,2-Dichlorobenzene	<0.56	0.1	<0.42	10
1,3-Dichlorobenzene	<0.56	0.1	<0.42	0.5
1,4-Dichlorobenzene	<0.42	0.25	<0.31	600
1,2,3-Trichlorobenzene	N/A	<0.1	N/A	<0.1
1,2,4-Trichlorobenzene	<398	<0.1	<957	<0.1
1,3,5-Trimethylbenzene	N/A	6.5	N/A	131
1,2,4-Trimethylbenzene	N/A	13.4	N/A	213
Styrene	<6	<0.1	<6	7
Isopropylbenzene	N/A	0.3	N/A	4.7
n-propylbenzene	N/A	1	N/A	7.7
sec-Butylbenzene	N/A	0.6	N/A	4.4
tert-Butylbenzene	N/A	1.2	N/A	<0.1
n-Butylbenzene	N/A	<0.1	N/A	485
p-isopropyltoluene	N/A	1.3	N/A	366
Others:				
Carbon disulfide	<6	<5	<31	<5
Acetone	630	605	755	800
2-Butanone (Methylethylketone, MEK)	130	<11	N/A	165
4-Methyl-2-penthanone (MIBK)	<11	1,750	<12	365
2-Hexanone (butylmthylketone)	<11	985	<12	30
Naphthalene	<398	67	<957	135
2-Methylnapthalene	<398	825	<957	<364
Acenaphthene	<398	91	<957	<364

Table 10. Soil Exposure Concentrations Used in the McChord Area D Risk Assessment.

	Site 4[1/]	Site 5 and 39[2/]	Site 6[3/]	Site 7[4/]
	RME	RME	RME	RME
Fluorene	<398	125	<957	<364
Phenanthrene	<398	305	<957	<364
2-chloroethyl-vinyl-ether	<0.18	<0.14	<0.14	0.13
Di-n-butylphthalate	<398	805	<957	<364
bis-(2-ethylhexyl)phthalate	<398	430	220	88
Di-n-Octylphthalate	<398	200	<957	<364
4-Methylphenol	250	<370	<957	<364
Benzoic Acid	480	<1,848	<4,783	<1,822
Beta BHC	<11	19	12	9.2
Delta BHC	<11	<8.3	16	<8.3
Chlorodane	<110	<83	460	<83
Dieldrin	<22	49	<22	<17
4,4' DDT	<22	37	<22	<17
4,4' DDD	<22	42	32	<17
4,4' DDE	<22	79	<22	<17

1/ Concentrations at Site 4 were derived using the results from Boring DB-24.
2/ Concentrations at Site 5 and 39 were derived using the results from Borings DB-5, DB-19, DB-27, DB-28, and DB-29.
3/ Concentrations at Site 6 were derived using the results from Borings DB-3, DB-17, and DB-18.
4/ Concentrations at Site 7 were derived using the results from Borings DB-2, DB-12, DB-15, DB-16, DB-25, and DB-26.
N/A Denotes not applicable

Table 11. Groundwater Exposure Concentrations used in the McChord Area D Risk Assessment.

	Site 4	Site 5 and 39	Site 6	Site 7	Offsite (W-1c)
	RME	RME	RME	RME	RME
Aluminum	<200	362	264	4,270	200
Arsenic	<10	<10	<10	14	<10
Barium	<200	<200	<200	<200	<200
Cadmium	<5	<5	6	<5	<5
Calcium	25,000	19,000	12,900	21,400	13,600
Chromium	<10	<10	<10	33	<10
Cobalt	<50	<50	<50	<50	<50
Copper	<25	<25	<25	<25	<25
Iron	161	334	195	30,000	227
Lead	<5	7.7	78	14	<5
Magnesium	9,451	7,930	<5,000	7,420	6,035
Manganese	38	43	22	1,450	<15
Mercury	<0.2	<0.2	<0.2	<0.2	<0.4
Nickel	<40	<40	<40	<40	<40
Potassium	<5,000	<5,000	<5,000	<5,000	<5,000
Sodium	5,860	6,530	7,080	6,430	<5,000
Thallium	<10	<10	<10	<10	<10
Vanadium	<50	<50	<50	<50	<50
Zinc	<20	24	<20	45	<20

Table 11. Groundwater Exposure Concentrations used in the McChord Area D Risk Assessment.

	Site 4		Site 5 and 39		Site 6		Site 7		Offsite (W-1c)	
Organics:	AVG	RME	AVG	RME	AVG	RME	AVG	RME	AVG	RME
Tetrachloroethylene (PCE)	0.315	0.52	<0.03	<0.03	<0.03	<0.03	<0.055	0.06	0.03	<0.03
1,1,2,2-Tetrachloroethane	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Trichloroethylene (TCE)	0.063	0.07	72.2	82	0.066	0.08	2.261	5.5	7.2	10.5
1,1,1-Trichloroethane (TCA)	0.24	0.39	6.866	18	0.087	0.16	0.02	0.025	0.07	0.07
1,1,2-Trichloroethane (TCA)	<0.02	<0.02	0.055	0.105	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
1,1-Dichloroethane (DCA)	<0.07	<0.07	3.429	5.3	<0.07	<0.07	0.445	0.45	0.16	0.16
1,2-Dichloroethane (DCA)	<0.03	<0.03	0.201	0.54	<0.03	<0.03	0.026	0.038	0.074	0.074
1,1-Dichloroethylene (DCA)	<0.13	<0.13	0.225	0.56	<0.13	<0.13	<0.13	<0.13	0.13	0.13
cis-1,2-Dichloroethylene (cDCE)	<0.01	<0.01	208.1	320	<0.1	<0.1	3.058	8	11.6	12.8
trans-1,2,-DEC (tDCE)	<0.1	<0.1	0.131	0.19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vinyl chloride (chloroethylene)	<0.18	<0.18	<0.18	<0.18	<0.18	<0.18	0.455	0.82	<0.18	<0.18
Chloromethane (methyl chloride)	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.655	1.05	<0.08	<0.08
Methylene Chloride (dichloromethane)	1.3	2.5	2.526	7	<0.2	<0.2	3.668	7	0.26	0.26
Chloroform (trichloromethane)	<0.05	<0.05	0.043	0.054	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dibromochloromethane	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Bromodichloromethane	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Trichlorofluoromethane	<5	<5	<0.1	<0.1	<5	<5	<5	<5	<5	<5
1,2-Dichloropropane	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
1,2,3-Trichloropropane	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
Hexachlorobutadiene	<10	<10	<0.1	<0.1	<10	<10	<10	<10	<10	<10

Table 11. Groundwater Exposure Concentrations used in the McChord Area D Risk Assessment.

	Site 4		Site 5 and 39		Site 6		Site 7		Offsite (W-1c)	
Aromatic Compounds:	AVG	RME	AVG	RME	AVG	RME	AVG	RME	AVG	RME
Benzene	0.09	0.09	<0.2	<.02	<0.2	<0.2	0.725	1.35	<0.2	<0.2
Ethylbenzene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	33.16	98.5	<0.2	<0.2
Toluene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	222.7	665	0.25	0.25
Xylenes (total)	<5	<5	<0.2	<0.2	<5	<5	202.1	400	<5	<5
Chlorobenzene	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.225	0.35	<0.2	<0.2
1,2-Dichlorobenzene	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.487	0.775	<0.4	<0.4
1,3-Dichlorobenzene	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.395	0.59	<0.4	<0.4
1,4-Dichlorobenzene	0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.89	0.92	<0.3	<0.3
1,2,3-Trichlorobenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
1,2,4-Trichlorobenzene	<10	<10	<0.1	<0.1	<10	<10	<10	<10	<10	<10
1,3,5-Trimethylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
1,2,4-Trimethylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
Styrene	<5	<5	<0.1	<0.1	<5	<5	<5	<5	<5	<5
Isopropylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
n-propylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
sec-Butylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
tert-Butylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
n-Butylbenzene	N/A	N/A	<0.1	<0.1	N/A	N/A	N/A	N/A	N/A	N/A
p-isopropyltoluene	N/A	N/A	<0.1	<X.1	N/A	N/A	N/A	N/A	N/A	N/A

Table 11. Groundwater Exposure Concentrations used in the McChord Area D Risk Assessment.

	Site 4		Site 5 and 39		Site 6		Site 7		Offsite (W-1c)	
Others:	AVG	RME	AVG	RME	AVG	RME	AVG	RME	AVG	RME
Carbon disulfide	<5	<5	11.33	11.33	<5	<5	<5	<5	<5	<5
Acetone	<10	<10	<10	<10	<10	<10	<57.5	<110	<10	<10
2-Butanone (Methylethylketone, MEK)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Methyl-2-penthanone (MIBK)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Hexanone (butylmethylketone)	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-Methylnapthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acenapthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Flourene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
2-chloroethyl-vinyl-ether	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	<0.13	0.13	<0.13	<0.13
Di-n-butylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
bis (2-ethylhexyl) phthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Di-n-Octylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
4-Methylphenol	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzoic acid	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50

Table 11. Groundwater Exposure Concentrations used in the McChord Area D Risk Assessment.

