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EASTERN REGIONAL OFFICE

April 1, 1999
Project 624419

Mr. Guy Gregory
Site Manager
Washington Department of Ecology.
4601 N. Monroe
Spokane, Washington 99205-1295

Dear Mr. Gregory:

Subject: Pasco Landfill Feasibility Study, Request for Schedule Extension

Per our telephone conversation on March 31, 1999 we are requesting a 14-day extension to the schedule for submittal of the revised Pasco Landfill Feasibility Study (FS). This extension would produce a due date for the revised FS of May 3, 1999.

Please call me at (425) 227-6160 if you have any questions or comments regarding this matter.

Sincerely,
PHILIP SERVICES CORPORATION

Donald A. Robbins, RG
Project Manager

ECOLOGY DRAFT – REV. 1

FEASIBILITY STUDY REPORT
PASCO LANDFILL
PASCO, WASHINGTON

April 28, 1999
Project No. 624419

Prepared for:
Pasco Landfill PLP Group

PHILIP SERVICES CORP.

PHILIP ENVIRONMENTAL SERVICES CORPORATION
A WHOLLY-OWNED SUBSIDIARY OF PHILIP SERVICES CORP.
P.O. Box 3552, Seattle, WA 98124
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ECOLOGY DRAFT – REV. 1

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EXECUTIVE SUMMARY

This report summarizes the results of the Feasibility Study conducted at the Pasco Landfill Site near Pasco, Washington in accordance with Enforcement Order DE94TC-E103 and amendments issued by the Washington State Department of Ecology. The objective of this report is to evaluate the feasibility and effectiveness of implementing alternative cleanup actions at the site. The Feasibility Study is based on the findings of the Phase I and Phase II Remedial Investigation activities and corresponding reports (Burlington Environmental, Inc. 1994 and Philip Environmental Services Corporation 1998) and the findings of the Risk Assessment/Cleanup Level Analysis Report (Philip Services Corp. 1998).

During the remedial investigation, several Interim Remedial Measures were implemented at the Pasco Sanitary Landfill Site to reduce the risks to human health and the environment from conditions that were discovered. These remedial measures included:

- immediately providing bottled water to all households whose potable wells may have been impacted by the Pasco Sanitary Landfill Site;
- providing city water to all households that were later shown to have impacted wells;
- installing and operating a soil vacuum extraction system to remove and destroy contaminants in soils before the contaminants could impact local groundwater; and
- installing and operating a NoVOCs™ in well air stripping system in groundwater to remove remaining contaminants to acceptable levels before the groundwater leaves the site.

These Interim Remedial Measures have effectively reduced the potential impact of wastes at the Pasco Sanitary Landfill Site to the surrounding community. In this way the operation of these measures has provided an important proof of concept for the remedial alternatives chosen in this Feasibility Study.

The site is located approximately 1.5 miles northeast of the city of Pasco. It occupies a 200-acre area consisting of gently rolling hills surrounded by range land and irrigated cropland. Since the 1960's the site has been used to dispose various kinds of waste. Immediately north of the site is the New Waste, Inc., an operating, permitted solid waste landfill.

The Remedial Investigation determined the extent and nature of contaminants at the Pasco Sanitary Landfill Site. The contaminants of concern were all found to be various solvents (volatile organic compounds) and their natural breakdown products. The Risk Assessment/Cleanup Level Analysis Report compared concentrations of these contaminants found in soils and groundwater to calculated cleanup levels and concluded that six areas at the Pasco Sanitary Landfill Site require consideration for remediation.

- Zone A

  This area contains approximately 35,000 drums of various industrial wastes including solvents and is impacting groundwater.

- Zone B

  This area contains approximately 5,000 drums of apparently solid pesticide derived waste and is not impacting groundwater.

- Zone C/D

  This area contains approximately 8,200 cubic yards of solid residue from bulk industrial sludges and wastes which were disposed of in unlined lagoons and is not impacting groundwater.

- Zone E

  This area contains approximately 12,000 cubic yards of waste derived from the decommissioning of a caustic chlorine plant and is not impacting groundwater.

- Municipal Landfill

  Contains approximately 1.5 million tons of municipal waste including solvents and is impacting groundwater.

All of these areas are presently situated under several feet of soil to minimize direct exposures to waste. In addition, the cover over Zones A through E includes a plastic liner to minimize precipitation percolation through the waste.

After reviewing the potential applicable or relevant and appropriate regulatory requirements for completing a remedial action at the Pasco Sanitary Landfill Site, a broad range of technologies were identified that might meet Remedial Action Objectives for the site. These technologies were further analyzed and screened to determine whether they could be applied to the specific conditions found at the Pasco Sanitary Landfill Site. The remaining technologies were carried forward and developed as Remedial Alternatives. These alternatives are described in detail in Section 5.

Section 6 includes a detailed comparative analysis of the Remedial Alternatives for each zone. The alternatives are analyzed using the Threshold Evaluation Criteria, Permanance Criteria, Restoration Time Frame Criteria and Cleanup Technology Hierarchy presented in WAC 173-340-360. A scoring method was devised to provide an objective evaluation of each alternative that closely follows the remedial alternative selection process outlined in WAC 173-340-360. The total score for an alternative is the best measure of the overall degree of protectiveness of the alternative. A summary of the remedial alternatives, key considerations and scores of the alternatives as the percent of a perfect score is presented in the tables at the end of this executive summary.

The site-wide preferred remedy is made up of the preferred remedial alternatives for each area of concern as indicated in Section 6. Taken together, the site-wide preferred remedy is summarized in the following tasks.

REMOVAL AND DESTRUCTION

- The present soil vacuum extraction system will be maintained and expanded to further remove and destroy the contaminants of concern from Zone A and to minimize the restoration time frame for soils and groundwater at the site.
- An active landfill gas extraction system will be installed at the Municipal Landfill to remove and destroy the contaminants of concern and to further minimize the restoration time frame for soils and groundwater at the site.
- The present NoVOCs™ groundwater treatment system will be maintained and expanded to treat groundwater from Zone A to acceptable levels before it leaves the site.

CONTAINMENT AND ISOLATION

- All areas of concern will be capped with engineered isolation systems including impervious liners to minimize rainfall percolation through waste and direct contact with wastes. These caps will be inspected and maintained in perpetuity.

PROTECTION OF AFFECTED HOUSEHOLDS

- Alternate water supplies will continue to be provided to those households whose wells have been adversely affected by the site.

CONTINUED MONITORING

- Groundwater and cap monitoring to confirm performance of all remedial alternatives.

ACCESS AND INSTITUTIONAL CONTROLS

- Appropriate access and institutional controls will be maintained at the site to prevent future exposure to wastes. This task is made easier due to the remote location of the site and use of the site as a municipal landfill.

These tasks will cost over $15,000,000 and will effectively reduce risk from the Pasco Sanitary Landfill Site to human health and the environment. The preferred remedial alternative was chosen to have the most certainty in reducing risk. In particular, it does not include excavation of waste or transporting wastes through the local community. Instead, the preferred remedial alternative favors well-known and easily implementable techniques to minimize potential future exposures to wastes at the Pasco Sanitary Landfill Site.

To accurately estimate the restoration time frame and prove the protectiveness of the preferred remedy, this Feasibility Study proposes a creative approach to implement the preferred remedy. Features of this approach are as follows:

- Fast Implementation

  The preferred remedy will be implemented as soon as possible, allowing for an appropriate public comment period.

- Continuous Monitoring

  During implementation and for five years after, active remediation systems and groundwater will be monitored on a quarterly basis.

- Performance Confirmation

  Continuous monitoring with routine reporting to Ecology will confirm the performance of the preferred remedy. Performance confirmation will identify appropriate changes to the remedial system, if necessary, to optimize the performance of the remedy.

- Enhanced Public Involvement

  As described in Section 7.2, an enhanced public involvement process will be implemented that will provide the public with information on this new and creative approach as soon as possible.

At the end of the performance confirmation period the data will be used to estimate the restoration time frame and determine the effectiveness of the site-wide remedy. Once these data are evaluated, another public participation process will be implemented and a Final Corrective Action Plan will be completed by the Washington State Department of Ecology.

TABLE ES-1

ZONE A

SUMMARY OF KEY CONSIDERATIONS AND REMEDIAL ALTERNATIVE RANKING

SCORE	REMEDIAL OPTION	KEY CONSIDERATIONS
79%	A-4 • Drum and Soil Removal to Cleanup Levels with Off-Site Incineration	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling • Substantial and disproportionate cost relative to risk reduction
79%	**A-2** • **Construct Zone A Cap** • **Expand SVE** • **Implement Access and Institutional Controls**	• **Complies with threshold criteria** • **Risk of a future release that is not intercepted by the treatment system is small based on groundwater data**
78%	A-3 • Drum Removal and Off-Site Incineration • Complete Alternative A-2 on Remaining Soils	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling • Substantial and disproportionate cost relative to risk reduction
75%	A-1 • Maintain Existing Cap • Expand SVE • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release that is not intercepted by the treatment system is small based on groundwater data • Existing cap is unreliable • Longest restoration time frame
70%	A-5 • Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling • Substantial and disproportionate cost relative to risk reduction

The preferred remedy in depicted in bold type.

TABLE ES-2

ZONE B

SUMMARY OF KEY CONSIDERATIONS AND REMEDIAL ALTERNATIVE RANKING

SCORE	REMEDIAL OPTION	KEY CONSIDERATIONS
80%	**B-2** • **Construct Zone B Cap** • **Implement Access and Institutional Controls**	• **Complies with threshold criteria** • **Risk of a future release is considered small based on present lack of groundwater impact**
77%	B-3 • Construct Zone B Cap • Construct Vertical and Horizontal Subsurface Barriers • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release is considered small based on present lack of groundwater impact • In the unlikely case that liquids may migrate from the zone, this is an approach to minimize potential future exposures
76%	B-1 • Maintain Existing Cap • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release is considered small based on present lack of groundwater impact • Existing cap is unreliable
74%	B-5 • Drum and Soil Removal to Cleanup Levels with Off-Site Incineration	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling • Wastes may not be accepted for off-site incineration
72%	B-4 • Drum Removal and Off-Site Incineration • Complete Alternative B-2 on Remaining Soils	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling • Wastes may not be accepted for off-site incineration
69%	B-6 • Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling

The preferred remedy in depicted in bold type.

TABLE ES-3

ZONE CD

SUMMARY OF KEY CONSIDERATIONS AND REMEDIAL ALTERNATIVE RANKING

SCORE	REMEDIAL OPTION	KEY CONSIDERATIONS
87%	<u>CD-3</u> • Construct Zone CD Cap • Install SVE System • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release is considered small based on present lack of groundwater impact • In the unlikely case that liquids may migrate from the zone, this is an approach to minimize potential future exposures • Substantial and disproportionate costs compared to risk reduction
87%	**<u>CD-2</u>** • **Construct Zone CD Cap** • **Implement Access and Institutional Controls**	• **Complies with threshold criteria** • **Risk of a future release is considered small based on present lack of groundwater impact**
86%	<u>CD-1</u> • Maintain Existing Cap • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release is considered small based on present lack of groundwater impact • Existing cap is unreliable
80%	<u>CD-4</u> • Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill • Install SVE System • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling
79%	<u>CD-5</u> • Waste Removal with Redisposal in an On-Site Lined Cell • Install SVE System • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling

The preferred remedy in depicted in bold type.

TABLE ES-4

ZONE E

SUMMARY OF KEY CONSIDERATIONS AND REMEDIAL ALTERNATIVE RANKING

SCORE	REMEDIAL OPTION	KEY CONSIDERATIONS
73%	**E-2** • **Construct Zone E Cap** • **Implement Access and Institutional Controls**	• **Complies with threshold criteria** • **Risk of a future release is considered small based on present lack of groundwater impact** • **Cost effective approach to minimize future exposures based upon RI results**
73%	E-1 • Maintain Existing Cap • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of a future release is considered small based on present lack of groundwater impact • Existing cap is unreliable
70%	E-3 • Waste Removal and Disposal Off-Site in a RCRA TSD	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling
66%	E-4 • Waste Removal and Disposal in an On-Site Lined Cell • Implement Access and Institutional Controls	• Complies with threshold criteria • Risk of uncontrolled release during intrusive operations and waste handling

The preferred remedy in depicted in bold type.

TABLE ES-5

GROUNDWATER

SUMMARY OF KEY CONSIDERATIONS AND REMEDIAL ALTERNATIVE RANKING

SCORE	REMEDIAL OPTION	KEY CONSIDERATIONS
92%	GW-3 • NoVOC's Treatment of the Groundwater from Zone A and the Municipal Solid Waste Landfill • Groundwater Monitoring • Provide Alternate Receptor Water Supply	• Complies with threshold criteria • Treats 95% of COCs • Substantial and disproportionate costs compared to risk reduction
91%	GW-4 • NoVOC's Treatment of the Groundwater from Zone A, the Municipal Solid Waste Landfill and the Off-Site Groundwater Plume • Groundwater Monitoring • Provide Alternate Receptor Water Supply	• Complies with threshold criteria • Shortest restoration time frame • Treats 99% of COCs • May adversely affect land use • Substantial and disproportionate costs compared to risk reduction
91%	**GW-2** • **NoVOC's Treatment of the Groundwater from Zone A** • **Groundwater Monitoring** • **Provide Alternate Receptor Water Supply**	• **Complies with threshold criteria** • **Treats 92% of COCs**
83%	GW-1 • Groundwater Monitoring • Provide Alternate Receptor Water Supply	• Complies with threshold criteria • Has the longest restoration time frame

The preferred remedy in depicted in bold type.

1 INTRODUCTION

This report summarizes the results of the Feasibility Study (FS) conducted for the Pasco Landfill site (the site) near Pasco, Washington. This work was completed by Philip Environmental Services Corporation (Philip) on behalf of the Pasco Landfill Potentially Liable Person (PLP) Group, in accordance with Enforcement Order DE94TC-E103 (the Order) and amendments issued by the Washington State Department of Ecology (Ecology). The objective of this report is to evaluate the feasibility and effectiveness of implementing alternative cleanup actions at the site. The FS is based on the findings of the Phase I and Phase II Remedial Investigation (RI) activities and corresponding reports (Burlington Environmental, Inc. 1994 and Philip Environmental Services Corporation 1998) and the findings of the Risk Assessment/Cleanup Level Analysis Report (Philip Services Corp. 1998).

The scope of work for the FS was specified in the Order as Task VII of Exhibit B. It has been completed in accordance with the project work plan documents approved by Ecology (Burlington Environmental Inc 1995, Section 4.7, Volume 1, Work Plan).

1.1 SITE DESCRIPTION

The site is located approximately 1.5 miles northeast of the City of Pasco, in the southwest quarter of Section 15, the northeast quarter of Section 21 and the northwest quarter of Section 22, Township 9 North, Range 30 East, Willamette Meridian, in Franklin County, Washington (Figure 1-1). The site occupies a 200-acre area consisting of gently rolling hills surrounded by rangeland and irrigated cropland. North of the site is New Waste, Inc. an operating permitted solid waste landfill.

The site initially operated as an open burning facility with limited solid waste recovery and recycling operations. The burning of refuse occurred in trenched areas at the site during the 1960s and early 1970s. After burning was discontinued, municipal waste disposal activities continued with the operation of a sanitary landfill until June 1993.

In 1972, Resource Recovery Corp. (RRC) was formed to operate a new industrial waste disposal facility at the site. Ecology issued State Waste Discharge permit No. 5301 to RRC for industrial waste disposal at the site, which occurred from April 1972 through December 1974.