	Site 4		Site 5 and 39		Site 6		Site 7		Offsite (W-1c)	
Pesticides:										
Beta BHC	<0.01	<0.01	<0.05	<0.05	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05
Delta BHC	<0.01	<0.01	<0.05	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05
Chlorodane	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	<0.5	<0.5	<0.5	<0.5
Dieldrin	<0.02	<0.02	<0.1	<0.1	<0.02	<0.02	<0.1	<0.1	<0.1	<0.1
4,4' DDT	<0.02	<0.02	<0.1	<0.1	<0.02	<0.02	<0.1	<0.1	<0.1	<0.1
4,4' DDD	<0.02	<0.02	<0.1	<0.1	<0.02	<0.02	<0.1	<0.1	<0.1	<0.1
4,4' DDE	<0.02	<0.02	<0.1	<0.1	<0.02	<0.02	<0.1	<0.1	<0.1	<0.1

Table 12. Surface Water and Sediment Exposure Concentrations used in the McChord Area D Risk Assessment.

	Emerson Lake				Whitman Lake			
	Surface Water (µg/liter)		Sediment (µg/kg)		Surface Water (µg/liter)		Sediment (µg/kg)	
Organics (ug/liter):	AVG	RME	AVG	RME	AVG	RME	AVG	RME
Trichloroethylene (TCE)	0.35	0.83	4.325	5.1	0.071	0.105	21.2	40
1,2-cis-Dichloroethylene (cDCE)	0.363	0.955	1.427	2.3	---	---	---	---

For current off-site residential exposures to groundwater, Well W-1c was used to represent the maximum concentrations which occur beyond the base boundary. Since the only analyses for samples from EPA Well W-1c were for volatiles, concentrations of other contaminants were taken from the results in Well DZ-07, which was considered the closest and most representative well analyzed for these contaminants.

For future off-site residential exposures, the highest concentrations found on-site were assumed (under worst case conditions) to be advected off-site. The analytical results in Well DA-07a were also used for this exposure scenario.

Two surface water bodies were chosen as worst case exposure points: Emerson Lake for off-site residents and Whitman Lake for on-site. The only data available for surface water and sediments was for TCE and the 1,2-DCE isomer. Both average and maximum exposure concentrations were developed based on different sampling rounds.

Contaminants in soil, groundwater, or sediments and surface water may enter the atmosphere by either volatilization or through disturbances which suspend particulate matter. Air modeling was performed using the techniques outlined in the Superfund Exposure Assessment Manual to estimate vapor and particulate inhalation exposure concentrations. These concentrations are summarized in the Human Health Risk Assessment, November 1990.

c. Chemical Intake by Exposure Pathway: Chemical intakes (mg/kg-day) were estimated for each exposure pathway using the exposure point concentrations and other exposure parameters, such as soil and water ingestion rates, body weights, and exposure frequencies and durations. Pathway-specific equations from the RAGS guidance were used to estimate chemical intakes.

3. Toxicity Assessment

For carcinogenic chemicals, slope factors are estimated using a conservative mathematical model which estimates the relationship between experimental exposures (i.e., doses) and the development of cancer (i.e., response) that is derived from human or animal studies. Since there is much uncertainty in the dose-response values generated using this procedure, the upper 95 percent confidence limit of the slope of the dose-response curve is normally used in deriving the slope factor.

For non-carcinogenic chemicals, reference doses (RfDs) are used as benchmarks for toxic endpoints of concern. The goal in developing an RfD is to identify the highest no-observed-adverse-effect-level (NOAEL) or the lowest-observed-adverse-effect-level (LOAEL) from well designed human or animal studies. One or more order-of magnitude uncertainty factors are incorporated to adjust this level based on the following considerations: (1) the duration of the experimental exposure, (2) effects elicited (if any), (3) extrapolation of the data to other species (i.e., interspecies variability, such as extrapolation to humans), and (4) sensitive subgroups (i.e., intraspecies variability). Additional modifying factors varying between a value of 1 and 10 may also be incorporated in the derivation of the RfD if additional considerations are necessary.

RfDs and slope factors for the Area D risk assessment were taken from EPA's computerized Integrated Risk Information System (IRIS); Health Effects Assessment Summary Tables (HEAST); Drinking Water Health Advisories; or personal communication with EPA Region 10 Risk Assessment staff.

4. Risk Characterization

a. Cancer Risk: Carcinogenic risk is estimated as the incremental probability of an individual developing cancer above the normal background population incidence over a lifetime as a result of exposure to a chemical either known or suspected to cause cancer. To estimate cancer risk, slope factors are combined with site exposure information to estimate the incremental cancer risk, which represents a probability of contracting cancer, and which is usually expressed in scientific notation (e.g., 1 x 10-4 or 1-04). An excess lifetime cancer risk of 1 x 10-4 indicates that, as a plausible upperbound, an individual has a one in ten thousand chance of developing cancer in a lifetime as a result of site-related exposure to a carcinogen.

For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upperbound lifetime cancer risk to an individual of between 1 x 10-4 and 1 x 10-6 using information on the relationship between dose and response (NCP 1990).

b. Non-cancer Risk: For non-carcinogens, the measure used to describe the potential for toxicity in an individual is not expressed as a probability. The potential for non-carcinogenic effects is evaluated by comparing an exposure level over a specified period (e.g., lifetime) with a reference dose derived for a similar exposure period. This

ratio of exposure to toxicity is called a Hazard Quotient. The Hazard Index (HI) is the sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. Potential non-carcinogenic effects may be of concern if the HI exceeds unity (i.e., HI > 1).

c. Human Health Risk Characterization Summary

A quantitative summary of the maximum risks for cancer risks and hazard indices identified for contaminants of concern over all receptors, sites and land use scenarios is presented in Tables 13A and 13B, respectively. Critical receptors and associated sites are also presented.

Table 14 summarize the maximum estimated risk for both carcinogenic and noncarcinogenic effects. The cumulative risk includes groundwater ingestion and volatile inhalation, and assumes exposure to the highest level of contamination for each contaminant found within the shallow unconfined aquifer. This cumulative risk recognizes that the contamination is likely to migrate within the plume and assumes that, for a future use scenario, a single drinking water production well could draw contamination from a large portion of the contaminant plume. The highest risks in the risk assessment tended to be associated with the future on-site residential scenario. Although this land use scenario is not considered likely given that the existing use of Area D will probably not change, remediation of the groundwater is required under the NCP to restore beneficial uses of the drinking water aquifer. Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

5. Uncertainty

Major components of the assessment which decreased the certainty of the results were (1) the toxicity reference values used, and the lack of values for several chemicals; (2) limitations in contaminant concentration data for soils, groundwater, and surface water; (3) the inclusion of concentrations at a level of one-half the detection limit for many chemicals; and (4) the use of a number of assumptions to establish exposure parameters in computing chemical intakes.

Table 13A. Maximum Estimated Cancer Risk for Contaminants of Concern under the Reasonable Exposure Scenario.[1/]

Chemical	Site	Target Population	Maximum Estimated Cancer Risk
Arsenic	7	Resident, Onsite, Future	8.0E-04[2/]
Benzene	7	Resident, Onsite, Future	6.2E-06
Beta BHC	7	Resident, Onsite, Future	1.5E-06
Bis (2-ethyhexyl)phthalate	4, 5/39, 6, 7	Resident, Onsite, Future	2.2E-06
	Offsite	Resident, Offsite, Future, Current	2.2E-06
Chlordane	5/39, 7	Resident, Onsite, Future	1.0E-05
	Offsite	Resident, Offsite, Future, Current	1.0E-05
Chromium	7	Resident, Onsite, Future	7.0E-06
1,1-Dichloroethane	Offsite	Resident, Offsite, Future	1.5E-05
	5/39	Resident, Onsite, Future	1.5E-05
1,2-Dichloroethane	Offsite	Resident, Offsite, Future	7.8E-06
	5/39	Resident, Onsite, Future	7.8E-06
1,1-Dichloroethylene	Offsite	Resident, Offsite, Future	2.4E-05
	5/39	Resident, Onsite, Future	2.4E-05
4,4'-DDT	5/39, 7	Resident, Onsite, Future	2.7E-06
	Offsite	Resident, Offsite, Future, Current	2.7E-06
Dieldrin	5/39	Resident, Onsite, Future	2.7E-05
Methylene Chloride	5/39, 7	Resident, Onsite, Future	1.4E-05
	Offsite	Resident, Offsite, Future	1.4E-05
Styrene	4, 6, 7	Resident, Onsite, Future	3.0E-06
	Offsite	Resident, Offsite, Current	3.0E-06
Trichloroethylene	5/39	Resident, Onsite, Future	9.1E-05
	Offsite	Resident, Offsite, Future	9.1E-05
Vinyl Chloride	7	Resident, Offsite, Future	7.5E-05