The industrial waste operation accepted primarily bulk sludges and drummed wastes for disposal. Industrial waste disposal was segregated into five primary zones at the site designated as Zones A, B, C, D, and E. Adjacent agricultural community concerns over the operation of the industrial waste disposal facility, primarily the acceptance of herbicide wastes, resulted in the termination of the use of the site as an industrial waste disposal facility in December 1974. Closure of the industrial waste portion of the site began in 1975 and was completed in 1980.

During the period after industrial waste disposal ceased, other types of landfill operations continued at the site, including the disposal of various bulk liquids, septic tank wastes, sewage sludges, and animal fat emulsions. These wastes were disposed in lagoons or spread over ground surface areas at two locations on-site (the Sludge Management Area [SMA] and the Landspread Area [LSA]). Another area of the site was used for the disposal of large quantities of baled refuse as part of the sanitary waste disposal operations. Landspreading of industrial wastewaters including animal fat emulsion coolants continued after the period of industrial waste disposal.

The following is a brief summary of the individual waste management areas at the site. The locations of the waste management areas are shown in Figure 1-2. A summary of documented waste disposal to the industrial waste disposal zones is contained in Table 1-1.

- **Zone A/North-South Burn Trench (BT-2)/Balefill -** disposal of solvents, paints, cleaners, and other industrial waste drums in Zone A, disposal and refuse burning in BT-2, and disposal of baled municipal waste in the Balefill Areas; Zone A is capped with polyethylene sheeting and a soil cover of approximately 2 feet (ft). The Burn Trench is currently covered with approximately 2 ft of native material. The Balefill Area is not completely covered.
- **Zone B** - disposal of 2,4-D tar, MCPA bleed, and other herbicide waste drums; capped with polyethylene sheeting and a soil cover of approximately 2 ft.
- **Zones C and D and the East-West Burn Trenches (BT-1) -** disposal of bulk plywood resin waste, wood treatment and preservative waste, lime sludge, cutting oils, paint and solvent waste, and other bulk liquid waste in Zones C and D; disposal and burning of refuse in BT-1; Zones C and D are capped with polyethylene sheeting and a soil cover of approximately 2.8 ft. BT-1 is currently covered with approximately 2 ft of native material.
- **Zone E and Temporary Storage 1/Sewage Lagoon 1 (TS-1/SL-1) -** disposal of chlor-alkali waste in Zone E; temporary storage of chlor-alkali sludge followed by disposal of septic tank and chemical toilet pumpings in TS-1/SL-1; Zone E is capped with polyethylene sheeting and approximately 3 ft of soil. TS-1/SL-1 is currently situated under native fill.

- **Zone U-1 and Temporary Storage 2 (TS-2)** - disposal of plywood resin waste, wood treatment and preservative waste, lime sludge, cutting oils, paint and solvent waste, and other bulk liquid waste in Zone U-1; off-loading and temporary storage of chlor-alkali sludge in TS-2; both areas are capped with 3 ft of native fill.
- **Municipal Landfill** - refuse burning; disposal of septic, municipal, and agricultural wastes; dried sludges from former sewage lagoons SL-2 and SL-3; capped with at least 3 ft of native soil.
- **Sewage Lagoons 2 and 3 (SL-2 and SL-3)** - disposal of septic tank and chemical toilet pumpings; dried sludges were excavated and moved to the sanitary landfill. These areas are covered with approximately 2 ft of native fill.
- **SMA and LSA** - land spreading of sewage sludges and animal fat emulsion coolants.

A more detailed synopsis of site background information, including discussions on land use, meteorology, geology, hydrogeology, hydrology, site history, and the waste disposal zones can be found in Section 1 of the Final Phase II RI Report (Philip Environmental Services Corporation 1998).

1.2 SUMMARY OF WORK COMPLETED TO DATE

1.2.1 SITE INVESTIGATION

Site investigation activities have been conducted at the site under the supervision of Ecology, the USEPA, or their contractors since 1984 to assess potential releases of hazardous substances to the environment. The site was nominated to the National Priority List (NPL) of Superfund sites by USEPA in June 1988 and placed on the NPL in February 1990. Phase I of the Remedial Investigation (RI) was begun in 1992, and was completed with the submittal of the Final Phase I RI Report in 1994. The Phase II RI activities began in May 1995. During the summer of 1995, it was determined that off-site groundwater had been impacted by releases from the site. This determination resulted in an increase in scope of the Phase II RI to include an expanded off-site groundwater investigation and identification of potentially impacted drinking water wells located hydraulically downgradient from the site.

During the Phase I and Phase II RI Investigations, geophysical investigations were conducted using ground penetrating radar, ground magnetics, and electromagnetic induction to identify the extent of the various waste areas. Hydrogeological parameters have been evaluated by conducting a pumping test and analyzing soil samples for moisture content, hydraulic conductivity, porosity and permeability.

Soil analyses have included various physical parameters, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, herbicides, dioxins/dibenzofurans, and radionuclides. Samples of bulk waste materials from Zones C, D, and E have been collected and analyzed for characterization in accordance with Washington Dangerous Waste Regulations (WAC 173-303) and Federal Resource Conservation and Recovery Act (RCRA) regulations. Soil gas has been investigated and analyzed for VOCs, oxygen, carbon dioxide, methane, and acid gas.

A total of 51 groundwater monitoring wells were sampled during the Phase II RI to evaluate potential impacts from historical disposal activities at the site. Groundwater samples were analyzed for VOCs, SVOCs, herbicides, Appendix I metals, Appendix II metals, and water quality parameters. Thirty-five groundwater monitoring wells are currently being sampled quarterly as part of the ongoing post RI groundwater monitoring program. The results of these analyses are reported to Ecology and the Benton-Franklin District Health Department in the quarterly and annual Groundwater Monitoring Reports for the site.

1.2.2 Risk Assessment/Cleanup Level Analysis

A risk assessment/cleanup level analysis (RA/CLA) report was prepared for the site and accepted by Ecology as Final in September 1998. The RA/CLA is a tool that is used during the RI/FS process to:

- identify site-specific Indicator Hazardous Substances (IHSs);
- evaluate reasonable maximum exposures (RMEs) under current and future exposure scenarios; and
- develop site-specific risk-based cleanup levels for the IHSs, for use in the FS.

Comparing detected concentrations to background and risk-based levels identifies the IHSs for soil and groundwater. The screening method used is sufficiently conservative to identify the IHSs that contribute the majority of potential site-related risk. These IHSs are used in the FS to evaluate whether alternative remedial actions protect public health and the environment.

The RA/CLA used conservative assumptions in screening IHSs and developing the site-specific cleanup levels. For example, it was assumed that all chemicals detected in on-site and off-site groundwater monitoring wells are present at all exposure points when adjusting groundwater cleanup levels downward for exposure to multiple chemicals. However, all chemicals have never been detected in any one location. The conservative assumptions tend to overestimate actual site risk, and result in the calculation of very low cleanup levels. In fact, cleanup levels in groundwater calculated for the Pasco Sanitary Landfill Site are much lower than levels allowed in municipal drinking water. For this reason, exceedances of these low risk-based cleanup levels do not necessarily indicate that an actual health impact has or will occur. Rather, the exceedance indicates that the chemical warrants consideration in the FS when evaluating alternative remedial actions.

1.2.3 INTERIM REMEDIAL MEASURES

Based on the results of the off-site groundwater investigation and other RI activities, and, in anticipation of this FS, the following Interim Remedial Measures (IRMs) were implemented at the site beginning in 1996.

1. Users of drinking water wells in the area potentially impacted by the off-site groundwater plume were provided bottled drinking water beginning in March 1996 during the continued investigation of the contaminant plume.

2. The City of Pasco municipal water supply system was extended east along Lewis Street to connect those users whose wells were identified as being impacted by groundwater contamination, in order to preclude exposure to contaminated groundwater. The installation of the water main extension and hookup to the city water system was completed in December 1997. At that time the bottled drinking water program was discontinued. Semi-annual sampling of drinking water wells in the area which were not shown to have been impacted, is performed as part of the ongoing post-RI groundwater monitoring.

3. A Soil Vapor Extraction (SVE) system was installed in the vicinity of Zone A in May 1997. The system removes and destroys contaminants in the vadose zone and limits the transport of contaminants to groundwater.

4. A NoVOCs™ in-well air stripping groundwater treatment system was installed to remove and destroy VOCs from groundwater and limit off-site migration of

contaminants. The configuration of the SVE and NoVOCs™ systems is shown on Figure 1-3.

A complete discussion of the SVE system, the NoVOCs™ system, and the city water extension project is contained in the Interim Measures Completion Report submitted to Ecology in February 1998 (Philip Environmental Services Corp., 1998). Performance of the IRM systems is communicated to Ecology on a quarterly basis with the Post-RI quarterly data submittals. The results of the SVE and NoVOCs™ systems are used in this FS to evaluate these technologies as part of the final remedial action at the site.

TABLE 1-1
WASTE INVENTORY

PASCO LANDFILL PHASE II RI

ZONE A			
INVENTORY A[1]		**INVENTORY B[2]**	
WASTE TYPE	**DRUMS**	**WASTE TYPE**	**DRUMS**
Paint Waste	21,654	Paint Waste	24,200
Metal Cleaning Waste	6,894	Metal Casting Waste	8,774
Metal Finishing Waste	1,668	Metal Finishing Waste	304
Wood Treatment Waste	1,100		
Oily Waste	433	Oily Waste	433
Tar Aromatic	248	Tar Aromatic	160
Wood Preservative	238	Cadmium Waste	11
Insecticide	191	Pesticide	425
Etching Solution	160	Acid Waste	544
Chemical Lab Reagent	1	Carcinogenics	9
TOTAL:	**32,587**	**TOTAL:**	**34,860**
Empty Pesticide Drums	1,045	Empty Pesticide Drums	863
Miscellaneous Lab Chemicals	29 Small Containers		
ZONE B			
INVENTORY A[3]		**INVENTORY B[4]**	
WASTE TYPE	**DRUMS**	**WASTE TYPE**	**DRUMS**
2,4-D	2,011	2,4-D Tar	1,914
MCPA Bleed	2,965	MCPA Bleed	2,813
Laboratory Samples	20	Tar	74
Filter Aid	110	Other	449
Pit Cleanings MCPA	20		
Pit Cleanings 2,4-D	20		
Water System Cleanings	30		
Water System Cleanings	14		
Ground Cleanings	66		
Floor Sweepings	85		
Filter Seal Tank	30		
Filter Cartridges	10		
Ester Pit Cleanings	10		
Tank Farm Sump	20		
TOTAL:	**5,411**	**TOTAL:**	**5,250**

[1]Source: RRC Monthly Reports to Ecology and October 19, 1973 Summary
[2]Source: Hand-written Summary Sheets, Undated
[3]Source: Letter from Rhodia, Inc., dated 6/28/73
[4]Source: Letter from RRC dated 8/24/84

TABLE 1-1
WASTE INVENTORY

PASCO LANDFILL PHASE II RI

ZONE C, D AND U-1

INVENTORY A[1]		
WASTE TYPE	**GALLONS**	**POUNDS**
Undesignated	327,000	
Chrome Plating Waste	8,790	
SUBTOTAL AS OF 9/30/73	**335,790**	
10/1/73 - 12/31/74		
Lime Sludge	26,413	
Cutting Oils	60,750	
Wood Preservative Waste	46,542	
Paint Waste Cleaning	95,711	
Wood Treatment Waste	148,120	
Resin Manufacture Waste	392,553	
Plywood Resin Waste	1,393,380	
Oily Sludge	166,680	
Paint and Solvent Waste	72,475	
Paint Waste		266,778
Fertilizer Manufacture		228,288
Waste	138,501	562,400
Chrome Rinse Water	46,970	1,949,652
Metal Finishing Waste	10,500	
Detergent Metal Wash	1,000	
Acid Sludge		312,350
Acid Wash Solution		176,000
Benzoic Acid and Tars	35,724	
Metal Rinse Solution	1,000	
Bilge Cleanings		
SUBTOTAL:	**2,972,109**	**3,495,468**

ZONE C

INVENTORY B[2]		
WASTE TYPE	**GALLONS**	**POUNDS**
Lime Sludge	684,967	
Metal Cleaning Waste	185,162	
Acids	7,000	
Metal Finishing Waste	17,000	
Metal Cleaning Waste		2,301,560
Metal Finishing Waste		1,460,602
TOTAL	**894,129**	**3,762,162**

ZONE D

INVENTORY B[2]		
WASTE TYPE	**GALLONS**	**POUNDS**
Cutting Oils	84,300	
Paint Waste	66,516	
Plywood Resin Waste		2,215,440
Oily Sludge	66,340	
Solvents	12,648	
Paint Waste		447,418
Fertilizer Manufacture Waste		228,288
Aromatic Tar		489,270
TOTAL:	**229,804**	**3,380,416**

[1]Source: RRC Monthly Reports to Ecology and October 1973 summary
[2]Source: Hand-written Summary Sheets, Undated

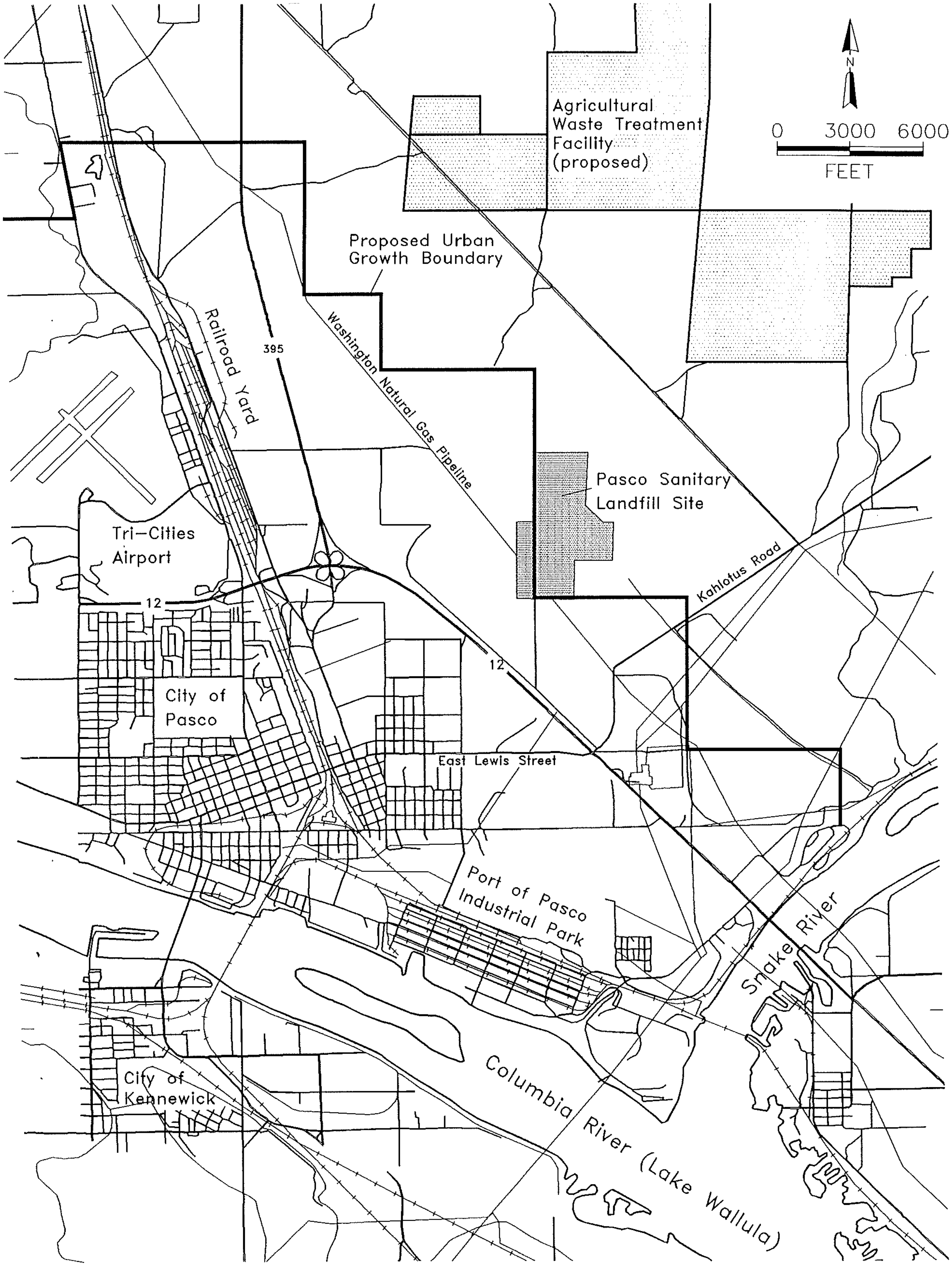
TABLE 1-1
WASTE INVENTORY

PASCO LANDFILL PHASE II RI

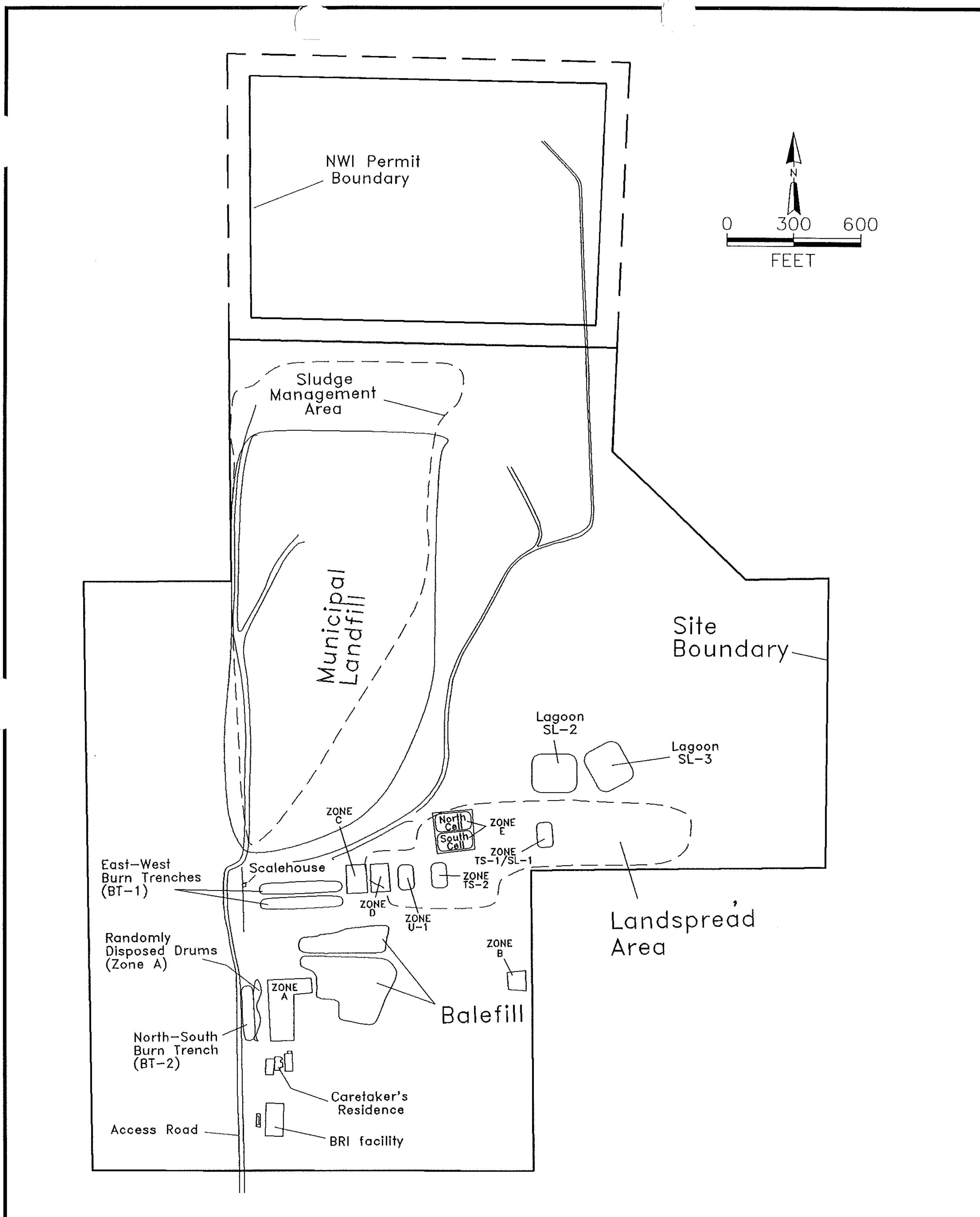
Zone E					
Inventory A[1]			Inventory B[2]		
Waste Type	Tons		Waste Type	Tons	
Chlor-Alkali Waste	11,088		Chlor-Alkali	11,582	
TOTAL:	**11,088**		**TOTAL[3]:**	**11,582**	

Unknown					
Inventory A[1]					
Waste Type	Quantity	Units			
Solidified Caustic Soda	44,500	Pounds			
Weed Killer	680	Pails			

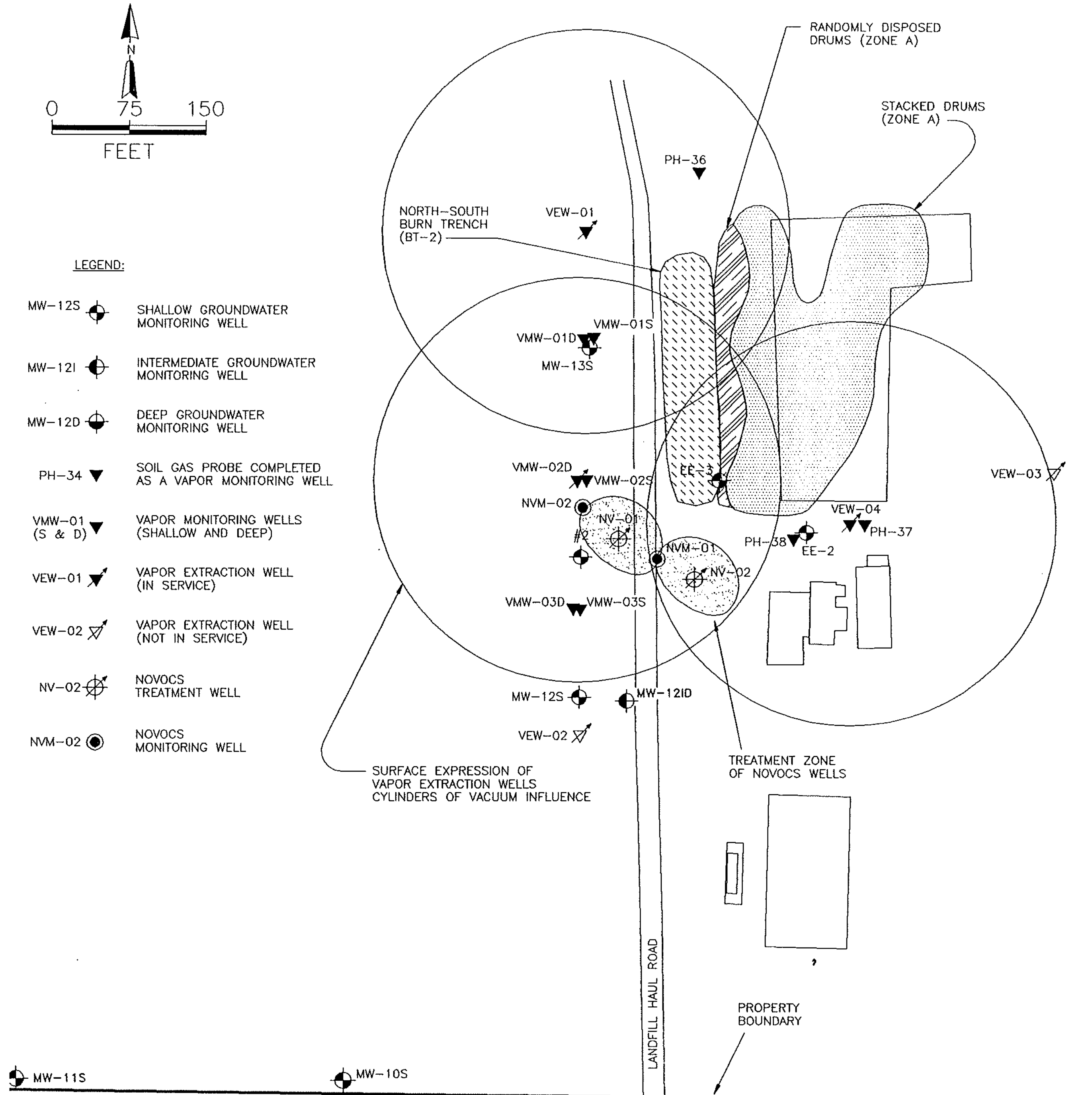
[1]Source: RRC Monthly Reports to Ecology and October 19, 1973 Summary
[2]Source: Hand-written Summary Sheets, Undated



PHILIP ENVIRONMENTAL	TITLE: Site Vicinity Pasco Landfill Feasibility Study	DWN: drp	DES.: plgfs05	PROJECT NO.: 624419
		CHKD:	APPD:	FIGURE NO.: 1–1
		DATE: 04/22/99	REV.: 3	



PHILIP ENVIRONMENTAL	TITLE: Site Plan Pasco Landfill Feasibility Study	DWN: drp	DES.: plgfs04	PROJECT NO.: 624419
		CHKD:	APPD:	FIGURE NO.: 1-2
		DATE: 04/22/99	REV.: 6	



NOTE:

VAPOR EXTRACTION CYLINDERS OF VACUUM INFLUENCE CENTERED ON VEW-01, VMW-02D, VEW-04.

ZONE OF INFLUENCE OF NOVOCS EXTRACTION WELLS CENTERED ON NV-01 AND NV-02.

PHILIP ENVIRONMENTAL	TITLE: Soil Vapor Extraction and NoVOCs System Configuration Pasco Landfill Feasibility Study	DWN: drp	DES.: plgfs06	PROJECT NO.: 624419
		CHKD:	APPD:	FIGURE NO.: 1-3
		DATE: 04/22/99	REV.: 2	

2 CONTAMINATION TO BE REMEDIATED AND PHYSICAL HAZARDS TO BE REMOVED

2.1 NATURE AND EXTENT OF CONTAMINATION

A brief summary of the conclusions regarding the nature and extent of contamination at the site is provided below. The discussion of individual waste zones is presented alphabetically followed by the former Municipal Landfill. As noted in Section 4.1 of the Final Phase II RI Report, no constituents were detected in site soils outside the individual waste management areas above site-specific cleanup levels during either Phase I or Phase II sampling. As noted in Sections 4.6, 4.7, and 4.8 respectively, Zones U-1 and TS-2, Lagoons SL-2 and SL-3, and the SMA and LSA are not impacting groundwater and soils within these areas are below site-specific cleanup levels. For these reasons, these areas are not considered further in the FS.

2.1.1 ZONE A/ NORTH-SOUTH BURN TRENCH/ BALEFILL

Evaluation of groundwater monitoring data indicates that VOCs migrating from waste in Zone A are impacting groundwater at the site. Analysis of soil-gas data reveals the presence of elevated concentrations of methane accompanied by depressed oxygen concentrations in the vadose zone surrounding Zone A, indicating that biological degradation of the waste is occurring. The data also indicate that a soil-gas plume containing VOCs has extended beyond the boundaries of Zone A and may be impacting groundwater in other areas of the site.

2.1.2 ZONE B

No herbicides were detected in any soil samples collected from the area adjacent to Zone B. Although some dioxin congeners were detected above background concentrations in soil samples collected from the area adjacent to Zone B, no dioxin congeners were detected above MTCA Method B formula values in any Zone B soil samples.

A total of 16 VOCs were detected in Zone B Wells. However, 14 of the 16 VOCs were only detected during one sampling event (June 1995) and 10 of the 16 VOCs detected in Zone B Wells were also detected in up-gradient background wells during the same sampling event. These data indicate that Zone B is not acting as a source of VOCs in groundwater.

2.1.3 ZONES C AND D

Six VOCs were detected in soil samples collected from directly beneath the zones. All six compounds were below their respective MTCA Method B formula values based on direct exposure. However, acetone was present in soils under Zone C above protection of groundwater levels. None of the six VOCs detected in the soil were present above their respective MTCA Method B formula values in groundwater samples collected from Zone C and D Wells.

Groundwater contaminated with solvents occurs downgradient of Zones C and D. However, each of the 20 VOCs detected in Zone C and D wells during Phase II sampling was also detected in wells upgradient from Zones C and D; 18 of the 20 VOCs were also detected in soil-gas samples from the areas adjacent to Zone A and the Municipal Landfill. The evaluation of the location, timing, and concentration of each VOC detected in the bulk waste material, in soil from beneath the zones, and in adjacent groundwater monitoring wells indicates that their presence in groundwater, with the possible exception of xylenes, is not associated with Zones C and D. Together, these data indicate that Zones C and D are not acting as significant sources of VOCs in groundwater.

2.1.4 ZONE E AND ZONE TS-1

Groundwater contaminated with VOCs and metals occurs downgradient of Zone E. However, the results of the Phase II Bulk Waste Characterization Analyses, the additional Zone E waste profiling analyses conducted during May 1997, and the evaluation of the location, timing, and concentration of each detected VOC and metal indicates that their presence in groundwater is not associated with Zone E. Together, these data indicate that Zone E is not acting as a significant source of contaminants in groundwater.

2.1.5 MUNICIPAL LANDFILL

Evaluation of groundwater monitoring data indicates that VOCs migrating from waste in the former Municipal Landfill are impacting groundwater at the site. Analysis of landfill gas data reveals the presence of elevated concentrations of methane accompanied by depressed oxygen concentrations along the western boundary of the former Municipal Landfill, indicating that biological degradation of the waste is occurring. The data also indicate that a soil-gas plume containing VOCs has extended beyond the boundaries of the former municipal landfill and may be impacting groundwater in other areas of the site.

2.2 Contaminant Fate and Transport

An analysis of geologic and hydrogeologic data collected from the Pasco Landfill site and other areas of the Pasco Basin indicates that four broad hydrostratigraphic units are present in the subsurface. These units are:

1. the unsaturated zone (including eolian sands, Touchet beds, and unsaturated portions of the Upper Pasco Gravels);
2. the unconfined aquifer system (including saturated portions of the Lower Pasco Gravels and the Middle Ringold formation);
3. the confining layer (made up of the Lower Ringold Formation and low permeability flows of the Columbia River Basalt); and
4. the confined aquifer system (made up principally of the more permeable interflow and interbed zones of the Columbia River Basalt Group).

The surface of the groundwater in the unconfined aquifer system occurs 20 to 80 feet below the ground surface. The groundwater flows to the south and southwest beneath the site. Horizontal gradients and hydraulic conductivity at the site show seepage velocities varying from a high of 19.2 ft/day in the central portion of the site to a low of 0.039 ft/day south and down-gradient from the site. Analysis of vertical gradients in the immediate vicinity of the site shows no apparent trends.

2.2.1 Site Soil and Soil-Gas

Analysis of soil data indicates that there has been no significant impact to the soils outside the footprint of the former Municipal Landfill and the primary disposal zones. Soil-gas analysis shows a large zone of VOC contaminated soil gas surrounding the former Municipal Landfill and Zone A. The RI concluded that the migration of dense vapors of chlorinated organic VOCs through the vadose zone was likely a major contributor to the contaminant loading seen in the groundwater at the site.