Table 13B. Maximum Estimated Hazard Indices for Contaminants of Concern under the Reasonable Exposure Scenario. 1/

Chemical	Site	Target Population	Maximum Estimated Hazard Index
Arsenic	7	Resident, Onsite, Future	4.5E-01
Bis(2-ethyhexyl)phthalate	4, 5/39, 6, 7	Resident, Onsite, Future	7.9E-03
Chlordane	5/39, 7 Offsite	Resident, Onsite, Future Resident, Offsite, Future, Current	1.3E-01 1.3E-01
Chromium	7	Resident, Onsite, Future	2.1E-01
4,4'-DDT	5/39, 7	Resident, Onsite, Future	3.2E-03
1,1-Dichloroethane	5/39 Offsite	Resident, Onsite, Future Resident, Offsite, Future	8.3E-03 8.3E-03
Cis-1,2-Dichloroethylene	5/39 Offsite	Resident, Onsite, Future Resident, Offsite, Future	1.0E+00 1.0E+00
1,1-Dichloroethylene	5/39 Offsite	Resident, Onsite, Future Resident, Offsite, Future	2.0E-03 2.0E-03
Dieldrin	5/39	Resident, Onsite, Future	3.3E-02
Manganese	4	Short Term Worker, Onsite, Future, Current	1.6E+00
Methylene Chloride	5/39, 7 Offsite	Resident, Onsite, Future Resident, Offsite, Future	4.7E-03 4.7E-03
Styrene	4,6,7 Offsite	Resident, Onsite, Future Resident, Offsite, Current	3.9E-04 3.9E-04
Thallium	4, 5/39, 6, 7	Resident, Onsite, Future	2.3E+00

1/ Critical Exposure Pathways/Receptors/Sites for Contaminants of Concern Evaluated for Area D

Contaminant of Concern	EPA Carcinogen Classification	Current Use		Future Use	
		Off Post	On Post	Off Post	On Post
ORGANICS:					
Benzene	A				ging,ginh/res/7
dieldrin	b2	ging/res		ging/res	ging/res/4,5&39,6,7, sing/res/5&39, ging/ltw/4,5&39,6,7
1,1-dichloroethylene	c	ging,ginh/res		ging,ginh/res	ging/ginh/res/4,5&39,6,7, ging/ltw/5&39
cis-1,2-diochloroethylene				ging/res	ging/res/5&39
methylene chloride	b2			ging,ginh/res	ginh/res/4, ginh,ging/res/5&39,7
trichloroethylene	b2	ging,ginh/res		ging,ginh/res	ginh,ging/res/5&39,7, ging/ltw/5&39
vinyl chloride	a	ging,ginh/res		ging,ginh/res	ging/res,ltw/4,5&39,6,7, ginh/res/4,5&39,6,7
Styrene	b2	ging/res			ging/res/4,6,7
1,1-Dichloroethane	b2			ging/res	ging/res,ltw/5&39, ging/res/7
1,2-Dichloroethane	b2			ging,ginh/res	ging,ginh/res/5&39
4,4-DDT	b2	ginh/res		ginh/res	ginh/res/5&39,7
BETA BHC	c	ging/res			ging/res/7
Chlordane	b2	ging/res		ging/res	ging/ltw/5&39,7, ging/res/4,5&39,6,7
Bis(2-ethylhexyl)phthalate	b2	ging/res		ging/res	ging/res/4,5&39,6,7
INORGANIC:	a	ging/res		ging/res	ging/sing/res,ltw/4,6,7, ging,sing/res/5&39, sing/ltw/5&39
Arsenic					
Chromium(VI)	a				spinh/res/4, spinh/res,ltw/5&39,6,7
Manganese			spinh/stw/4		spinh/stw/4
Thallium		ging/res		ging/res	ging/res,ltw/4,5&39,6,7

ging	groundwater ingestion	spinh	soil particulate inhalation
res	resident	ginh	Groundwater Vapor Inhalation
stw	short-term worker	sing	Soil Ingestion
4	site 4	ltw	Long-Term Worker

2/ 8.OE-04 means 8.0 x 10^{-4} or 8.0 chances of contracting cancer per 10,000.

Table 14. Risk from Exposure to RME Concentrations in Groundwater (Baseline). Off-Post Residents (Current).

	Noncancer		Cancer					Noncancer		Cancer	
Contaminant	Oral RfD (mg/kg-d)	Inh RfD (mg/kg-d)	Oral CPF 1/(mg/kg-d)	Inh. CPF 1/(mg/kg-d)	RME Concentration (mg/L)	Oral dose (mg/kg/d)	Inh. dose* (mg/kg/d)	Oral HI	Inhalation HI	Oral Risk	Inhalation Risk
Arsenic	1.00E-03	N/A	1.75E+00	1.50E+01	5.00E-03	1.57E-04	N/A	1.57E-01	N/A	3E-04	N/A
Barium	7.00E-02	1.00E-04	N/A	N/A	1.00E-01	3.14E-03	N/A	4.49E-02	N/A	N/A	N/A
Cadmium	5.00E-04	N/A	N/A	6.10E+00	2.50E-03	7.86E-05	N/A	1.57E-01	N/A	N/A	N/A
Chromium	5.00E-03	N/A	N/A	4.10E+01	5.00E-03	1.57E-04	N/A	3.14E-02	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	2.50E-03	7.86E-05	N/A	N/A	N/A	N/A	N/A
Manganese	2.00E-01	3.00E-04	N/A	N/A	7.50E-03	2.36E-04	N/A	1.18E-03	N/A	N/A	N/A
Thallium	7.00E-05	N/A	N/A	N/A	5.00E-03	1.57E-04	N/A	2.24E+00	N/A	N/A	N/A
Benzene	N/A	N/A	2.90E-02	2.90E-02	1.00E-4	3.14E-06	1.26E-05	N/A	N/A	9E-08	4E-07
Bromodichloromethane	2.00E-02	N/A	1.30 E-01	N/A	5.00E-05	1.57E-06	6.29E-06	7.86E-05	N/A	2E-07	N/A
Chloroform	1.00E-02	2.30E-03	6.10E-03	8.10E-02	2.50E-05	7.86E-07	3.14E-06	7.86E-05	1.37E-03	5E-09	3E-07
Chloromethane	N/A	N/A	1.30E-02	6.30E-03	4.00E-05	1.26E-06	5.03E-06	N/A	N/A	2E-08	3E-08
1,4-Dichlorobenzene	N/A	2.00E-01	2.40E-02	N/A	1.50E-04	4.71E-06	1.89E-05	N/A	9.43E-05	1E-07	N/A
1,2-Dichloroethane	N/A	N/A	9.10E-02	9.10E-02	7.40E-05	2.33E-06	9.30E-06	N/A	N/A	1E-07	8E-07
1,1-Dichloroethylene	9.00E-03	N/A	6.00E-01	1.80E-01	6.50E-05	2.04E-05	8.17E-06	2.27E-04	N/A	1E-06	1E-06
cis-1,2-Dichloroethylene	1.00E-02	N/A	N/A	N/A	1.28E-02	4.02E-04	1.61E-03	4.02E-02	N/A	N/A	N/A
Tetrachloroethylene	1.00E-02	N/A	5.10E-02	3.30E-03	1.50E-05	4.71E-07	1.89E-06	4.71E-05	N/A	2E-08	6E-09
1,1,2-Trichloroethane	4.00E-03	N/A	5.70E-02	5.70E-02	1.00E-05	3.14E-07	1.26E-06	7.86E-05	N/A	2E-08	7E-08

Table 14. Risk from Exposure to RME Concentrations in Groundwater (Baseline). Off-Post Residents (Current).

	Noncancer		Cancer					Noncancer		Cancer	
Contaminant	Oral RfD (mg/kg-d)	Inh RfD (mg/kg-d)	Oral CPF 1/(mg/kg-d)	Inh. CPF 1/(mg/kg-d)	RME Concentration (mg/L)	Oral dose (mg/kg/d)	Inh. dose* (mg/kg/d)	Oral HI	Inhalation HI	Oral Risk	Inhalation Risk
Trichloroethylene	N/A	N/A	1.10E-02	5.95E-03	1.05E-02	3.30E-04	1.32E-03	N/A	N/A	4E-06	8E-06
Vinyl Chloride	N/A	N/A	2.30E-00	1.48E-01	9.00E-05	2.83E-06	1.13E-05	N/A	N/A	7E-06	2E-06
Total Noncancer Hazard Index =				**2.68**		TOTAL:		2.68E-00	1.46E-03	3E-04	1E-05
Total Noncancer Hazard Index (w/o area background)=**				**0.04**		TOTAL (W/O AREA BACKGROUND **):		4.07E-02	1.46E-03	1E-05	1E-05
Total Cancer Risk =				**3E-04**							
Total Cancer Risk (w/o area background) =**				**2E-05**							

Lifetime Dose Factor Calculations Age (yrs.)	ED (days)	EF (d/d)	BW (kg)	IR (Ld)	Dose Factor (L/kg)
0-1	1095	1	12	1.00	91.25
2-5	1095	1	17	0.83	53.46
6-8	1095	1	25	0.93	40.73
9-12	1095	1	36	1.10	33.46
13-15	1095	1	51	1.10	23.62
16-18	1095	1	61	1.30	23.34
19-75	20805	1	70	2.00	594.43
		AT = 27375			860.2863821
		Lifetime cummulative dose factor (L/kg/d):			0.031425987

Equations:

Oral Lifetime Avg. Dose = Cw[(IR*EF*ED)/BW]/AT

Where: Cw = contaminants concentration in water (mg/L)

IR = Age-specific water intake rate (L/d)

EF = Exposure frequency (d/d)

ED = Exposure duration (Total: 75 years)

BW = Age-specific body weight (kg)

AT = Averaging time (27375 d)

* Inh. lifetime average dose = 4 oral dose.