2.2.2 SITE GROUNDWATER

The results of the Phase II RI show that shallow groundwater (within 50 feet of the groundwater surface) at the site has been impacted by VOCs (primarily chlorinated VOCs) migrating from the wastes within the former Municipal Landfill and Zone A. The deeper groundwater does not appear to be impacted.

2.2.3 OFF-SITE GROUNDWATER

Impacts to off-site groundwater from the site were first discovered in the summer of 1995. The results of the Phase II RI and ongoing groundwater monitoring programs indicate that VOCs in excess of established site specific clean up standards are present in groundwater hydraulically down-gradient from the site. Analysis of the Phase II RI and ongoing groundwater monitoring data indicate that the impacts to off-site groundwater have resulted from releases of VOCs from Zone A and the former Municipal Landfill.

2.3 INDICATOR HAZARDOUS SUBSTANCES

According to WAC 173-340-708 (2)(a), when defining cleanup requirements at a site contaminated with a large number of hazardous substances, those substances that contribute a small percentage of the overall threat to human health and the environment may be eliminated from consideration. The remaining hazardous substances serve as preliminary IHSs for purposes of defining site cleanup requirements and selecting a cleanup action.

The screening process used to develop the preliminary and subsequently the final IHSs in soil and groundwater is consistent with the regulations specified by the Model Toxics Control Act (MTCA) in WAC 173-340. This process is depicted in Figures 7 and 8 of the RA/CLA, and described in detail in Section 2.4 of the RA/CLA Report.

Thirteen chemicals were identified as the final IHSs for groundwater: acetone, benzene, chromium (assumed hexavalent at the direction of Ecology), 1,2-dichloroethane, 1,1-dichloroethene, cis- and trans-1,2dichloroethene, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethene, and vinyl chloride. Chromium was identified as an IHS for groundwater, due to the fact that detected concentrations of total chromium were assumed to be in the hexavalent form for the purpose of the RA/CLA. This was done at the direction of Ecology. The objections of the PLP Group, based on analytical data from the RI for both total and hexavalent chromium, are noted in the RA/CLA Response to

Comments letter to Ecology dated August 31, 1998. One final soil IHS, acetone, was identified for the protection of groundwater. The RA/CLA concluded that no IHSs exist at the site for direct contact with soil or protection of air.

2.4 CLEANUP STANDARDS

A preliminary step to developing site specific cleanup levels, is the establishment of RME scenarios for soil and groundwater. Because the site is, and will be, used for landfill support operations, the RME scenario for soil is industrial land use. Because groundwater in the area is used for drinking water the RME scenario for groundwater is drinking water. As a result, MTCA Method B cleanup levels were identified for groundwater and Method C cleanup levels were identified for soil. The establishment of RMEs for the site is described in detail in Section 3.3 of the RA/CLA report.

2.4.1 CLEANUP LEVELS

MTCA Method B cleanup levels were developed for the final IHSs in groundwater using the procedure presented in WAC 173-340-720 (3).

The Method B cleanup levels for individual IHSs were adjusted downward, as necessary, to meet the total risk and hazard index (HI) goals for the combined IHSs. The HI cannot exceed one and the total excess cancer risk cannot exceed one in 100,000 (1×10^{-5}) (WAC 173-340-700-(3)(b)). It was necessary to adjust the Method B cleanup levels for four final IHSs to meet the total risk and HI goals specified under MTCA. The calculated Method B levels for groundwater are shown in Table 2-1.

Method C soil cleanup must be adjusted downward, if necessary, to meet the total risk and HI goals identified in WAC 173-340-740 (5)(a). The HI cannot exceed one and the total excess cancer risk cannot exceed one in 100,000 (1×10^{-5}). However, since only one final IHS (acetone) was identified for soil, no adjustments to the cleanup level were necessary. The Method C soil level for acetone is also presented in Table 2-1.

2.4.2 POINTS OF COMPLIANCE

The MTCA regulations, WAC 173-340-720(6), define the point of compliance for groundwater as "the point or points where the groundwater cleanup levels established… (for the site)… must be attained". Where hazardous substances remain on site as part of a containment strategy within the cleanup action, Ecology may approve a conditional point of compliance as close as practicable to the source but not to exceed the property boundary (WAC 173-340-720 (6)(c)).

The point of compliance for soil is defined similarly in WAC 173-340-740 (6). For those cleanup actions that involve containment of hazardous substances, the cleanup may be determined to comply with the cleanup levels provided the requirements for containment technologies are met.

2.5 CONTAMINANTS AND ZONES REQUIRING REMEDIATION

The following discussion details the dimensions of each of the zones, estimates the volume of the waste, estimates the volume of impacted soil directly beneath the zone as applicable, and notes which compounds are present in groundwater above the established site specific cleanup levels. As noted in the RI and restated in Section 2.1 above, VOCs in groundwater are the primary contaminant of concern at this site.

ZONE A

The approximate surface area boundary of buried drums at Zone A is best illustrated by the Phase II EM-31 in-phase geophysical survey data as provided in Figure 3-61, of the Final Phase II RI. Based on this data, the estimated surface area of Zone A is 1.54 acres. Based on the site history completed in the RI, it is estimated that the depth of waste is approximately twelve feet, equal to a stack of drums four high. This yields a waste volume of approximately 29,820 cubic yards.

During the nine rounds of groundwater sampling events included in the RI report (through February 1997), prior to the implementation of the IRMs, eleven of the twelve VOC groundwater IHSs were present above the established cleanup levels at monitoring well EE-3 immediately adjacent to the Zone. Six of these eleven compounds (PCE, TCE, cis-1,2-DCE, 1,1-DCE, vinyl chloride, and 1,2-DCA) were detected above their cleanup levels at MW-10S, at the site boundary. These two wells are referenced as they represent the heart of the plume emanating from Zone A.

All eleven of the VOCs present above cleanup standards at EE-3 are currently being remediated from the vadose zone by the SVE system. Assuming that vadose zone soils are contaminated from the base of the drums to the surface of the groundwater (approximately 63 feet bgs), over the surface area of the drums noted above, a total of 94,425 cubic yards of soil are impacted by VOCs.

<u>ZONE B</u>

The approximate surface area of Zone B per the 1975 surveyed boundaries is 6,880 square feet. Based on the site history completed in the RI, it is estimated that the depth of the drums is approximately twelve feet, equal to a stack of drums four high. This yields a waste volume of approximately 3,060 cubic yards.

During the RI, soil samples collected immediately adjacent to Zone B had trace detections of 21 dioxin congeners above calculated background levels. As determined by the RA/CLA none of these dioxin congeners exceeded the MTCA Method C cleanup level. No dioxins were detected in groundwater samples during the RI. No herbicides were detected in either soil or groundwater samples collected during the RI. Dioxins are relatively immobile in soils, therefore it is estimated that not more than 10 feet of soil beneath the footprint of the drums (2,550 cubic yards) may potentially require remediation.

During the nine rounds of groundwater sampling events included in the RI report (through February 1997), only one groundwater IHS, 1,1-DCE, was detected above the established cleanup levels at the Zone B monitoring wells. This occurred only in the first Phase II sampling round in June 1995, in the upgradient well MW-25S. This compound was not detected in subsequent RI sampling events. As noted in Section 2.1.2 above, Zone B is not acting as a source of VOCs in groundwater.

<u>ZONES C AND D</u>

The approximate surface area of Zones C and D combined per the 1975 surveyed boundaries is 24,830 square feet. Boring B-19 demonstrated a waste depth of nine feet. This depth yields a waste volume of approximately 8,280 cubic yards.

During the RI, soil samples collected immediately below Zone C showed concentrations of acetone above the established cleanup level from beneath the waste to the sample collected at a depth of 46 feet bgs (RI Table 3.23). This cleanup level is based on protection of groundwater. It is important to note that the presence of acetone in groundwater at Zone A is the reason that a cleanup level for acetone in soil was established for the site. Acetone is not found in groundwater immediately downgradient from Zones C and D. While acetone concentrations in soils beneath Zone C are above the established site-specific cleanup levels for the protection of groundwater, in actuality acetone in soil beneath Zone C is not impacting groundwater.

Other non-chlorinated VOCs were present below Zones C and D. Assuming a footprint equal to the dimensions of Zones C and D combined and from directly beneath the waste to 46 feet bgs, a total of 36,785 cubic yards of soil are impacted by acetone and other non chlorinated VOCs.

During the nine rounds of groundwater sampling events included in the RI report (through February 1997), only one groundwater IHS, PCE, was consistently detected above the established cleanup levels at the Zone C and D monitoring well EE-7. 1,1-DCE was detected above it's cleanup level once in September 1995 at MW-18S. Due to the reasons noted in Section 2.1.3 above, Zones C and D are not acting as a significant source of VOCs in groundwater.

ZONE E

The approximate surface area of Zone E per the 1975 surveyed boundaries is 32,550 square feet. Based on observations during the Phase II field work, the depth of waste was estimated at ten feet. This yields a waste volume of approximately 12,060 cubic yards. Given the type of waste in Zone E and the lack of corresponding contaminants in the groundwater down gradient of the zone, for the purposes of this FS, it is assumed that not more than 10 feet of soil beneath the footprint of the zone (12,060 cubic yards) may potentially require remediation.

During the nine rounds of groundwater sampling events included in the RI report (through February 1997), only one groundwater IHS, PCE, was consistently detected above the established cleanup levels at the Zone E monitoring well MW-27S. 1,1-DCE was detected above its cleanup level twice in September 1995 and March 1996 and 1,2-DCA once in June 1995 also at MW-27S. During these nine sampling events, throughout the site, chrome was detected above its established cleanup level only in monitoring wells EE-8 and MW-19S. Chrome concentrations in wells MW-14S and EE-2 immediately down gradient of these wells are all below the cleanup level and have often been non-detect. As noted in Section 2.1.4 above, Zone E is not acting as a significant source of metals or VOCs in groundwater.

MUNICIPAL LANDFILL

As noted in Section 1.3 of the Final Landfill Closure Plan (Woodward Clyde Consultants 1997) the Municipal Landfill covers approximately 36.7 acres and contains approximately 1.5 million tons of waste.

During the nine rounds of groundwater sampling events included in the RI report (through February 1997), six groundwater IHSs have been detected in landfill monitoring wells, above the site-specific cleanup levels. PCE is consistently detected above the established cleanup levels at all of the landfill monitoring wells. TCE, 1,1-DCE, and vinyl chloride have been consistently detected above cleanup standards in monitoring well #4. 1,2-TCA was detected during one round in monitoring well #4 and MW-16S and cis-1,2-DCE was detected once in MW-17SR, above their respective cleanup levels.

<u>GROUNDWATER</u>

The Municipal Landfill and Zone A are the sources of groundwater contamination above the site specific cleanup levels. Six compounds, PCE, TCE, cis-1,2-DCE, 1,1-DCE, vinyl chloride, and 1,2-DCA, are present above clean up levels beyond the site boundary. The Landfill and Zone A are the sources of PCE above cleanup levels beyond the site boundary. Although the Landfill and Zone A are both sources of the remaining compounds, Zone A appears to be the only source of these compounds above cleanup levels beyond the site boundary.

Using the PCE plume as depicted from the last RI sampling round, February 1997, the total volume of groundwater impacted by the site can be estimated at 48 million gallons of water. This was calculated using a surface dimension based on the contour of the plume above the 0.80 ug/L clean up level, a porosity of 30%, and a depth dimension of 50 feet (as noted in Section 2.2.2).

2.6 SUMMARY OF CONTAMINATION TO BE REMEDIATED

The following summarizes the media impacted and contamination to be remediated.

Zone	Waste	Soil	Groundwater
A	Yes	Yes, directly beneath zone, from beneath waste to surface of groundwater	Yes
B	Yes	Minimal impact to soil assumed. Potentially impacted 10 feet below waste.	No
C/D	Yes	Yes, acetone exceeds cleanup level for protection of groundwater in soil above 46 ft. However, no impacts to groundwater are seen.	No
E	Yes	Minimal impact to soil assumed. Potentially impacted 10 feet below waste.	No
Landfill	Yes	Yes	Yes
Groundwater	N/A	N/A	Impact above site-specific cleanup levels on-site at Landfill and Zone A. Plume appears to extend off-site to MW-42.

TABLE 2-1

FINAL INDICATOR HAZARDOUS SUBSTANCES
SITE-SPECIFIC CLEANUP LEVELS

PASCO LANDFILL FEASIBILITY STUDY

GROUNDWATER

ANALYTE	CLEANUP LEVEL
Acetone	400.0
Benzene	2.0
Chromium (hexavalent)	80.0
1,2-Dichloroethane	0.5
1,1-Dichloroethene	0.07
1,2-Dichloroethene (cis)	40.0
1,2-Dichloroethene (trans)	50.0
Tetrachloroethene	0.8
Toluene	500.0
1,1,1-Trichloroethane	200.0
1,1,2-Trichloroethane	0.8
Trichloroethene	4.0
Vinyl chloride	0.02

Notes: Concentrations in µg/L.
Chromium in solution is assumed to be hexavalent (at the direction of Ecology).

SOIL

ANALYTE	CLEANUP LEVEL
Acetone	80,310

Notes: Concentrations in µg/kg.
Cleanup level based on protection of groundwater.

3 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

This section identifies and evaluates federal and state requirements that are potentially applicable or relevant and appropriate (ARARs) for remedial actions at the Pasco Sanitary Landfill (the site) located in Pasco, Washington. The ARAR identification process is based on criteria presented in WAC 173-340-710.

Washington Administrative Code (WAC) 173-340-360(2) (Selection of Cleanup Actions - Threshold Requirements) and 173-340-710(1)(a) (Applicable State and Federal Laws) require that cleanup actions conducted under the Model Toxics Control Act (MTCA) shall comply with applicable state and federal laws. "Applicable state and federal laws" include legally applicable requirements and those requirements that the Washington Department of Ecology may determine are relevant and appropriate [WAC 173-340-710(1)(a)].

The Memorandum of Agreement between EPA Region 10 and Ecology that assigns Ecology as the lead agency for the Pasco Landfill Site states at paragraph A.7 that "work on state lead NPL sites will be done using only state authorities". Further, the same agreement states at paragraph D.1 that "All remedial actions at NPL Sites must comply with promulgated federal and more stringent state standards, requirements, criteria and limitations that are legally applicable or relevant and appropriate to the circumstances at the site (ARARs)".

In order to be defined as a "legally applicable" requirement, the requirement must be promulgated under state or federal law and must specifically address a hazardous substance, cleanup action, location or other circumstance at the site. "Relevant and appropriate" requirements are limited to those requirements promulgated under state and federal laws that, while not legally applicable, are determined by Ecology to address circumstances sufficiently similar to those encountered at the site that the use of the requirements is well suited to particular site conditions. WAC 173-340-710(3) also includes a limited number of regulations that are automatically considered to be relevant and appropriate requirements.

Identification of ARARs must be made on a site specific basis and involves a two part analysis: first, a determination is made whether a given promulgated requirement is applicable; then, if it is not applicable, a determination is made whether it is both relevant and appropriate.

A requirement may be either "applicable" or "relevant and appropriate" for a given situation but not both.

The following discussion emphasizes the primary ARARs for the Pasco Landfill site. A complete list of potential ARARs is presented in Tables 3-1 and 3-2.

3.1 PRIMARY ARARS

3.1.1 MODEL TOXICS CONTROL ACT - RCW 70.105D

MTCA is the primary governmental statute governing the conduct of the overall investigation and cleanup process for the site and is therefore applicable. MTCA specifies: the criteria for approving cleanup actions, the order of preference for implementing cleanup technologies, policies for permanent solutions, the application of these criteria to particular situations, and the process for making decisions. The MTCA cleanup regulation specifies that all cleanup actions must be protective of human health and the environment, comply with cleanup standards, comply with all applicable state and federal regulations, and provide for appropriate measurements of compliance.

Amendments to the MTCA (RCW 70.105D.090) exempt remedial actions conducted pursuant to an Agreed Order or a Consent Decree from the procedural requirements of several state laws. These include the State Clean Air Act (RCW 70.94), Solid Waste Management - Reduction and Recycling Act (RCW 70.95), and Hazardous Waste Management Act (RCW 70.105), which are applicable to the Pasco Landfill. In addition, the exemption also applies to the procedural requirements of any laws requiring or authorizing local governmental permits or approval for the remedial action. Therefore, while substantive compliance is necessary, permits and approvals are not required for remedial actions at the site. Substantive requirements are included in the Consent Decree, Agreed Order, or Enforcement Order implementing the cleanup action.

In a similar way, federal laws and regulations indicate that remedial actions taken under CERCLA that are conducted entirely on site do not require federal state or local permits. On-site remedies must comply with the substance of the relevant and appropriate requirements but do not need to comply with the administrative or procedural requirements.

3.1.2 MODEL TOXICS CONTROL ACT CLEANUP REGULATION - WAC 173-340

The MTCA cleanup regulation under Chapter 173-340 WAC, which implements the requirements of the MTCA, is the principal regulatory vehicle under which the remedial measures for the Pasco Landfill site will be implemented, and is therefore applicable. This regulation establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have been released.

WAC 173-340-700 establishes cleanup levels for environmental media, including groundwater, surface water, soil, and air. The Pasco Landfill Risk Assessment and Cleanup Level Analysis Report dated September 1998 and accepted by Ecology was completed in compliance with WAC 173-340-700 and establishes chemical specific cleanup levels for the Pasco Landfill Site.

3.1.3 STATE ENVIRONMENTAL POLICY ACT (SEPA) – RCW 43.21C

SEPA applies to remedial measures at the Pasco Landfill. SEPA requires all governmental agencies to identify and consider the effects of public or private proposals on the quality of the environment. The statute is implemented by the SEPA Rules at WAC 197-11. Under WAC 197-11-784, a "proposal" includes both actions and regulatory decisions of agencies, as well as actions proposed by applicants. A threshold determination by the lead agency is required for any proposal which meets the definition of action and is not categorically exempt from SEPA. (WAC 197-11-310(1)). The purpose of the threshold determination process is for the lead agency to decide whether to require preparation of an Environmental Impact Statement (EIS). The decision to proceed with remedial measures at the Pasco Landfill will constitute an "action" under SEPA for which Ecology will act as lead agency. Ecology will require the PLPs to prepare and submit a SEPA Checklist which identifies potential impacts on the environment resulting from the remedial measures.

If Ecology determines that the proposal is a major action with probable, adverse impacts on the environment, Ecology will issue a Determination of Significance that requires preparation of an EIS. (WAC 197-11-360). The function of an EIS is to provide impartial discussion of significant environmental impacts and inform decisionmakers and the public of reasonable alternatives, including mitigation measures. (WAC 197-11-400). If Ecology determines that there will be no probable adverse environmental impacts from the proposed remedial measures, Ecology will issue a Determination of Non-Significance (DNS) and no EIS will be required. (WAC 197-11-340). Ecology will give public notice of the DNS and SEPA Checklist and these documents will be sent to other agencies with jurisdiction and affected tribes, if any.

Ecology is required to coordinate SEPA and MTCA in order to avoid duplication of effort. (RCW 43.21C.036). This may include combining documents, notices, and public review and comment periods fulfilling the requirements of both the MTCA Cleanup Regulation (WAC 173-340) and the SEPA Rules (WAC 197-11). Coordination and avoidance of duplication between the two regulatory processes is described in Ecology Policy 130A. In the event Ecology determines that the Pasco Landfill remedial measures will not have a probable, adverse environmental impact, the DNS can be issued and subject to public review and comment with the draft Cleanup Action Plan prepared under the MTCA.

3.1.4 DANGEROUS WASTE REGULATIONS - WAC 173-303

The Washington State Dangerous Waste Regulations (Chapter 173-303 WAC) are the state equivalent of the federal RCRA legislation, and contain a series of rules addressing (among other topics) the identification, generation, handling, storage, and disposal of dangerous wastes. The majority of RCRA authority has been delegated to the Department of Ecology and is implemented through the Dangerous Waste Regulations.

Amendments to the MTCA, discussed above, exempt cleanup actions conducted under an Agreed Order or Consent Decree from the procedural requirements of several state laws, including the Hazardous Waste Management Act. Since implementation of the Act is afforded through the Dangerous Waste Regulations, this exemption also applies to the WAC 173-303 rules. In addition, an amendment to the Hazardous Waste Management Act provides a conditional exemption to state-only dangerous wastes generated when a remedial action is conducted pursuant to a Consent Decree with Ecology. The exemption is not applicable to materials considered as hazardous waste under RCRA. The Consent Decree must provide management practices for the waste being generated, and must include a treatment or disposal location approved by Ecology. In addition, waste being treated or disposed onsite must be managed in a manner approved by Ecology. The amendment also allows extremely hazardous wastes to be managed onsite as part of a remedial action under a Consent Decree.

Accordingly, no WAC 173-303 procedural requirement will be applicable to remedial actions conducted at the site if the actions are conducted pursuant to a Consent Decree or Agreed Order. WAC 173-303 substantive requirements pertaining to dangerous waste generation, handling, storage, and disposal may be applicable if non-exempt dangerous waste is generated and/or transported off the site during cleanup.

The Dangerous Waste Regulations also include 173-303-610 ("Closure and Post Closure") and 173-303-665 ("Landfills") which establish general performance standards and criteria for the closure and post closure monitoring of dangerous waste landfills. Because Zones A through E at the Industrial Waste Area stopped receiving waste materials prior to the effective date of this regulation and do not meet the definition of regulated facilities, these regulations are not considered to be legally applicable to these Zones so long as the waste remains in place. They may be relevant (to containment options) since they address a situation which could be considered sufficiently similar, and may be appropriate depending upon the proposed action and area of contamination. There is no evidence to suggest that the Landfill received any waste that was characterized differently from municipal wastes during the years of Landfill operation so that these regulations are neither applicable nor relevant and appropriate at the Landfill.

In September 1991 Ecology approved the Area of Contamination Interprogram Policy. This policy supports and broadens the analysis provided above. The purpose of the policy was to "clarify the definitions of generation and disposal as they apply to waste, soil and debris found at MTCA sites". One of the examples (E) includes a discussion of capping contaminated soils which designate as either dangerous or extremely hazardous waste. The Area of Contamination (AOC) is defined as that portion of the site that contains continuous contamination. Example E states "Capping the wastes in place will not trigger the DW regulations nor will movement of these wastes within the AOC".

As indicated above, RCRA authority has been delegated to the Department of Ecology. As part of this authority, Subpart S-Corrective Action for Solid Waste Management Units, 40 CFR §264.552 is administered by Ecology. WAC 173-303-646 is the corresponding state regulation. These regulations are not applicable to Zones A through E, because as stated above, the Zones do not meet the definition of regulated facilities. However, for remedial alternatives which involve waste consolidation, creating a new cell for disposal of wastes on-site, or removing waste for off-site disposal, these regulations are both relevant and appropriate. Under these regulations Ecology may designate one or more corrective action management units (CAMUs) at the Pasco Landfill Site. Placement or consolidation of wastes into these CAMUs does not constitute land disposal of hazardous wastes or the creation of a unit subject to minimum technology requirements.

3.1.5 CRITERIA FOR MUNICIPAL SOLID WASTE HANDLING – WAC 73-351

WAC 173-351 describes requirements for the management of municipal solid waste and includes closure, post-closure, and landfill standards. WAC 173-351 specifies that the criteria are the minimum requirements for a landfill closure conducted as a MTCA cleanup action. Therefore, the criteria are applicable to the site.

Three primary classes of ARARs are developed below to provide guidance on how to identify and comply with ARARs. These ARAR classes are: chemical-specific requirements, location-specific requirements, and action-specific requirements. Each class is discussed individually in Sections 3.2, 3.3, and 3.4, below.

3.2 POTENTIAL CHEMICAL-SPECIFIC ARARS

According to the EPA (1988), chemical-specific ARARs are:

> ". . . usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.[1] If a chemical has more than one such requirement that is [an] ARAR, the most stringent generally should be complied with."

The Pasco Landfill Risk Assessment and Cleanup Level Analysis Report dated September 1998 and accepted by Ecology was completed in compliance with WAC 173-340-700

[1] "Some federal or state statutes, such as the Clean Water Act, may establish a methodology for setting site-specific discharge limitations. Such requirements may also be ARARs, depending on site-specific considerations."

and establishes chemical specific cleanup levels for the Pasco Landfill Site. Cleanup levels were established by considering the following:

1. Hazardous substance concentrations that protect human health and the environment;
2. The location on the site where cleanup levels must be obtained; and
3. Additional regulatory requirements that apply to a cleanup action that a specified in applicable state and federal laws.

The resulting cleanup levels are presented in the Risk Assessment and Cleanup Level Analysis Report and are the chemical specific ARARs that apply to the Pasco Landfill Site.

3.3 Potential Location-Specific ARARS

The location of a site and its proximity to humans and ecosystems must be considered in selecting appropriate remedial measures. The EPA defines location-specific ARARs as:

> ". . . restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations" (EPA, 1988).

Examples of special locations include floodplains, historic places, wetlands, wildlife refuges, non-attainment areas, and other sensitive or critical ecosystems or habitats. Currently, no potential location-specific ARARS have been identified or are known to affect remedial activities at the Pasco Landfill.

3.4 Potential Action-Specific ARARS

Action-specific ARARs apply when remedial technologies are selected to effect a remedy. Action-specific ARARs are:

> ". . . usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes" (EPA, 1988).

These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Because there may be several alternative actions for any remedial site, it is possible that very different requirements will come into play. Action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved or implemented.

A listing of the potential remedial measures that may activate action-specific ARARs at the Pasco Landfill is presented in Table 3-3.

TA[illegible] 3-1
POTENTIAL WASHINGTON STATE ARARs FOR THE PASCO LANDFILL

Potential Requirements	Determination of Applicable or Relevant and Appropriate	Comments
Model Toxics Control Act (MTCA) Chapter 70.105D RCW	Applicable	MTCA is the key governmental regulation governing the conduct of the overall investigation and cleanup process for the site and is therefore applicable. MTCA describes the requirements for selecting: cleanup actions, preferred technologies, policies for use of permanent solutions, the time frame for cleanup, and the process for making decisions. The regulations specify that all cleanup actions be protective of human health, comply with all applicable state and federal regulations, and provide for appropriate compliance monitoring.
Model Toxics Control Act Cleanup Regulations WAC 173 - 340	Applicable	WAC 173-340 implements the requirements of the MTCA and contains the primary regulations under which the Pasco Landfill site RI/FS process is being conducted. These regulations establish administrative procedures and standards to identify, investigate, and cleanup facilities where hazardous substances have been released.
State Environmental Policy Act (SEPA) Chapter 43 - 21C RCW	Applicable	SEPA applies to remedial actions at the Pasco Landfill site. Ecology is the lead agency for MTCA remedial actions performed under a Consent Decree or Agreed Order. (WAC 197-11-253). The SEPA threshold determination process is triggered when a government decision is required for a public or private proposal that may impact the environment and is not categorically exempt from SEPA. The purpose of the threshold determination is to provide Ecology with sufficient information upon which to decide whether an Environmental Impact Statement (EIS) will be required for the proposal. The proposed remedial actions for the Pasco Landfill will be subject to the threshold determination process. An Environmental Checklist will be prepared by the PLPs and submitted to Ecology. If Ecology decides, based on the Environmental Checklist and other available information, that the remedial measures will have a probable, adverse environmental impact, Ecology will require an EIS. If Ecology determines that the proposed remedial measures will not have a probable, adverse environmental impact, Ecology will issue a Determination of Non-Significance (DNS). Ecology is required to coordinate the SEPA and MTCA processes in order to avoid duplication of effort. RCW 43.21C.036. In the event that Ecology issues a DNS, the DNS can be issued and subject to public review and comment at the same time as the Cleanup Action Plan under MTCA.

POTENTIAL WASHINGTON STATE ARARs FOR THE PASCO LANDFILL

POTENTIAL REQUIREMENTS	DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE	COMMENTS
Dangerous Waste Regulations WAC 173 - 303		Dangerous Waste Regulations apply to all persons who handle dangerous wastes including (but not limited to) generators, transporters, owners, and operators of dangerous waste recycling, transfer, storage, treatment, and disposal facilities. Several sections of the Dangerous Waste Regulations that are potentially applicable to the Pasco Landfill are presented below.
Designation of Waste WAC 173-303-070	Applicable	These requirements establish the methods and procedures to determine if solid waste requires management as dangerous wastes. The substantive requirements of this section may be applicable if remedial activities involve the generation of dangerous waste.
Requirements for Generators of Dangerous Waste WAC 173-303-170	Applicable	Substantive requirements for generators of dangerous waste established under this chapter may be applicable to remedial actions if dangerous wastes are generated.
Closure and Postclosure WAC 173-303-610	Relevant and Appropriate	These regulations establish general performance standards and criteria for the closure and post closure monitoring of dangerous waste landfills. Because Zones A through E at the Industrial Waste Area stopped receiving waste materials prior to the effective date of this regulation and do not meet the definition of regulated facilities, these regulations are not considered to be legally applicable to these Zones. They may be relevant (to containment options) since they address a situation which could be considered sufficiently similar, and may be appropriate depending upon the proposed action and area of contamination. There is no evidence to suggest that the Landfill received any waste that was characterized differently from municipal wastes during the years of Landfill operation so that these regulations are neither applicable nor relevant and appropriate at the Landfill. In September 1991 Ecology approved the Area of Contamination Interprogram Policy. This policy supports and broadens the analysis provided above. The purpose of the policy was to "clarify the definitions of generation and disposal as they apply to waste, soil and debris found at MTCA sites". One of the examples (E) includes a discussion of capping contaminated soils which designate as either dangerous or extremely hazardous waste. The Area of Contamination is defined as that portion of the site that contains continuous contamination. Example E states "Capping the wastes in place will not trigger the DW regulations nor will movement of these wastes within the AOC".

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POTENTIAL WASHINGTON STATE ARARs FOR THE PASCO LANDFILL

POTENTIAL REQUIREMENTS	DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE	COMMENTS
Corrective Action WAC 173-303-646	Relevant and Appropriate	RCRA authority has been delegated to the Department of Ecology. As part of this authority, Subpart S-Corrective Action for Solid Waste Management Units, 40 CFR §264.552 is administered by Ecology. WAC 173-303-646 is the corresponding state regulation. These regulations can not be considered applicable to Zones A through E, because as stated above, the Zones do not meet the definition of regulated facilities. However for remedial alternatives which involve waste consolidation or otherwise creating a new cell for redisposal of wastes on-site, these regulations are both relevant and appropriate. Under these regulations Ecology may designate one or more corrective action management units (CAMUs) at the Pasco Landfill Site. Placement or consolidation of wastes into these CAMUs does not constitute land disposal of hazardous wastes or the creation of a unit subject to minimum technology requirements.
Landfills WAC 173-303-665	Relevant and Appropriate	Landfill regulations apply to facilities that dispose of dangerous wastes in landfills. For the same reasons stated above, these regulations are not applicable. Requirements that may be relevant and appropriate to Zones A through E are those pertaining to the final cover (capping) design and construction in those site locations where capping may be required.
Solid Waste Management - Recovery and Recycling Act Chapter 70.95 RCW		
Minimum Functional Standards for Solid Waste Handling WAC 173-351	Applicable	MTCA regulations (WAC 173-340-710(6)(c)) direct that WAC 173-304 shall be the minimum requirements for conducting MTCA cleanup actions during closure of a landfill. This is an applicable requirement intended to demonstrate compliance with the selection of cleanup actions.
General Closure and Postclosure Requirements, Landfilling Standards WAC 173-304-407 & WAC 173-304-460	Applicable	These regulations complement WAC 173-303-610 in specifying landfill closure and postclosure requirements. WAC 173-304-460 provides specifications for landfill capping.