** Metals detected were determined to be consistent with concentration of metals in the area of background samples.

Table 14. Risk from Exposure to RME Concentrations in Groundwater (Baseline). On-Post Residents (Future).

	Noncancer		Cancer					Noncancer		Cancer	
Contaminant	Oral RfD (mg/kg-d)	Inh. RfD (mg/kg-d)	Oral CPF 1/(mg/kg-d)	Inh. CPF 1/(mg/kg-d)	RME Concentration (mg/L)	Oral dose (mg/kg/d)	Inh. dose* (mg/kg/d)	Oral HI	Inhalation HI	Oral Risk	Inhalation Risk
Arsenic	1.00E-03	N/A	1.75E+00	1.50E+01	1.40E-02	4.40E-04	N/A	4.40E-01	N/A	8E-04	N/A
Barium	7.00E-02	1.00E-04	N/A	N/A	1.00E-01	3.14E-03	N/A	4.49E-02	N/A	N/A	N/A
Cadmium	5.00E-04	N/A	N/A	6.10E+00	6.00E-03	1.89E-04	N/A	3.77E-01	N/A	N/A	N/A
Chromium	5.00E-03	N/A	N/A	4.10E+01	3.30E-02	1.04E-03	N/A	2.07E-01	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	7.80E-02	2.45E-03	N/A	N/A	N/A	N/A	N/A
Manganese	2.00E-01	3.00E-04	N/A	N/A	1.45E+00	4.56E-02	N/A	2.28E-01	N/A	N/A	N/A
Thallium	7.00E-05	N/A	N/A	N/A	5.00E-03	1.57E-04	N/A	2.24E+00	N/A	N/A	N/A
Benzene	N/A	N/A	2.90E-02	2.90E-02	1.35E-03	4.24E-05	1.70E-04	N/A	N/A	1E-06	5E-06
Bromodichloromethane	2.00E-02	N/A	1.30 E-01	N/A	5.00E-05	1.57E-06	6.29E-06	7.86E-05	N/A	2E-07	N/A
Chloroform	1.00E-02	2.30E-03	6.10E-03	8.10E-02	5.40E-05	1.70E-06	6.79E-06	1.70E-04	2.95E-03	1E-08	5E-07
Chloromethane	N/A	N/A	1.30E-02	6.30E-03	1.05E-03	3.30E-05	1.32E-04	N/A	N/A	4E-07	8E-07
1,4-Dichlorobenzene	N/A	2.00E-01	2.40E-02	N/A	9.20E-04	2.89E-05	1.16E-04	N/A	5.78E-04	7E-07	N/A
1,2 Dichloroethane	N/A	N/A	9.10E-02	9.10E-02	5.40E-04	1.70E-05	6.79E-05	N/A	N/A	2E-06	6E-06
1,1-Dichloroethylene	9.00E-03	N/A	6.00E-01	1.80E-01	5.60E-04	1.76E-05	7.04E-05	1.96E-03	N/A	1E-05	1E-05
cis-1,2-Dichloroethylene	1.00E-02	N/A	N/A	N/A	3.20E-01	1.01E-02	4.02E-02	1.01E+00	N/A	N/A	N/A
Tetrachloroethylene	1.00E-02	N/A	5.10E-02	3.30E-03	5.20E-04	1.63E-05	6.54E-05	1.63E-03	N/A	8E-07	2E-07
1,1,2-Trichloroethane	4.00E-03	N/A	5.70E-02	5.70E-02	1.05E-04	3.30E-06	1.32E-05	8.25E-04	N/A	2E-07	8E-07

Table 14. Risk from Exposure to RME Concentrations in Groundwater (Baseline). On-Post Residents (Future).

	Noncancer		Cancer					Noncancer		Cancer	
Contaminant	Oral RfD (mg/kg-d)	Inh. RfD (mg/kg-d)	Oral CPF 1/(mg/kg-d)	Inh. CPF 1/(mg/kg-d)	RME Concentration (mg/L)	Oral dose (mg/kg/d)	Inh. dose* (mg/kg/d)	Oral HI	Inhalation HI	Oral Risk	Inhalation Risk
Trichloroethylene	N/A	N/A	1.10E-02	5.95E-03	8.20E-02	2.58E-03	1.03E-02	N/A	N/A	3E-05	6E-05
Vinyl Chloride	N/A	N/A	2.30E+00	1.48E-01	8.20E-04	2.58E-05	1.03E-04	N/A	N/A	6E-05	2E-05
Total Noncancer Hazard Index =				**4.56**		TOTAL:		4.55E+00	3.53E-03	9E-04	1E-04
Total Noncancer Hazard Index (w/o area background)=**				**1.01**		TOTAL (w/o area background **):		1.01E+00	3.53E+03	1E-04	1E-04
Total Cancer Risk =				**1E-03**							
Total Cancer Risk (w/o area background)=**				**2E-04**							

Lifetime Dose Factor Calculations:

Age (yrs.)	ED (days)	EF (d/d)	BW (kg)	IR (Ld)	Dose Factor (L/kg)
0-1	1095	1	12	1.00	91.25
2-5	1095	1	17	0.83	53.46
6-8	1095	1	25	0.93	40.73
9-12	1095	1	36	1.10	33.46
13-15	1095	1	51	1.10	23.62
16-18	1095	1	61	1.30	23.34
19-75	20805	1	70	2.00	594.43
					860.2863821
		AT = 27375			
		Lifetime cummulative dose factor (L/kg/d):			0.031425987

Equations:

Oral Lifetime Avg. Dose = CW[(IR*EF*ED)/BW]/AT

IR = Age-specific water intake rate (L/d)

EF = Exposure frequency (d/d)

ED = Exposure duration (Total: 75 years)

BW = Age-specific body weight (kg)

AT = Averaging time (27375 d)

* Inh. lifetime average dose = 4 oral dose

** Metals detected were determined to be consistent with concentrations of metals in the area background samples.

Table 14. Risk from Exposure to RME Concentrations in Groundwater (Baseline). On-Post Workers (current).