POTENTIAL REQUIREMENTS	DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE	COMMENTS
Washington Department of Health – Public Water Supplies WAC 246-290	Relevant and Appropriate	Regulatory requirements necessary to protect users of public drinking water supplies are established under this regulation. The rules are intended to conform with the federal Safe Drinking Water Act. WAC 246-290-310 establishes maximum contaminant levels (MCLs) that define the water quality requirements for public water supplies. It also establishes both primary and secondary MCLs and specifies that the enforcement of the primary drinking water standards is the first priority of the Department of Health. Standards set under WAC 246-290-310 are the same as those set under the Safe Drinking Water Act. Since ground water under the Pasco Landfill Site is currently not used as a drinking water source these requirements are not applicable. However because ground water is used as a drinking water source in the vicinity of the site these standards are relevant and appropriate and were considered in the Risk Assessment and Cleanup Levels Analysis Report.
Washington Department of Fish and Wildlife WAC 232-012	Applicable	WAC 232-012-011 and -014 defines the requirements that the Department of Game must take to protect endangered or protected wildlife.
Water Well Construction Chapter 18.104 RCW		
Minimum Standards for Construction and Maintenance of Water Wells WAC 173-160	Applicable	These requirements are applicable to remedial actions that include the design and construction of wells (resource protection wells) that may be used for groundwater extraction, monitoring, or re-injection of treated groundwater (as necessary) at the Pasco Landfill site. Procedures are also specified for well abandonment or decommissioning.
Water Pollution Control/Water Resources Act Ch. 90.48 RCW/Ch. 90.54 RCW		
Surface Water Quality Standard WAC 173-201A	Applicable	Substantive standards established for the control and prevention of discharges to surface waters under this regulation may be applicable to remedial actions at the Pasco Landfill. The regulation requires that all discharges to surface waters meet standards protective of aquatic life.
National Pollution Discharge Elimination System Permit Program WAC 173-220		Establishes a state permit program pursuant to the federal NPDES system. Substantive sections of the regulation may be applicable to remedial alternatives that involve discharges to surface waters. Discharges may include site run-off, spillage, leaks, sludge, or treated waste disposal.

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POTENTIAL WASHINGTON STATE ARARs FOR THE PASCO LANDFILL

Potential Requirements	Determination of Applicable or Relevant and Appropriate	Comments
Washington Clean Air Act Chapter 70.94 RCW and Chapter 43.21A RCW		
General Regulations for Air Pollution Sources WAC 173-400	Applicable	Substantive standards established for the control and prevention of air pollution under this regulation may be applicable to remedial actions at the Pasco Landfill. The regulation requires that all sources of air contaminants meet emission standards for visible, particulate, fugitive, odors, and hazardous air emissions.
Controls for New Sources of Air Pollution WAC 173-460	Applicable	This regulation may be applicable if any remedial actions performed at the Pasco Landfill create new sources of air emissions. The regulation requires that emissions from new sources be tested for the toxic air contaminants listed in the regulation. Emissions must be quantified and used in risk modeling to evaluate ambient impacts and establish acceptable source impact levels. These standards may be applicable because the regulation specifically pertains to sites subject to MTCA actions.

TABLE 3-2

POTENTIAL FEDERAL ARARs FOR THE PASCO LANDFILL

Potential Requirements	Determination of Applicable or Relevant and Appropriate	Comments
Clean Air Act of 1977, as amended Title 42 USC 7401, et seq.	Relevant and Appropriate	The Clean Air Act regulates emissions of hazardous pollutants to the air. Controls for emissions are implemented through federal, state, and local programs. Pursuant to the CAA, EPA has promulgated National Ambient Air Quality Standards, National Emissions Standards for Hazardous Air Pollutants, and New Source Performance Standards. The Clean Air Act is implemented in the State of Washington through the Washington Clean Air Act criteria which are potential ARARs for the Pasco Landfill site. See Table 1 for a listing of Washington Clean Air Act criteria. The Memorandum of Agreement between EPA and Ecology which designates the Pasco Landfill as an Ecology lead site indicates that work on NPL state lead sites shall be done using only state authorities.
Clean Water Act of 1977 Title 42 USC 1251	Relevant and Appropriate	The Clean Water Act establishes the guidelines and standard to control discharge of pollutants to waters of the U.S.
Water Quality Standards 40 CFR 131		40 CFR 131 establishes the requirements and procedures for states to develop and adopt water quality standards based on federal water quality criteria that are at least as stringent as the federal standards. Washington state has received EPA approval and ah adopted more stringent water quality criteria under WAC 173-201A.
National Pollution Discharge Elimination System (NPDES) 40 CFR 122 to 125		The NPDES program controls release of toxic pollutants through monitoring requirements and implementation of a best management practices program. The substantive requirements of the program would be required if discharge of treated waste water were to occur as part of a remedial alternative; however a permit would not be required due to a MTCA exemption.

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POTENTIAL FEDERAL ARARs FOR THE PASCO LANDFILL

POTENTIAL REQUIREMENTS	DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE	COMMENTS
Safe Drinking Water Act of 1974 Title 42 USC 300, et seq. National Primary and Secondary Drinking Water Standards, 40 CFR 141, 143	Relevant and Appropriate	MTCA requires that groundwater cleanup levels be at least as stringent as maximum contaminant levels (MCLs), secondary maximum contaminant levels (SMCLs), and non carcinogen maximum contaminant level goals (MCLGs) established under the safe drinking water act where groundwater is a current or future source of drinking water. Since groundwater under the Pasco Landfill Site is currently not used as a drinking water source these requirements are not applicable. However because groundwater is used as a drinking water source in the vicinity of the site these standards are relevant and appropriate and were considered in the Risk Assessment and Cleanup Levels Analysis Report
Comprehensive Environmental Response, Compensations, and Liability Act (CERCLA) National Oil and Hazardous Substances Pollution Contingency Plan (NCP) 40 CFR 300	Relevant and Appropriate	The NCP establishes a consistent set of rules (organizational and procedural requirements) that the EPA and state agencies must follow when cleaning up sites on the National Priorities List(NPL). The Memorandum of understanding between Ecology and EPA which transfers the Pasco Landfill Site to an Ecology site states that work on state lead NPL sites will be done using only state authorities and for this reason the NCP is not applicable. However, the NCP is relevant and appropriate because the Pasco Landfill Site is on the NPL.

TA 3-2

POTENTIAL FEDERAL ARARs FOR THE PASCO LANDFILL

POTENTIAL REQUIREMENTS	DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE	COMMENTS
Hazardous Materials Transportation Act 49 USC 1801, et seq.		
Hazardous Materials Regulation 49 CFR 171	Applicable	To transport hazardous materials on public roads, the materials must be properly classed, described, packaged, marked, labeled, and in condition for shipment. These requirements are applicable to offsite shipment of hazardous materials generated during remedial activities.
Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements 49 CFR 172	Applicable	These requirements also are applicable if hazardous waste is generated during remediation and is transported off-site. Tables are used to identify requirements for labeling, packaging, and transportation based on categories of waste types. Specific performance requirements are established for packaging.
Resource Conservation and Recovery Act Title 42 USC 6901 et seq.	Relevant and Appropriate	The Resource Conservation and Recovery Act (RCRA) consists of standards and criteria controlling the treatment, storage, and disposal of hazardous wastes. The EPA has granted the State of Washington the authority to implement RCRA through the Department of Ecology's Dangerous Waste Program (WAC 173-303). Therefore, the RCRA criteria that are potential ARARs for the Pasco Landfill are not detailed here. State of Washington equivalent criteria are presented in Table 1. Considering the AOC Policy, CAMU concept and time of waste disposal: RCRA is relevant and appropriate for on-site remedial scenarios and RCRA is applicable for off-site scenarios.

TABLE 3-3
POTENTIAL ACTION-SPECIFIC ARARs FOR THE PASCO LANDFILL

State Citation	Federal Citation	Description	Potential Requirements
WAC 170-303-170 through 202	40 CFR 262.12, .20-.34, .44	Requirements for generators of hazardous or dangerous waste.	Applicable if wastes from treatment processes are prepared for disposal off-site.
WAC 173-160	None	Regulations for construction and maintenance of new water wells.	Applicable for new and existing wells.
WAC 173-162	None	Requires regulation and licensing of well contractors and operators.	Not and ARAR - Administrative requirements only.
WAC 173-216-060	40 CFR 403.5	Describes prohibited discharges to publicly owned treatment works (POTW).	Applicable for discharges to POTW.
WAC 173-303-140	40 CFR 268	Land disposal restrictions.	Applicable if listed or characteristic wastes are disposed off-site.
WAC 173-303-610(1)	40 CFR 264.110	Introductory language to dangerous waste closure and post-closure regulation setting forth the facilities that are bound by the regulations.	Administrative or procedural requirement.
WAC 173-303-610(2)	40 CFR 264.111	Closure performance standard.	Not applicable because the remedial actions will occur within the same area of contamination (AOC) . AOCs are areas delineated by the extent of continuous contamination, although one AOC may contain varying types of concentrations of chemicals of concern. These provisions may be relevant and appropriate depending on the circumstances of the release, including the hazardous properties of the waste, its composition, the characteristics of the site, the nature of the release or threatened release from the site, and the nature and purpose of the requirement.
WAC 173-303-610(3)	40 CFR 264.112	Description of contents of the closure plan and procedure for obtaining an amendment of the plan.	Not an ARAR - Administrative or procedural requirement.
WAC 173-303-610(4)(a)-(e)(i)	40 CFR 264.113(a)-(e)(i)	Sets for time lines for implementing the closure plan and specifies when permit modifications must be obtained.	Not an ARAR - Administrative or procedural requirement.
WAC 173-303-610(4)(e)(ii)	40 CFR 264.113(d)(4)(e)(2)	Requires removal of all dangerous wastes from the unit.	Not an ARAR because of the date wastes were last disposed in Zones A through E and the type of waste disposed in the Landfill.
WAC 173-303-610(5)	40 CFR 264.114	Requires disposal or decontamination of equipment, structures, and soils.	Not applicable because the remedial actions will occur in the same AOC. May be relevant and appropriate depending on the circumstances of the release, including the hazardous properties of the waste, its composition, the characteristics of the site, the nature of the release or threatened release from the site, and the nature and purpose of the requirement.
WAC 173-303-610(6)	40 CFR 264.115	Requires certification of closure by Ecology.	Not an ARAR - Administrative or procedural requirement.
WAC 173-303-610(7)	40 CFR 264.117	Requires post-closure care for 30 years, monitoring, maintenance, and specifies the use of the property.	Not applicable because the remedial actions will occur within the same AOC. May be relevant and appropriate depending on the circumstances of the release, including the hazardous properties of the waste, its composition, the characteristics of the site, the nature of the release or threatened release from the site, and the nature and purpose of the requirement.
WAC 173-303-610(8)	40 CFR 264.118	Specifies the contents of the post-closure plan and the procedure for amendment of the plan.	Not an ARAR - Administrative or procedural requirement

TABLE 3-3
POTENTIAL ACTION-SPECIFIC ARARs FOR THE PASCO LANDFILL

State Citation	Federal Citation	Description	Potential Requirements
WAC 173-303-630	40 CFR 264.170-178	Management of containers.	Applicable for storage of hazardous waste generated from on-site treatment processes in containers.
WAC 173-303-640	40 CFR 264.190-191	Design, construction, maintenance, inspection, and closure of tanks.	Applicable if tanks are installed to store or treat by-products from remedial processes.
WAC 173-303-670	40 CFR 264.340-351	Incineration requirements for hazardous and dangerous waste.	Not applicable but may be relevant and appropriate if wastes are incinerated within a CAMU on-site.
WAC 173-340-360(7) and (8)	None	Model Toxics Control Act Cleanup Regulation (MTCA) regarding groundwater restoration and containment.	Applicable - Regulation outlines requirements for containment and groundwater restoration for cleanup of hazardous substances.
WAC 173-340-410	None	MTCA requirements regarding compliance monitoring during remedial activities.	Applicable - Required for protecting human health and confirming attainment of cleanup standards.
WAC 173-340-440 and .702(4)	None	MTCA requirements regarding institutional controls to limit activities at a site that may result in exposure to hazardous substances.	Applicable to all scenarios where wastes are left on-site.
WAC 173-340-704, -705, and -706	None	Use of methods A, B, and C for determining cleanup levels.	These regulations are applicable and were considered as part of the Risk Assessment and Cleanup Levels Analysis.
WAC 173-340-707	None	MTCA analytical methods for evaluating the effectiveness of a cleanup action.	Applicable if remedial action requires chemical analyses.
WAC 173-340-708	None	MTCA regulation on human health risk assessment procedures.	These regulations are applicable and were considered as part of the Risk Assessment and Cleanup Levels Analysis..
WAC 173-400 WAC 173-460 WAC 173-470	40 CFR 50.6 and .12 40 CFR 60.5	General regulations for air pollution sources; general provisions and standards of performance for incinerators; particulate matter emission standards; control standards for toxic air pollutants.	Applicable for remedial processes emitting air pollutants.
WAC 173-303-646	40 CFR 264.552 and .553	Corrective action regulations that describe the use of corrective action management units (CAMUs)	Applicable to remedial alternatives where Ecology designates one or more CAMUs at the site for treatment and or disposal of wastes.
WAC 296-62	29 CFR 1910.210	General safety and health standards for workers, including requirements for responses involving hazardous substances.	Applicable for protection of remedial action workers.
WAC 446-50	49 CFR 171-177	Transportation regulations and law for hazardous materials.	Applicable for off-site transportation of hazardous or dangerous waste.
Toxics Cleanup Program Area of Contamination Policy (6 Sep 91)	None	Material designated as dangerous waste can be consolidated, contained, or treated within an area of contiguous contamination without triggering Dangerous Waste Regulations.	Applicable to wastes capped in place or handled on-site.

TA 3-2

POTENTIAL FEDERAL ARARs FOR THE PASCO LANDFILL

Potential Requirements	Determination of Applicable or Relevant and Appropriate	Comments
Clean Air Act of 1977, as amended Title 42 USC 7401, et seq.	Relevant and Appropriate	The Clean Air Act regulates emissions of hazardous pollutants to the air. Controls for emissions are implemented through federal, state, and local programs. Pursuant to the CAA, EPA has promulgated National Ambient Air Quality Standards, National Emissions Standards for Hazardous Air Pollutants, and New Source Performance Standards. The Clean Air Act is implemented in the State of Washington through the Washington Clean Air Act criteria which are potential ARARs for the Pasco Landfill site. See Table 1 for a listing of Washington Clean Air Act criteria. The Memorandum of Agreement between EPA and Ecology which designates the Pasco Landfill as an Ecology lead site indicates that work on NPL state lead sites shall be done using only state authorities.
Clean Water Act of 1977 Title 42 USC 1251	Relevant and Appropriate	The Clean Water Act establishes the guidelines and standard to control discharge of pollutants to waters of the U.S.
Water Quality Standards 40 CFR 131		40 CFR 131 establishes the requirements and procedures for states to develop and adopt water quality standards based on federal water quality criteria that are at least as stringent as the federal standards. Washington state has received EPA approval and ah adopted more stringent water quality criteria under WAC 173-201A.
National Pollution Discharge Elimination System (NPDES) 40 CFR 122 to 125		The NPDES program controls release of toxic pollutants through monitoring requirements and implementation of a best management practices program. The substantive requirements of the program would be required if discharge of treated waste water were to occur as part of a remedial alternative; however a permit would not be required due to a MTCA exemption.

4 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

4.1 INTRODUCTION

This section identifies the remedial action objectives (RAOs) for waste and underlying soils at the municipal solid waste landfill and each of the industrial waste zones, and for groundwater site-wide. Based on these RAOs, general response actions are described that could be implemented to meet the RAOs. A list of remedial technologies and process options is then developed that can be used to assemble remedial alternatives.

4.2 REMEDIAL ACTIONS OBJECTIVES FOR EACH MEDIA

Results of the RI and the RA/CLA indicated that wastes contained in the zones, soils directly beneath the zones, and groundwater are the media of interest at the Pasco Landfill site. Surface soils were not found to be impacted by hazardous substances, and are eliminated from further evaluation. Table 4-1 summarizes the remedial objectives for the zone wastes, subsurface soils and groundwater. These objectives are primarily concerned with minimizing the potential of exposure of human and ecological receptors to any of the wastes placed in the zones and municipal solid waste landfill, reducing the potential for migration of contaminants from wastes to the groundwater, and preventing of exposure of human and ecological receptors to groundwater impacted by contaminants from the zones.

4.3 GENERAL RESPONSE ACTIONS

General response actions, treatment technologies, and process options describe those actions which will satisfy the remedial action objectives developed for each medium of interest. These response actions include institutional controls, containment, in-situ and ex-situ treatment, excavation and disposal. These general response actions are included in Table 4-2 with their associated remedial technologies and process options.

General response actions for the Municipal Landfill are capping and active gas collection in accordance with the approved closure plan and WAC 173-351. This response action is based on the "Presumptive Remedy for CERCLA Municipal Landfill Sites", which is applicable to this site (Section 5.3.2).

4.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

A list of potentially applicable remedial technologies and process options was developed for the site. These were then screened based on expected effectiveness, implementability, and relative cost, and a determination was made on their applicability for use in developing remedial alternatives. Tables 4-2 and 4-3 present the list of remedial technologies, process options and screening comments. Technologies that were deemed applicable or potentially applicable were used to develop remedial alternatives for each media in each zone.

TABLE 4-1
REMEDIAL ACTION OBJECTIVES

ZONE	MEDIA IMPACTED	REMEDIAL ACTION OBJECTIVE
Zone A	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure Remove and destroy contaminants from beneath waste. Minimize transport of contaminants from soil to groundwater
	Groundwater	Prevent ingestion, inhalation or dermal absorption.
Zone B	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize the potential for transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure
Zone C	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize the potential for transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure Remove and destroy contaminants from beneath waste.
Zone D	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize the potential for transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure Remove and destroy contaminants from beneath waste.
Zone E	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize the potential for transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure

TABLE 4-1
REMEDIAL ACTION OBJECTIVES

ZONE	MEDIA IMPACTED	REMEDIAL ACTION OBJECTIVE
Municipal Landfill	Waste	Prevent direct exposure. Prevent contaminant releases to atmosphere. Minimize transport of contaminants from zone to subsurface soils and groundwater.
	Soil	Prevent direct exposure Minimize transport of contaminants from soil to groundwater
	Groundwater	Prevent ingestion, inhalation or dermal absorption.

TABLE 4-2
SCREENING COMMENTS FOR WASTE/SOIL REMEDIATION TECHNOLOGIES

General Response	Remedial Technologies	Process Options	Description	Screening Comments
No Action	No Action	No Action		**Not retained.** Would not meet RAOs.
Institutional Controls	Restrict access and land use	Deed Restrictions	Deeds for site property would include restrictions on residential building, excavation, and groundwater use	**Retained** for further consideration in design of remedial alternatives.
		Security fencing and warning signs	Restrict access with fencing	**Retained** for further consideration in design of remedial alternatives.
Containment	Surface Controls	Grading	Modify existing grade on and around waste zones to prevent precipitation run on	**Retained** for further consideration in design of remedial alternatives.
		Diversion/Collection	Divert surface water away from waste zones and collect	**Retained** for further consideration in design of remedial alternatives.
		Revegetation	Plant additional vegetation to stabilize cover over waste zones	**Retained** for further consideration in design of remedial alternatives.
	Cover/Capping	Existing Cap	Waste zones covered with native soil and plastic liner	**Retained** for further consideration in design of remedial alternatives.
		Engineered Cap	Construct a cap over waste zones in accordance with WAC 173-303	**Retained** for further consideration in design of remedial alternatives.
	Subsurface Horizontal Barriers	Grout Injection	Jet or permeation grouting using angled borings under the waste zones to construct an impermeable layer	**Not retained** at Zone A due to volume of waste generated by jet grouting. **Retained** at Zone B to enhance containment alternative. Not required at Zones C, D, and E.

TABLE 4-2
SCREENING COMMENTS FOR WASTE/SOIL REMEDIATION TECHNOLOGIES

General Response	Remedial Technologies	Process Options	Description	Screening Comments
Excavation/ Treatment/ Disposal	Physical Removal	Excavation	Excavation of wastes from the zones for either on-site or off-site disposal	**Retained** for further consideration in design of remedial alternatives.
	Disposal Onsite	RCRA Landfill	Construct an on-site landfill per the WAC 173-303 specifications for placement of excavated wastes	**Retained** for further consideration in design of remedial alternatives.
		Subtitle D Landfill	Place excavated wastes in the New Waste Landfill if the waste are characterized non-hazardous	**Not retained.** Although the waste in Zone C did not designate as either a characteristic RCRA waste or a Washington Dangerous Waste, this option was not determined to be more protective of human health and the environment and does not minimize future liabilities.
	Disposal Offsite	RCRA Landfill	Transport and disposal of excavated wastes to a permitted hazardous waste landfill	**Retained** for further consideration in design of remedial alternatives.
		Subtitle D Landfill	Transport and disposal of excavated wastes to a permitted solid waste landfill if the waste are characterized as non-hazardous	**Not retained.** Although the waste in Zone C did not designate as either a characteristic RCRA waste or a Washington Dangerous Waste, this option was not determined to be more protective of human health and the environment and does not minimize future liabilities.

TABLE 4-2
SCREENING COMMENTS FOR WASTE/SOIL REMEDIATION TECHNOLOGIES

General Response	Remedial Technologies	Process Options	Description	Screening Comments
Waste/Soil Treatment	In Situ Biological Treatment	Enhanced Anaerobic Biodegradation	Introduction of nutrients and other rate limiting components to increase the population of naturally occurring micro-organisms that can biodegrade contaminants of concern	**Not retained** due to: • areas of high concentrations of contaminants in waste soil; • difficult to implement beneath the zones; • incompatible with SVE system.
		Bioventing	Introduction of air into the subsurface to increase the natural rate of aerobic biodegradation	**Not specifically retained.** Aerobic biodegradation will occur in conjunction with SVE. Not applicable at Zones B and E.
	In Situ Physical/Chemical Treatment	Soil Flushing	Injection and extraction of cosolvents into the subsurface to remove contaminants of concern	**Not retained** due to implementability and relative cost
		Soil Vapor Extraction (SVE)	Extraction of air and volatile compounds from the vadose zone by vacuum. Treatment of off-gas	**Retained.** Has been operating successfully as an Interim Remedial Measure since May 1997.
		Solidification/Stabilization	Injection of grout or other materials into the waste zones produce a more stable monolith	**Not retained** due to poor effectiveness for volatile organic contaminants, waste characterization analyses indicate metals are stabilized
	In Situ Thermal Treatment	Thermally Enhanced SVE	Use of heat to enhance to volatility of contaminants that are then remove via vacuum extraction	**Not retained.** Standard SVE is performing well.
		Vitrification	In situ voltage application to melt soils and form a more stable glass monolith	**Not retained** due to implementability associated with drums, organic wastes, potential off-gases, etc.

TABLE 4-2
SCREENING COMMENTS FOR WASTE/SOIL REMEDIATION TECHNOLOGIES

General Response	Remedial Technologies	Process Options	Description	Screening Comments
Waste/Soil Treatment (continued)	Ex Situ Biological Treatment	Composting	Mixing excavated soils with organic substrates such as wood chips to support the biodegradation of contaminants in excavated soils	**Not retained** due to poor effectiveness for site contaminants and likely soil volumes
		Landfarming	Mixing fertilizers and other rate limiting components into excavated soils to promote biodegradation and volatilization of contaminants	**Not retained** due to poor effectiveness for site contaminants and likely soil volumes
		Slurry Phase	Using slurry reactors to biodegrade contaminants of concern	**Not retained** due to poor effectiveness for site contaminants and large soil volumes
	Ex Situ Physical Treatment	Solidification/Stabilization	Seal or fix wastes and soil into a relatively impermeable, stable monolith	**Not retained** due to poor effectiveness for volatile organic contaminants, waste characterization analyses indicate metals are stabilized
	Ex Situ Thermal Treatment	Thermal Desorption/Catalytic Oxidation	Waste/soil are heated to volatilize contaminants, off-gas is treated by catalytic oxidation to destroy contaminants	**Not retained** due to implementability, cost, availability, effectiveness, and residual waste disposal
		Incineration	Contaminants are destroyed using extremely high temperatures.	**Retained** for Zones A, B, and D.
	Air Emissions/Off-gas treatment	Thermal/Catalytic Oxidation	Vapor phase contaminants destroyed using high temperatures	**Not retained** due to cost.
		Photo-catalytic Oxidation	Vapor phase contaminants destroyed using lower temperatures than thermal oxidation by using a catalyst bed to enhance the oxidation reaction	**Not retained** due to cost.

TABLE 4-2
SCREENING COMMENTS FOR WASTE/SOIL REMEDIATION TECHNOLOGIES

General Response	Remedial Technologies	Process Options	Description	Screening Comments
		Vapor Phase Carbon Adsorption	Vapor phase contaminants are sorbed to activated carbon. Carbon is regenerated and off-gas is treated at a permitted facility.	**Retained.** In use at site since May 1997 as part of IRM.
		Biofiltration	Vapor phase contaminants pass through a porous media supporting microorganisms capable of degrading the contaminants	**Not retained** due to the high air flo' rates needed for SVE.

TABLE 4-3
SCREENING COMMENTS FOR GROUNDWATER REMEDIATION TECHNOLOGIES

GENERAL RESPONSE	REMEDIAL TECHNOLOGIES	PROCESS OPTIONS	DESCRIPTION	SCREENING COMMENTS
No Action	No Action	No Action		**Not retained.** Will not meet RAOs.
Natural Attenuation	Long-Term Groundwater Monitoring	Network of groundwater monitoring wells sampled at regular intervals	Groundwater monitoring wells will be sampled for parameters to demonstrate the natural attenuation of contaminants of concern in the groundwater.	**Retained**.
Institutional Controls	Alternate Water Supply	Public Water Supply	Affected domestic wells would be replaced by hookup to a public purveyor.	**Retained.** Has been in effect since December 1997 as part of the interim remedial measures at the site.
		Replacement Water Wells	Drill new domestic well to an uncontaminated depth.	**Not retained.** Alternate water supply already in place.
	Groundwater Restrictions	Deed Restrictions	Include restrictions for domestic use of groundwater for properties that overlie the contaminant plume exceeding MCLs.	**Retained**
Containment	Vertical Barriers	Sheet Piling	Interlocking steel or HDPE sheets driven around the perimeter of the waste zone and keyed into a natural horizontal barrier.	**Not retained.** Not implementable due to depth to groundwater.
		Deep Soil Mixing	Counter rotating augers are drilled into the aquifer while a grouting agent is simultaneously mixed with the native soil creating an impermeable wall.	**Not retained.** Not implementable due to depth to groundwater.
		Deep Grout Injection	Direct injection of grouting agent to permeate aquifer. Injection points coalesce, forming an impermeable barrier.	**Not retained**. Difficult to implement at depths required. Cost of full containment high compared to other demonstrated technologies.

TABLE 4-3
SCREENING COMMENTS FOR GROUNDWATER REMEDIATION TECHNOLOGIES

Containment (continued)		Slurry Wall		**Not retained.** Not implementable due to depth to groundwater.
		Hydraulic Barrier	Withdrawal of groundwater to reverse the natural flow, and prevent further downgradient migration of impacted groundwater.	**Not retained** due to the extremely prolific nature of the aquifer beneath the site requiring huge amounts of groundwater withdrawal to effectively contain the plume.
In Situ Treatment	In Situ Biological Treatment	Co-Metabolic Treatment	Introduction of methane, phenol or other substrate that promotes the cometabolic degradation of chlorinated solvents by indigenous microorganisms.	**Not retained** due to relatively high seepage velocity complicating injection of substrate and residence time with microorganisms.
		Oxygen Enhancement with Air Sparging	Increase the rate of aerobic biodegradation by the injection of air into the saturated zone.	**Not retained.** Current NoVOCs system is more cost-effective and efficient.
		Oxygen Enhancement with H_2O_2	Increase the rate of aerobic biodegradation by the injection of H H_2O_2 into the saturated zone.	**Not retained.** Would require enormous amounts of H_2O_2 to impact contamination in prolific aquifer.
		Phytoremediation	Use of hybrid poplar trees or other plants to withdraw impacted groundwater.	**Not retained** due to the depth of groundwater.
	In Situ Physical/Chemical Treatment	Air Sparging	Physical stripping of volatile compounds from the groundwater by the injection of air into the saturated zone.	**Not retained.** Current NoVOCs system is more cost-effective and efficient.
		Dual Phase Extraction	Extraction and treatment of ground-water to depress the water table, while simultaneously using soil vapor extraction to remove volatile compounds.	**Not retained** due to the extremely large amounts of groundwater removal required to depress the water table in the prolific aquifer.

TABLE 4-3

SCREENING COMMENTS FOR GROUNDWATER REMEDIATION TECHNOLOGIES

In Situ Treatment (continued)		Passive Treatment Walls	Construction of subsurface permeable wall containing treatment media such as zero valent iron to chemically remove contaminants of concern.	**Not retained** due to the depth to groundwater and high seepage velocity.
		NoVOCs In-Well Air Stripping/Recirculating Well	Use of dual screened well to create a toroidal treatment zone by removing volatile compounds via air stripping during the transfer of water from the base of the plume to the top of the water table.	**Retained.** Currently being used successfully to remove volatile compounds from the areas of highest impact from Zone A.
Ex Situ Treatment	All technologies require groundwater extraction	All process options require groundwater extraction	Extraction of groundwater and treatment.	**Not retained** due to prolific nature of aquifer that precludes groundwater extraction from being implemented.

5 DEVELOPMENT OF ALTERNATIVES

5.1 CLEAN UP ACTION SELECTION CRITERIA

Under MTCA, remedial alternatives must meet the following threshold requirements (WAC 173-340-360(2)):

- Protection of human health and the environment
- Compliance with cleanup standards
- Compliance with applicable state and federal laws
- Contain provision for compliance monitoring.

Meeting these requirements was the primary consideration in developing remedial alternatives for the site.

5.2 KEY ENGINEERING CONSIDERATIONS

This section briefly summarizes the important history and physical characteristics of each waste zone that were taken into consideration when developing remedial alternatives for the site.

5.2.1 ZONE A

Wastes in Zone A include solvents, paints, cleaners and other industrial waste. The wastes were disposed in drums in two locations within the zone. The first area located along the western edge of the zone contains randomly disposed drums and the remainder of the cell contains drums that are stacked three or four drums high. Approximately 35,000 drums of waste were disposed in Zone A.