	Noncancer		Cancer			Noncancer		Cancer		Noncancer		Cancer	
Contaminant	Oral (mg/kg-d)	Inh. RID (mg/kg-d)	Oral CPF (mg/kg-d)	Inh. CPF (mg/kg-d)	RME Concentration (mg/L)	Oral Dose	Inhal. Dose* (mg/kg/)	Oral Dose	Inhal. Dose* (mg/kg/d)	Oral HI	Inhalation HI	Oral Risk	Inhalation Risk
Arsenic	1.00E-03	N/A	1.75E+00	1.50E+01	1.40E-02	2.40E-04	N/A	1.28E-04	N/A	2.40E-01	N/A	2E-04	N/A
Barium	7.00E-02	1.00E-04	N/A	N/A	1.00E-01	1.71E-03	N/A	9.14E-04	N/A	2.45E-02	N/A	N/A	N/A
Cadmium	5.00E-04	N/A	N/A	6.10E+01	6.00E-03	1.03E-04	N/A	5.49E-05	N/A	2.06E-01	N/A	N/A	N/A
Chromium	5.00E-03	N/A	N/A	4.10E+01	3.30E-02	5.66E-04	N/A	3.02E-04	N/A	1.13E-01	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	7.80E-02	1.34E-03	N/A	7.13E-04	N/A	N/A	N/A	N/A	N/A
Manganese	2.00E-01	3.00E-04	N/A	N/A	1.45E+00	2.49E-02	N/A	1.33E-02	N/A	1.24E-01	N/A	N/A	N/A
Thallium	7.00E-05	N/A	N/A	N/A	5.00E-03	8.57E-05	N/A	4.57E-05	N/A	1.22E+00	N/A	N/A	N/A
Benzene	N/A	N/A	2.90E-02	2.90E-02	1.35E-03	2.31E-05	9.26E-05	1.23E-05	4.94E-05	N/A	N/A	4E-07	1E-06
Bromodichloromethane	2.00E-02	N/A	1.30E-01	N/A	5.00E-05	8.57E-07	3.43E-06	4.57E-07	1.83E-06	4.29E-05	N/A	6E-08	N/A
Chloroform	1.00E-02	2.30E-03	6.10E-03	8.10E-02	5.40E-05	9.26E-07	3.70E-06	4.94E-07	1.97E-06	9.26E-05	1.61E-03	3E-09	2E-07
Chloromethane	N/A	N/A	1.30E-02	6.30E-03	1.05E-03	1.80E-05	7.20E-05	9.60E-06	3.84E-05	N/A	N/A	1E-07	2E-07
1,4-Dichlorobenzene	N/A	2.00E-01	2.40E-02	N/A	9.20E-04	1.58E-05	6.31E-05	8.41E-06	3.36E-05	N/A	3.15E-04	2E-07	N/A
1,2-Dichloroethane	N/A	N/A	9.10E-02	9.10E-02	5.40E-04	9.26E-06	3.70E-05	4.94E-06	1.97E-05	N/A	N/A	4E-07	2E-06
1,1-Dichloroethylene	9.00E-03	N/A	6.00E-01	1.80E-01	5.60E-04	9.60E-06	3.84E-05	5.12E-06	2.05E-05	1.07E-03	N/A	3E-06	4E-06
cis-1,2-Dichloroethylene	1.00E-02	N/A	N/A	N/A	3.20E-01	5.49E-03	2.19E-02	2.93E-03	1.17E-03	5.49E-01	N/A	N/A	N/A
Tetrachloroethylene	1.00E-02	N/A	5.10E-02	3.30E-03	5.20E-04	8.91E-06	3.57E-05	4.75E-06	1.90E-05	8.91E-04	N/A	2E-07	6E-08
1,1,2-Trichloroethane	4.00E-03	N/A	5.70E-02	5.70E-02	1.05E-04	1.80E-06	7.20E-06	9.60E-07	3.84E-06	4.50E-04	N/A	5E-08	2E-07
Trichloroethylene	N/A	N/A	1.10E-02	5.95E-03	8.20E-02	1.41E-03	5.62E-03	7.50E-04	3.00E-03	N/A	N/A	8E-06	2E-05
Vinyl chloride	N/A	N/A	2.30E+00	1.48E-01	8.20E-04	1.41E-05	5.62E-05	7.50E-06	3.00E-05	N/A	N/A	2E-05	4E-06

Total Noncancer Hazard Index=	**2.49**	TOTAL:	2.48E+00	1.93E-03	3E-04	3E-05
Total Noncancer Hazard Index (w/o area background)=**	**0.55**	TOTAL (w/o area background**):	5.51E-01	1.93E-03	3E-05	3E-05
Total Cancer Risk =	**3E-04**					
Total Cancer Risk (w/o area background) =**	**6E-05**					

Equations:
Oral Lifetime Avg. Dose = (CW*IR*EF*ED)/(BW*AT)
Where: Cw = Contaminant concentation in water mg/L
IR = Daily water intake rate (2.0 L/d)
EF = Exposure frequency (219 d/year)
ED = Exposure duration (40 years)
BW = Body weight (70 kg)
AT = Averaging time: (NC=14,600 days)
(C=27,375)

* Inh. lifetime avg. dose = 4* oral dose

** Metals detected were determined to be consistent with concentrations of metals in the area background samples.

Due to the uncertainty in these and other areas, conservative assumptions were made in order to ensure protection of human health. Cancer and non-cancer risk estimates must be carefully interpreted, particularly when evaluating non-carcinogenic effects where uncertainty factors of 2 to 3 orders of magnitude are used in dose-response assessments.

B. Environmental Risks

1. Chemicals of Concern

Seven wetlands and ponds in Area D are fed by groundwater and surface water. The Baseline Ecological Risk Assessment evaluated other chemicals which may be affecting the aquatic and terrestrial biota of this area. Based on the results of the groundwater and soil sampling effort, samples of pond surface water and sediments were analyzed for 23 organic chemicals and 13 metals using analytical techniques which provided the lowest possible detection limits. In these samples, six pesticides (4,4'-DDT; 4,4'-2,2-bis(para-chlorophenyl)-bi-dichloroethane [4,4'DDD]); 4,4'-dichlorodiphenylethane [4,4-DDE]); endrin ketone; dieldrin; and chlordane), three organic chemicals (TCE, cis-1,2-DCE, and trans-1,2-DCE), and three metals (copper, lead, and zinc) were found above detection limits.

2. Exposure Assessment

The Ecological Risk Assessment considered the risks to animals and plants resulting from exposure to the contaminated surface water and sediment. The assessment was performed in several phases described below:

a. Potential contaminant exposure routes from the (potential waste disposal area) source to biota that reside at the site were defined.

b. Plants, terrestrial animals, and aquatic organisms that may potentially be exposed to contaminants were identified.

c. The risk assessment for the site was performed. Because of the number of chemicals of potential concern (81 in this assessment), the task was divided into two parts: (1) an initial risk screen to identify the primary chemicals and metals of concern; and (2) a quantitative risk assessment of the identified potentially harmful chemicals.

Based on the results of a survey, twelve species were considered to have potentially high exposure intensity to contaminants in wetlands and ponds. These animals include bullfrog, painted turtle, great blue heron, Canada goose, mallard, wood duck, ring-billed gull, river otter, muskrat, raccoon, beaver, and coyote. For this group, potential exposure to contamination was considered high primarily because of their diverse feeding habits, contact with wetland sediments, or duration of exposure in the wetlands and ponds.

3. Risk Characterization and Summary

Measured maximum concentrations of the chemicals found in the surface water and maximum calculated concentrations in interstitial water (as partitioned from the maximum sediment concentrations) were compared to those concentrations that are expected to cause chronic (long-term, non-lethal) effects to biota. Only those chemicals expected to cause chronic toxicity were evaluated in the full risk assessment. These chemicals are chlordane, 4,4'-DDT, 4,4'-DDD, 4,4'-DDE, dieldrin, endrin ketone, copper, lead, and zinc.

The six pesticides and three metals listed above were quantitatively evaluated to assess the risk first for all aquatic (and terrestrial) biota, and then for species expected to exist in Area D/ALGT wetlands and ponds. Concentrations of interstitial water in sediments were estimated using conservative assumptions. Duck Pond, and Carter and Whitman Lakes, contained 4,4'-DDT in sediments, and, therefore, interstitial water concentrations that may pose chronic toxicity to invertebrates, although the concentrations in Carter and Whitman Lakes impact less than 5 percent of the species. Carter and Whitman Lakes contained zinc in sediments and interstitial water concentrations which also pose chronic toxicity to invertebrates. Additionally, Whitman Lake surface water concentration of zinc may pose acute risk to approximately 17 percent of species. Baxter Lake surface water may pose an acute and chronic risk to invertebrates due to copper and zinc. Estimated concentrations of chlordane in Duck Pond interstitial water present potential acute toxicity and potential chronic toxicity to nearly all invertebrates. A summary of these chemicals potentially causing a risk is listed below:

Surface Water

- Copper: Baxter Lake
- Zinc: Baxter Lake, Carter Lake, and Whitman Lake

Sediment

- Chlordane: Duck Pond
- DDT: Duck Pond, Carter Lake, and Whitman Lake

4. Uncertainty

Sources of uncertainty in the ecological risk assessment include: (1) the analytical data for chemicals in groundwater, surface water and sediments; (2) the toxicity data bases (i.e., LC 50 and ACR values); (3) estimates of interstitial water concentrations from sediment concentrations; (4) measurement of lake specific water quality parameters (e.g., hardness); and (5) estimates of wildlife sediment ingestion. Because conservative parameters were used throughout the ecological risk assessment process, it is expected that the risks are overstated.

VII. DESCRIPTION OF ALTERNATIVES

A. Soil, Surface Water, and Sediment

Based on the Human Health and Ecological Baseline Risk Assessment, the levels of contamination in the soil, surface water, and sediment will not result in unacceptable exposure to hazardous substances. Therefore, it was determined that no remedial action is necessary for soil, surface water, or sediment to ensure protection of human health and the environment, and no remedial alternatives were considered or developed. However, groundwater contamination does exceed MCLs and four remedial alternatives were evaluated in the feasibility study for the clean-up of the groundwater. A description of these alternatives and the applicable or relevant and appropriate requirements (ARARs) that apply are contained in the following section.

B. Groundwater Alternatives

The four remedial alternatives include two common features:

(1) Groundwater Monitoring

A long-term monitoring program would be instituted using both on- and off-site wells to measure the effectiveness of the remedial action during implementation.

If additional existing private drinking water wells are found to be potentially affected by the contaminant plume, remaining residents of ALGT will be offered connections to the Lakewood Water District supply system. The Air Force will update the affected communities as the remedial action progresses and monitor the contaminated private wells.

(2) Institutional Controls

Administrative and institutional controls will include provisions for permanent alternate water supply, access restrictions, notification to appropriate agencies, and public awareness. In addition, appropriate controls would be described in a restrictive covenant on the Area D property and would be recorded with the register of deeds for Pierce County. This restrictive covenant would run with the land and be binding on McChord's successors and assigns. Although the baseline risk assessment determined that no unacceptable risk exists in the soil for future residential use, McChord AFB directives would specifically prohibit future development of landfills 5, 6, 7, and 39 for human habitation, as an added precaution. The McChord AFB directives would also restrict the uses of shallow groundwater within Area D.

1. No Action (monitoring only)

The NCP requires that the "no action" alternative be considered for every site to determine a baseline against which other remedial alternatives can be measured. Under this alternative, no remedial actions would be taken beyond those already in place (i.e., providing an alternative water supply to residents with contaminated wells). Monitoring would be implemented only to evaluate changes in the contaminant plume.

2. One Groundwater Extraction System, One Carbon Adsorption Treatment Facility, and Irrigation/Recharge of Treated Groundwater

The purpose of this alternative is to create a hydrologic barrier to prevent further off-base migration of contaminated groundwater at concentrations above the MCLs and contain the contaminated plume on-site. The alternative consists of a single extraction system that will extract the contaminated groundwater from one or more wells located near the western property boundary of McChord AFB. The extracted groundwater would be pumped to a single multi-bed carbon adsorption facility for treatment. Assuming a

flowrate of 100 gallons per minute (gpm) and an influent TCE concentration of 10 ug/l, the carbon adsorption unit should treat the TCE to less than 0.1 ug/l.

The carbon adsorption system would bring the contaminated groundwater into direct contact with activated carbon by passing the water through the beds of carbon. The activated carbon selectively adsorbs hazardous organic chemicals. Used carbon would be recycled through combustion off-site at a facility operating in compliance with EPA's Off-Site Disposal Policy.

The treated groundwater would be tested for compliance with the effluent standards. Depending on the season of the year, treated groundwater would either be used for irrigation of the golf course or would be recharged back to the ground into a passive recharge system downgradient of the extraction well. The exact number and location of extraction wells and recharge systems would be determined during design.
Under alternative 2, further off-base migration of the plume would be prevented. However, the plume would not be remediated on base and would remain in the unconfined aquifer on base for the foreseeable future.

The reasonable maximum exposure (RME) for the off-base resident after remediation under this scenario presents a combined residual risk at remediation goals for all site-related contaminants and all pathways of 1E-05 (carcinogenic risk) and a hazard index of 0.04 (non-carcinogenic risk). The residual risk for a future use on-base resident would be equal to the baseline risk of 2E-04 (carcinogenic risk) and a hazard index of 1.01 (noncarcinogenic risk).

3. Three Groundwater Extraction Systems, Two Carbon Adsorption Treatment Facilities, and Irrigation/Recharge of Treated Groundwater

The purpose of this alternative would be to create a hydrologic barrier to prevent further off-base migration of contaminants at concentrations above the MCLs and to treat the most contaminated groundwater beneath the Area D site. This alternative expects to remediate the contaminated plume off-site and on-site.

This alternative consists of three groundwater extraction systems, each consisting of one or more wells: one located near the western property boundary of McChord AFB; one located in the north portion of the contaminant plume; and one located near Sites 5 and 39. The extracted groundwater would be pumped to two multi-bed carbon adsorption

facilities for treatment. Assuming a flow rate of 100 gpm and an influent TCE concentration of 8 ug/l, the carbon adsorption unit at Treatment Plant 1 (near the western property boundary of McChord AFB) should treat the TCE to less than 0.1 ug/l. Assuming a flowrate of 200 gpm and an influent TCE concentration of 48 ug/l, the carbon adsorption unit at Treatment Plant 2 (near Sites 5 and 39) should treat the TCE to less than 0.1 ug/l.

The treated groundwater would then be tested for compliance with the effluent standards. Depending on the season of the year, treated groundwater from Treatment Plant 1 would either be used for irrigation at the Whispering Firs golf course would be recharged back to the ground into a recharge system downgradient of the extraction well. The exact number and location of extraction wells and recharge systems would be determined during design.

The treated groundwater from Treatment Plant 2 would be recharged back to the ground through upgradient recharge trenches or wells to further enhance groundwater cleanup by flushing the treated groundwater through the deeper zones of the contaminated aquifer where areas of higher concentrations of TCE and DCE may exist. The exact number and location of extraction wells and recharge systems would be determined during design. Under Alternative 3, remediation of Area D/ALGT contaminated groundwater plume is expected to require a minimum of 50 years.

The reasonable maximum exposure (RME) for the off-base resident after remediation under this scenario presents a combined residual risk of 1E-05 (carcinogenic risk) and a hazard index of 0.04 (non-carcinogenic risk) after achieving remediation goals for all site-related contaminants and all pathways.

4. Three Groundwater Extraction Systems, Two Carbon Adsorption Treatment Facilities with the Addition of Bioremediation, and Irrigation/Recharge of Treated Groundwater

The groundwater extraction and carbon treatment schemes for this alternative are the same as Alternative 3. However, at the carbon treatment facility located in the vicinity of Sites 5 and 39, a supplemental biological treatment system would add nutrients and oxygen to the treated groundwater. Nutrients and oxygen may stimulate the growth of bacteria in groundwater which are capable of breaking down TCE and DCE. Five wells

would recharge the nutrient-rich groundwater into the area of the plume with the highest concentrations of contaminant.

In-place bioremediation technology is a developing innovative technology and its reliability is not known. Therefore, experimental testing would be necessary to determine its effectiveness within Area D/ALGT. The use of this technology has been limited to relatively small areas due to the difficulties involved in delivering nutrients and oxygen-rich water to the contaminated areas. Treatment of an entire plume is not considered feasible. In addition, the success of bioremediation is questionable for the relatively low levels of VOC-contamination (e.g., 70 ug/l TCE maximum) found at the Area D/ALGT site.

Under Alternative 4, remediation of the contaminated groundwater plume may be less than 50 years, but significant additional research and pilot testing would be required to demonstrate this.

The reasonable maximum exposure (RME) for the off-base resident after remediation under this scenario presents a combined residual risk of 1E-05 (carcinogenic risk) and a hazard index of 0.04 (non-carcinogenic risk) after achieving remediation goals for all site-related contaminants and all pathways.

ARARs in the Description of Alternatives

The principal ARARs for all of the groundwater alternatives above are the Federal Clean Water Act (CWA) (33 USC 1251), the Safe Drinking Water Act (SDWA) (40

USC 300), the Resource Conservation and Recovery Act (RCRA) (42 USC 6901), the Water Pollution Control Act (Chapter 90.48 RCW), and the State of Washington Model Toxics Control Act (Chapter 70.105D RCW).

Under the CWA:

(1) State Anti-degradation Requirements/Use Classification require every state to classify all the water within its boundaries according to intended use. The aquifers beneath Area D/ALGT, including the contaminated unconfined aquifer, are Class II (i.e., drinking water) aquifers;

(2) CWA section 304 specifies ambient water quality criteria (AWQC) which were developed for the protection of human health and aquatic life. The AWQC were compared to contaminant levels found in surface waters potentially affected by Area D (Table 4A) and are discussed further in the section entitled Environmental Risks; and

(3) CWA section 301 (b) requires that, at a minimum, all direct discharges meet technology-based limits for conventional pollutant control technology. Since remedial actions at CERCLA sites need meet only the substantive requirements of the National Pollutant Discharge Elimination System (NPDES) regulations; effluent limits are determined on a case-by-case basis using best professional judgement. Carbon adsorption was the type of pollutant control technology evaluated for the groundwater alternatives. Carbon adsorption is an available proven technology for treatment of VOC-contaminated groundwater.

CERCLA section 121(d)(2)(A) requires on-site CERCLA remedies to attain standards or levels of control established under the SDWA (i.e. MCLs or MCLGs [maximum contaminant level goals]). According to the NCP (55 FR 8848), where MCLGs are set at zero, the remedial actions shall attain MCLs for groundwaters that are current or potential sources of drinking water.

Since the source of halogenated solvents could not be made, TCE and DCE are not classified as RCRA-listed spent halogenated solvents (F001-F005). Consequently, the groundwater is not contaminated with a RCRA listed waste. TCE and DCE would only be subject to LDR's if determined to be a characteristic waste.

The requirements of the Department of Ecology Dangerous Waste Regulations (WAC 173-303-170) for generators of dangerous waste would apply for removal of spent carbon generated during carbon adsorption of the groundwater contaminants.

The MTCA compliance cleanup levels for groundwater are determined by one of the following methods: (1) the calculated levels using risk equations in WAC 173-340-720, (2) concentrations established by applicable state and federal regulations, (3) concentrations which are anticipated to result in no acute or chronic toxic effects on human health, and (4) concentrations which are anticipated to result in an excess lifetime cancer risk less than one in one million. The total excess lifetime cancer risk shall not exceed one in one hundred thousand and the hazard index for substances with similar non-carcinogenic toxic effects shall not exceed one.

VIII. SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives for the McChord AFB Area D/ALGT site were compared according to nine criteria developed on the basis of statutory requirements of CERCLA Section 121 and the NCP. The nine criteria are subdivided into three categories: (1) threshold criteria which relate directly to statutory findings and must be satisfied by each chosen alternative; (2) primary balancing criteria, which include technical factors such as the long and short term effectiveness, implementability, reduction of toxicity, mobility, and volume and cost; and (3) modifying criteria, which are measures of the acceptability of the alternatives to state agencies and the community. The following sections summarize the evaluation of the candidate remedial alternatives according to these criteria. Table 15 includes a summary of the comparative analysis, or relative ranking, of the alternatives.

A. Threshold Criteria

1. Overall Protection of Human Health and the Environment

This criterion measures how the alternative, as a whole, achieves and maintains protection of human health and the environment.

The "no action" alternative is not protective of human health or the environment because it does not prevent the migration of contaminants to the lower aquifer. Also, this alternative does not change contaminant concentrations or exposure, the residual risk is equivalent to the baseline risk.

Alternatives 3 and 4 provide a higher level of protection in a shorter time than Alternative 2. Alternatives 3 and 4 reduce the residual risks to residents and workers on-site and off-site because it is designed to remediate the plume on and off the Air Force base property. Alternative 2 does not include treatment of groundwater beneath the Air Force base property and, therefore, is not protective if this groundwater is used for drinking water. Under Alternative 2 risks to on-site residents and workers remain identical to those calculated in the baseline risk assessment.

Table 15. Summary of Alternative Analyses.

Criteria	1: No Action	2: Extraction Scheme 1, Carbon Adsorption and Recharge	3: Extraction Scheme 2, Carbon Adsorption and Recharge	4: Extraction Scheme 2, Carbon Adsorption, In-Situ Bio-remediation, and Recharge
Short-Term Effectiveness During Construction	N/A	High	High	High
Long-Term Effectiveness	Low	Medium	High	High
Reduction of Toxicity, Mobility, and Volume	Low	Medium	High	High
Implementability	N/A	High	High	Low
Compliance with ARARs	Low	Low	High	High
Protection of Human Health and Environment	Low	Medium	High	High
State Acceptance	Low	Low	High	Medium
Community Acceptance[1/]				
Capital Cost	$306,500	$831,200	$1,407,400	$1,641,000
Operating Costs	$45,000/yr[2/] $22,500/yr[3/]	$139,000/yr[2/] $117,000/yr[3/]	$341,000/yr[2/] $318,000/yr[3/]	$409,000/yr[2/] $386,000/yr[3/]
Net Present Worth (i=10%, n=30 yrs)	$558,000	$1,972,000	$4,445,000	$6,089,000
Net Present Worth (i=4%, n=30 yrs)	$738,000	$2,896,000	$6,949,000	$9,899,000

N/A: Not Applicable

1/ Support agencies and community acceptance will be discussed in the Responsiveness Summary.

2/ Operating Cost for first 2 years.

3/ Operating cost for remaining 28 years.

2. Compliance with ARARs

Compliance with ARARs is a consideration of how the alternatives comply with waste regulations that explicitly apply to the site and those regulations that are sufficiently relevant to warrant inclusion. In some extenuating situations, waivers from selected ARARs may be obtained.

Alternative 1, does not comply with ARARs. Contaminated groundwater would continue to exceed maximum contaminant levels (MCLs) and would likely contaminate additional drinking water supplies. Alternative 2 does not comply with ARARs. Although some clean-up of contaminated groundwater is achieved, the remaining contamination (under Area D on the Air Force base) exceeds MCLs.

Alternatives 3 and 4 provide similar compliance with ARARs. Contaminated groundwater is removed and treated, and further migration is limited. One potential point of non-compliance is the injection of biological agents into the sub-surface under the bioremediation Alternative 4. However, a waiver may be obtained for this activity because it may assist in the remediation.

B. Primary Balancing Criteria

3. Long-term Effectiveness and Permanence

This criterion evaluates the long-term effectiveness of alternatives in maintaining protection of human health and the environment after remedial action objectives have been met.

Alternatives 3 and 4 provide a higher degree of long-term effectiveness and permanence than either Alternative 1 or 2. The risk of contaminating the deeper potable aquifer would still remain at the site after the response actions of Alternatives 1 and 2. Neither alternative remediates the contaminated plume. And the risk of contaminating the deeper potable aquifer would remain.

4. Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives were also evaluated according to their ability to reduce the toxicity, mobility, or volume of contaminants through treatment.

Alternatives 3 and 4, with more aggressive extraction and treatment systems, meet the preference for treatment to reduce the toxicity, mobility, and volume of the contamination more effectively than Alternative 2. Alternative 1 does not reduce these properties of the contamination.

5. Short-term Effectiveness

This criterion addresses the effects of the alternatives during the construction and implementation phase until remedial action objectives are met.

None of the alternatives evaluated are expected to pose risks to human health (e.g., workers) during construction or implementation. Any risks during construction can be adequately controlled with engineering controls and standard health and safety practices.

Alternatives 3 and 4 provide greater short-term effectiveness by remediating the groundwater significantly faster than Alternatives 1 or 2, neither of which are expected to achieve remedial action objectives in the foreseeable future.

6. Implementability

This criterion addresses the technical and administrative feasibility of implementing the alternatives and the availability of services and materials required during implementation.

Alternatives 2 and 3 are readily implementable using available technology. Construction of extraction and recharge systems and installation of carbon adsorption units would not be difficult. Equipment and specialists are readily available for these well developed technologies. Additionally, there should be no difficulty in obtaining any permits that may be required during design and construction.

Alternative 4 includes a developing, innovative technology and its reliability and implementability are not yet known. The insitu bioremediation of groundwater requires a complex delivery system and has not been demonstrated to be effective on groundwater contaminated with low levels of organics.

7. Cost

Cost is another criteria by which candidate alternatives are compared. Costs in this case are measured as capital, operation and maintenance (O&M), and present worth costs. A summary of these costs for each of the alternatives is included in Table 15.

Alternative 2 is the least expensive of the treatment alternatives and is roughly one-half the cost of Alternative 3 and one-third the cost of Alternative 4.

C. Modifying Criteria

Modifying criteria are used in the final evaluation of the remedial alternatives, and include comment from Ecology and from the public.

8. State Acceptance

The State of Washington Department of Ecology (Ecology) concurs with the preferred remedial alternative. Ecology has been involved with the development and review of the Remedial Investigation, Feasibility Study, Proposed Plan, Record of Decision, and other project activities such as public meetings.

9. Community Acceptance

Based on verbal comments received during the public meeting held April 11, 1991 and written comments received during the comment period ending May 8, 1991, the community appears to accept the preferred remedial alternative. Specific responses and comments to the remedial alternatives may be found in the attached Responsiveness Summary.

IX. THE SELECTED REMEDY

Based on the RI and the Baseline Risk Assessment, it was determined that no remedial action is necessary for soil, surface water, or sediment to ensure protection of human health and the environment.

The selected remedy for the contaminated groundwater is Alternative 3 - Installation of Three Groundwater Extraction Systems, Two Carbon Adsorption Treatment Facilities,

and Irrigation/Recharge of Treated Groundwater. This remedy addresses the risk posed by the contaminated groundwater through treatment which permanently and significantly reduces the volume, toxicity, and mobility of the hazardous substances.

A. Major Components of the Selected Remedy

The major components of the selected remedy include:

- Install groundwater extraction wells capable of capturing the groundwater contaminant plume in the unconfined aquifer. An estimated three extraction systems will be necessary to achieve this goal.

- Install one of the three groundwater extraction systems near areas of highest concentration of contaminants within the contaminant plume.

- Install on-site groundwater treatment facilities to remove contaminants from the extracted groundwater. The preferred treatment is carbon adsorption, with an estimated two treatment facilities necessary to achieve this goal.

- Monitor the groundwater contaminant plume and the extraction/treatment system during groundwater remediation activities to ensure that groundwater remediation goals are achieved and maintained throughout the contaminant plume.

- Implement administrative and institutional controls such as restrictive covenants and McChord Air Force Base command directives, that supplement engineering controls and minimize exposure to releases of hazardous substances during remediation.

The goal of this remedial action is to restore groundwater to its beneficial use, which is, at this site, a potential drinking water source by attaining drinking water standards throughout the groundwater aquifer. Based on information obtained during the remedial investigation and on an analysis of all remedial alternatives, the Air Force, EPA, and the Ecology believe that the selected remedy will achieve this goal. It may be apparent, during implementation or operation of the groundwater extraction system and its modifications, that contaminant levels have ceased to decline and are remaining constant

at levels higher than the remediation goal over some portion of the contaminant plume. In such a case, the system performance standards and/or the remedy may be reevaluated.

The selected remedy will include groundwater extraction for an estimated period of 50 years, during which the system's performance will be carefully monitored on a regular basis and adjusted as warranted by the performance data collected during operation. Modification may include any or all of the following:

- Discontinuing pumping at the individual wells where cleanup goals have been attained.
- Alternating pumping at wells to eliminate stagnation points.
- Pulse pumping to allow aquifer equilibration and to allow adsorbed contaminants to partition into groundwater.
- Installing additional extraction wells to facilitate or accelerate cleanup of the contaminant plume.

It may also become apparent during design, implementation, or operation of the effluent recharge system that the system is not effective. For example, the recharge piping may clog because of the natural water chemistry or the disturbed soils may prevent effective infiltration. In such a case, the recharge system may be reevaluated. If necessary, other alternatives for effluent recharge would be considered (e.g., discharge to surface water). Requirements for effluent discharge must then satisfy the substantive provisions of the National Pollutant Discharge Elimination System (40 CFR Parts 121-125).

To ensure that cleanup levels are maintained, the aquifer will be monitored annually at those wells where pumping has ceased following discontinuation of groundwater extraction, and at groundwater monitoring wells located throughout the site.

The residual spent carbon will be transported off-site for regeneration (e.g., through combustion) at a facility operating in compliance with EPA's Off-Site Disposal Policy. No other residuals from the treatment process are anticipated.

Post-ROD studies prior to remedial design may include a bench-scale treatability study to obtain information to design the carbon adsorption system. In addition, pump tests may be required to obtain engineering data for design of the extraction and discharge systems.

B. Remedial Action Objectives/Remediation Levels

The risk assessment concluded that groundwater contamination originating from Area D presents a threat to human health and the environment. Existing conditions at the site pose a threat predominantly from ingestion and vapor inhalation exposure to VOC-contaminated groundwater.

The objective of the remedial action is to restore groundwater to its beneficial use, a drinking water source. The groundwater will be restored to levels consistent with state and Federal ARARs. Remediation levels will be attained throughout the contaminated plume.

Remediation goals were established for contaminants of concern with levels that either: (1) exceed an ARAR or (2) are not protective of human health and the environment. Remediation goals were not established for metals measured at levels determined to be consistent with naturally occurring background concentrations. Remediation goals have been established as shown in Table 16.

Of the contaminants that present risks based on current and future land use, site concentrations of arsenic and manganese were found to be consistent with naturally occurring background concentrations. Thallium presented a risk based on the result of one sample; this analytical result is thought to be erroneous. Of the remaining contaminants, styrene, beta-BHC, chlordane, dieldrin, and 4,4'-DDT were never detected in the groundwater during the RI. Groundwater was identified as the critical exposure pathway for these contaminants. Methylene chloride and bis(2-ethylhexyl) phthalate were determined to be laboratory contaminants and therefore do not present a risk. The remaining organics for which remediation goals were not set were detected infrequently and at low concentrations. These compounds do not currently exceed levels that are protective of human health or the environment. Groundwater monitoring will confirm that these volatile organics, as well as pesticides, do not appear in the groundwater at levels of concern in the future.

Table 16. Remedial Action Objectives.

Contaminant	Media	RME Concentration in Groundwater (μg/l)	Remediation Goal (μg/l)	Basis	Remedial Action Objective	Reason
TCE	Groundwater	76	5	MCL	Pump and treat, groundwater monitoring	Exceeds MCL, MTCA, GWCL
cis-1,2-DCE	Groundwater	222	70	MCL	Pump and treat, groundwater monitoring	Exceeds MCL in groundwater
Vinyl Chloride	Groundwater	0.7	0.04	MTCA Method B detection limit (EPA Method 524.2)	Pump and treat, groundwater monitoring	Exceeds MTCA Method B GWCL
1,1-DCE	Groundwater	0.41	.07	MTCA Method B	Pump and treat, groundwater monitoring	Exceeds MTCA Method B GWCL

MCL	Maximum Contaminant Level (from Safe Drinking Water Act)
GWCL	Groundwater cleanup level
MTCA	Model Toxics Control Act
RME	Reasonable Maximum Exposure

Residual risks from the remediated groundwater at these remediation goals were evaluated for current off-site residents and future on-site workers following remediation. Relevant exposure pathways included ingestion of drinking water and inhalation of volatiles while showering. The results of these analyses using EPA Region 10 exposure parameters and risk assessment guidance are summarized as follows:

- Current Off-site Residents; cancer- 1E-5, non-cancer- 0.04.
- Future On-Site Workers; cancer- 8E-6, non-cancer- 0.12.

Cancer risks for off-site residents for groundwater ingestion and inhalation will be reduced by approximately 50 percent when compared to risks calculated in the Baseline Risk Assessment. The hazard index for off-site residents based on meeting remediation goals and reasonable maximum exposure concentrations was 0.04.

For the future on-site worker, cancer risks and hazard indices for groundwater ingestion and inhalation will be reduced by approximately 80 percent after remedial goals for groundwater treatment are achieved.

Risks to any future on-site residents from groundwater exposures will be further mitigated through institutional controls and deed restrictions which will be strictly enforced by the Air Force.

X. THE STATUTORY DETERMINATIONS

The selected remedy meets the statutory requirement of Section 121 of CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan.

A. Protection of Human Health and the Environment

The selected remedy reduces the risk posed by the contaminated groundwater and will attain a 10^{-4} to 10^{-6} risk level for carcinogens and a Hazard Index of less than one. The contaminated groundwater will be extracted and treated using carbon adsorption which will result in no short-term threats or adverse cross-media impacts.

B. Attainment of Applicable or Relevant and Appropriate Requirements (ARARs) of Environmental Laws

The selected remedy will comply with all applicable or relevant and appropriate requirements (ARARs) of Federal, as well as more stringent, promulgated State environmental and public health laws.

1. Applicable or Relevant and Appropriate Requirements

Action-Specific

- State of Washington Hazardous Waste Management Act (Chapter 70.105 RCW) requirements for dangerous waste and extremely hazardous waste as codified in Chapter 173-303 WAC.

- State of Washington requirements for Water Well Construction (Chapter 18.104 RCW) as codified in Chapter 173-160 WAC.

- State of Washington requirements (Chapter 173-154 WAC) for the management of groundwater in a manner that protects, to the extent practicable, the upper aquifers of multiple aquifer systems from depletions, excessive water level declines or reductions in water quality.

- Water Pollution Control Act (Chapter 90.48 RCW), Pollution Disclosure Act of 1971 (Chapter 90.52), and Water Resources Act of 1971 (Chapter 90.54 RCW) require the use of all known, available, and reasonable methods (AKARTs) of treatment prior to discharge to groundwater.

- Requirements of the Clean Water Act section 402 (40 CFR Parts 121-125) for effluent discharge would be applicable if it is necessary to use an alternate effluent discharge system.

- Requirements of the State Waste Discharge Permit Program (Chapter 173-216 WAC) for discharge of waste materials into groundwater.

- State of Washington requirements for hazardous waste operations conducted at uncontrolled hazardous waste sites as set forth in WAC 262-62 Part P (Hazardous Waste Operations and Emergency Response).

Chemical-Specific

- Federal requirements of the Safe Drinking Water Act (40 USC 300) for groundwater used as drinking water, as set forth in 40 CFR 141.

- State of Washington Hazardous Waste Cleanup - Model Toxics Control Act (Chapter 70.105D RCW) requirements for the identification, investigation, and clean up of hazardous waste sites as codified in Chapter 173-340 WAC.

- Substantive water resource antidegradation fundamentals of the State of Washington Pollution Control Act (Chapter 90.48 RCW) and Water Resources Act of 1971 (Chapter 90.54 RCW).

- Water Pollution Control Act (Chapter 90.48 RCW), Pollution Disclosure Act of 1971 (Chapter 90.52), and Water Resources Act of 1971 (Chapter 90.54 RCW) require the use of all known, available, and reasonable methods (AKARTs) of treatment prior to discharge to groundwater.

Location-Specific

There are no location-specific ARARs identified for Area D/ALGT.

2. To-Be-Considered

There are no To-Be-Considered guidelines identified for Area D/ALGT.

C. Cost Effectiveness

The selected remedy is cost-effective and provides overall effectiveness proportionate to its costs and duration for remediation of the contaminated groundwater.

D. Use of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to Maximum Extent Practicable

The Air Force, EPA, and Ecology have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for the Area D/ALGT site. The risk from the groundwater contamination is permanently reduced through treatment to acceptable exposure levels without transferring the risk to another media (e.g., air). The selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume achieved through treatment, short-term effectiveness, implementability, and cost. Also State and community acceptance were considered.

E. Preference for Treatment as Principal Element

On-site treatment of the VOC-contaminated groundwater using carbon adsorption satisfies the statutory preference in which treatment, as a principal element, permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances.

XI. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for Area D/ALGT was released for public comment in March 1991. The Proposed Plan identified Alternative 3, extraction and on-site treatment of VOCs in the groundwater, as the preferred alternative. Upon review of public comment, it was determined that no significant changes to the remedy, as it was originally identified in the Proposed Plan, were necessary.