The zone is located in a former swale that has been filled with various types of refuse. Surrounding and adjacent to Zone A are three additional waste disposal areas: a former burn trench, balefill and construction waste landfill. An extensive excavation including excavation of one or more of these adjacent areas would be required to access the drums in Zone A.

According to information provided in the Phase I and II RI, the surface area of Zone A is estimated to be 1.54 acres, the depth is estimated to be 12 feet and the volume is estimated to be 29,820 yd^3.

Intrusive investigation of Zone A was considered during the RI and determined to be too problematic because of the access issues described above, the unknown effects of aerating the waste, and likely poor condition of the drums and the potential for uncontrolled releases to occur as a result of the investigation. For these reasons no direct observations of the physical status of Zone A waste have been made. In the Phase I RI Zone A wastes were described as generally containing a high percent of solids. However, given the high rate of VOC removal from the SVE system, and the apparent impacts from Zone A to groundwater it is likely that some free liquids and or liquid saturated soils exist within or under the zone.

To date, Zone A appears geotechnically stable with no evidence of subsidence at the surface. Given the contents and condition of the zone, this stability is unexpected.

Zone A Conceptual Model

Based on results of the RI the following conceptual model was developed:

- The drums are in poor condition;
- Many drums have already leaked their liquid contents;
- Many drums and some impacted soils of COC's still contain free liquids (up to ten percent by mass); and
- The NoVOCs™ and SVE systems appear capable of handling all COCs that have been seen in down-gradient groundwater to date.

The presence of some free liquids is consistent with and supported by the following observations:

1. Analytical data of groundwater down-gradient at Zone A over the past five years prior to the NoVOCs™ and SVE systems being implemented show concentrations of various compounds increasing and decreasing randomly from quarter to quarter. These results are consistent with occasional new leakage from drums that would be expected given the conceptual model.
2. The SVE and NoVOCs™ systems are removing over 40 pounds of VOCs per day and have done so for more than one year. This removal rate is consistent with the presence of liquid wastes in drums and therefore supports the conceptual model.

The presence of free liquids at up to 10% of COC's by mass is supported by the following observations:

1. Wastes in drums were described as containing a high percent of solids.
2. Impacted soils are unlikely to be saturated given the amount of soil between the bottom of the zone and the water table.
3. Low concentrations of COCs are found in groundwater.
4. Ground water contamination is not found at depth.

The two primary alternatives to this conceptual model are that either all of the drums have released their contents or that none of the drums have released their contents. Clearly, the later alternative is inconsistent with the ongoing release of contaminants to groundwater at Zone A. In addition, the former alternative is inconsistent with the groundwater plume emanating from Zone A. The plume fits a logarithmic decay, which is consistent with the proposed conceptual model. If most or all of the drums had released their contents sometime in the past, we would expect to see a pulse. No such slug of contaminants is found down-gradient of Zone A. In this way, the groundwater plume data do not support either alternate conceptual model but instead are consistent with the proposed conceptual model.

5.2.2 ZONE B

Wastes in Zone B include primarily 2,4-D tar, MCPA bleed and other herbicide waste. The wastes were disposed in drums stacked three or four drums high. Approximately 5,000 drums of waste were disposed in Zone B.

The zone is located in a remote location with no barriers to access. A six-foot high chain link fence with barbed wire top surrounds the zone. Zone B was constructed at the toe of north facing slope so that the drums in Zone B are accessible from the east, south and west.

According to information provided in the Phase I and II RI, the surface area of Zone B is estimated to be 0.16 acres, the depth is estimated to be 12 feet and the volume is estimated to be 3,058 yd^3.

During the RI, intrusive investigation of Zone B was determined to be too dangerous because of the unknown effects of aerating the waste, and likely poor condition of the drums. However, during the summer of 1998 a two square foot hole at the southwestern end of the zone was noticed during groundwater sampling. Subsequently a limited drum investigation was conducted. The investigation included excavation of a small amount of cap material and visual inspection of as many as three drums. Because the drums were in poor condition and the hole for inspection was small, it was difficult to determine the exact number of drums. Wastes could be seen inside the drums. The physical condition of the wastes were consistent with reports in the Phase I RI. Wastes appeared black, dry, and solid with a characteristic pesticide odor. When probed with a shovel the wastes appeared somewhat oily

A small amount of slumping and subsidence has occurred within and around Zone B. As indicated above, wastes appear solid and the drums are in poor condition. The small amount of subsidence can be explained as the result of settling that occurred when partially full drums corroded.

Zone B Conceptual Model

Based on results of the RI the following conceptual model for Zone B was developed:

- The drums are in poor condition;
- little or no free liquids or saturated soils are believed to be present within Zone B, however, a conservative estimate of 10% free liquids is used in calculations;
- impacted soil is limited to approximately ten feet below the bottom of the waste.

5.2.3 ZONES C AND D

Zones C and D are located next to each other, were formed using the same disposal methods and contain similar wastes. Wastes in Zones C and D include bulk plywood resin waste, wood treatment and preservative waste, lime sludge, cutting oils, paint waste, solvent waste and other bulk liquid waste. The wastes were disposed as bulk liquids in unlined lagoons within Zones C and D.

The zones are located in a remote location with no barriers to access. Zones C and D were constructed on a topographical high point on the site and wastes are accessible from all directions.

According to information provided in the Phase I and II RI, the surface areas of Zones C and D are estimated to be 0.27 acres and 0.25 acres, the depths are estimated to be 6 feet and 9 feet and the volumes are estimated to be 2,645 yd^3 and 3,655 yd^3. Combined, including the area between the zones, the approximate area is 0.57 acres and the volume is 8,277 yd^3 respectively.

During the RI, wastes were characterized from both Zones C and D. In addition, a single soil boring was completed through each zone and soil samples taken from below the waste to the surface of the water table. Analysis of wastes using the Toxic Characteristic Leachate Procedure (TCLP) indicates leachable amounts of VOCs and metals are present in the wastes. A sample from Zone D exceeded the TCLP test for 1,2-DCA, all other results were negative.

No slumping or subsidence has occurred within or around Zones C and D. Given the physical conditions of the waste described above the zones are expected to remain geotechnically stable.

Zones CD Conceptual Model

Based on results of the RI the following conceptual model for Zones C and D was developed:

- Wastes within the zones are hard and dry;
- No free liquids or saturated soils are believed to be present within Zones C and D;
- COCs (acetone) released from the zone are undergoing natural degradation in the vadose zone before they impact groundwater.

5.2.4 ZONE E

Zone E contains primarily chlor-alkali waste. Wastes were disposed as bulk solids. A top liner exists over the waste and there is some evidence to suggest that a bottom liner was installed. Approximately 11,000 tons of waste was disposed in Zone E.

The zone is located in a remote location with no barriers to access. Zone E was constructed in a relatively flat area so that the waste in Zone E is accessible from all directions.

According to information provided in the Phase I and II RI, the surface area of Zone E is estimated to be 0.75 acres. The depth of Zone E is unknown, however, soil borings were advanced to 9 feet below ground surface without reaching the lower boundary of the waste. For the purposes of this FS, the depth of waste is assumed to be 10 feet. The volume is estimated to be 12,056 yd^3.

During the RI, bulk waste samples were taken and analyzed for corrosivity, flammability, reactivity, total metals, TCLP metals, TCLP VOCs, TCLP pesticides, TC Organics and fish bioassay. Metals analysis indicated the presence of barium, cadmium, chromium, lead and mercury. The physical condition of the waste is consistent with reports in the RI and the lack of any apparent impact to groundwater. The waste appeared dry, blue-gray and clay-like. The waste also included process derived items such as filter cartridges, graphite anode supports and discarded portions of tank liners

No slumping or subsidence has occurred within or around Zone E. Given the physical conditions of the waste described above the zone is expected to remain geotechnically stable.

Zone E Conceptual Model

Based on results of the RI the following conceptual model for Zone E was developed:

- Wastes within the zone are dry and clay-like.
- No free liquids or saturated soils are believed to be present within Zone E.
- COCs from Zone E have not impacted groundwater.

5.2.5 GROUNDWATER

The plume of groundwater impacted by COCs extends approximately 9000 feet from the sources at Zone A and the Municipal Landfill and is approximately 1800 feet wide.

Groundwater Conceptual Model

Based on the results of the RI, the following conceptual model for groundwater was developed:

- Transport of contaminants from Zone A and the landfill are impacting groundwater.
- The combination of nutrient and contaminant loading from the landfill and Zone A to groundwater results in the formation of an anaerobic biodigester that actively biodegrades contaminants in groundwater.
- Within 500 feet down-gradient of Zone A or the landfill, groundwater is reoxygenated and biodegradation appears to stall.
- The mass flux rate of COCs down gradient of Zone A (calculated in Attachment B) (note this is also down gradient of the Sanitary Landfill) is estimated at 1.57 pounds per day;
- The mass flux rate down gradient of the Sanitary Landfill, excluding A is estimated at 0.11 pounds per day;
- The total mass of COCs present outside Pasco Sanitary Landfill property is estimated at 546 pounds.

5.3 DETAILED DESCRIPTION OF VIABLE ALTERNATIVES

The following sections describe in detail the remedial alternatives composed of the retained technologies and process options described in Section 4. Remedial alternatives were developed which would meet the remedial action objectives summarized in section 4.2, and meet the threshold requirements as specified in WAC 173-340-360(2). The descriptions below include a conceptual design or remedial procedure, operation and maintenance considerations and estimated costs.

The cost estimates were prepared to allow comparative evaluation of alternatives, not for budgeting purposes. The conceptual designs and remedial procedures are subject to change during final design of the selected alternative, and these changes would affect the cost of the remedial action. The uncertainties in the FS designs and associated cost estimates are such that actual costs could vary from these estimates. However, the uncertainty in the *relative* cost of the alternatives is much less than the uncertainty in the magnitude of the costs, and these cost estimates are suitable for comparative evaluation of the alternatives.

All costs for long term O&M were calculated in 1999 dollars using a discount rate of seven percent before taxes and after inflation to account for the time value of money. Because the exact duration of O&M is unknown, the present value of O&M costs were calculated as an annuity that will pay O&M costs in perpetuity. The annuity for annual O&M is calculated as follows:

pv (rate,npr,pmt,fv)

Where:

pv is the present value.
rate is the discount rate per period which is assumed to be 4%.
npr is the number of periods which is assumed to be 200 for annual O&M[1]
pmt is the payment which is the annual cost of O&M in 1999 dollars
fv is the future value of the annuity at the end of payments in 1999 dollars

To make sure the cash flow can be sustained in perpetuity the future value is set to equal the present value and an iterative solution is obtained.

For non-annual costs, the same technique is used and the present values are added to calculate the total funds required to sustain the cash flow in perpetuity. For example, the annuity required to rebuild the IWA caps every forty years was calculated as follows:

PV (rate,npr,pmt,fv)

Where:

PV is the present value.
rate is the discount rate per period which is assumed to be $(1.04^{40}-1)\%$.
npr is the number of periods which is assumed to be 5 for annual O&M[1].
pmt is the payment which is the cost to rebuild the cap in 1999 dollars
fv is the future value of the annuity in 1999 dollars

Again to make sure the cash flow can be sustained in perpetuity the future value is set to equal the present value and an iterative solution is obtained.

Alternatives were developed for the waste/soil media for each waste zone requiring remedial action. Alternatives for the groundwater media are addressed separately. For ease of future discussion each alternative has been assigned an alphanumeric designation that incorporates the zone's letter name, and for the case of groundwater, GW.

5.3.1 Common Elements

Several alternatives were developed sharing common elements. To avoid repetition, this section will present the descriptions of these elements. They will then be referenced in the descriptions of remedial alternatives.

Institutional Controls and Access Restrictions

All remedial alternatives where contaminated material may remain on site include institutional controls. Deed restrictions would be instituted to ensure that site use restrictions would remain in force regardless of the transfer of property ownership. Restrictions on groundwater use at the site would be employed until groundwater cleanup criteria have been attained.

[1] It should be noted that the answer to these formulae is not dependent on the number of periods chosen since pv is set to equal fv.

Site use restriction would prohibit residential or agricultural uses incompatible with the presence buried wastes. For alternatives that include capping of the waste zones, restrictions would be included that prevent the penetration of the caps or any site use that could damage their effectiveness. Access to the site would be restricted by adding fencing and warning signs to those waste zones not already fenced. These site use restrictions would remain in effect indefinitely.

Alternate Water Supply

This element consists of closing domestic wells identified as being impacted by chemicals of concern, and replacing this water supply with water from the City of Pasco system. This option has been successfully implemented as an interim remedial measure at the site, and will remain in effect until groundwater monitoring demonstrates that cleanup criteria have been met.

Groundwater Monitoring

Groundwater monitoring will be implemented in some form for all alternatives being considered for the Pasco Landfill Site. Monitoring will be similar to the post-RI program currently being implemented. Groundwater monitoring data will be used to evaluate the performance of alternatives that include groundwater treatment. For waste removal alternatives monitoring would remain in effect until cleanup criteria are met. For those alternatives that rely on containment, groundwater monitoring would continue indefinitely.

5.3.2 MUNICIPAL SOLID WASTE LANDFILL

Data from the RI indicate that the Municipal Solid Waste Landfill (MSWL) complies with the assumptions of the U.S. EPA Directive 9355.0-49FS, "Presumptive Remedy for CERCLA Municipal Landfill Sites". Based on this determination, only a containment alternative is proposed for the MSWL.

This alternative is described in the Ecology-approved Pasco Sanitary Landfill Closure Plan (Woodward-Clyde, 1997). The plan calls for the installation of a final cover and active landfill gas extraction. It is expected that the combination of eliminating leachate production, and the drying of the solid waste by the active landfill gas extraction, will be sufficient to reduce contaminant loading to the groundwater. Because groundwater downgradient of the landfill is currently just above the cleanup levels set for the site, this reduction in loading should reduce groundwater concentrations to below cleanup levels.

Estimated Cost

The estimated capital cost to implement the approved closure plan is $3,700,000. Operation and maintenance costs are estimated at $68,000 per year which equates to a present value of approximately $1,000,000 using the procedure above.

5.3.3 Zone A

The following sections describe the remedial alternatives for waste/soil media at Zone A.

5.3.3.1 Alternative A-1

Alternative A-1 consists of the following elements:

- Maintain the existing soil cap;
- Expanded SVE; and
- Access and institutional controls.

The existing native soil cover over the drums of Zone A has prevented direct human contact with wastes contained in the zone to date, and has not shown any evidence of failure. This alternative would include periodic inspections of the cover, and provide for repair if failures occur in the future.

Expansion of the currently operating SVE system would consist of installing one additional four-inch extraction well. This well would be installed at the northeast corner of Zone A, and would be of similar design and construction to the wells installed as part of the IRM. Currently the northeast portion of Zone A is not under the influence of the IRM system. No additional equipment other than the well and associated piping would be required for this element. The blower installed as part of the IRM has sufficient excess capacity to allow for the additional leg to be added to the system with minor modifications.

By adding another extraction well in this area the radius of influence of each well would be reduced, but the current radii are more than sufficient to cover the area beneath Zone A. This is also advantageous as it will reduce the amount of "clean" soil vapor now being extracted by the system, thus increasing the overall remediation efficiency.

The current three-well SVE system, operating as part of the IRMs, has been removing VOCs at an average rate of approximately 45 pounds per day (Figure 5-1). As of October 23, 1998 the system has removed over 27,000 pounds of volatile organic compounds from the subsurface beneath Zone A. This technology is removing these compounds before they impact the groundwater, and migrate off-site. After removal, these compounds are sorbed onto granular activated carbon (GAC) in the off-gas treatment system. When the GAC has reached the point of breakthrough it is transported to a permitted GAC regeneration facility. At this facility the GAC is regenerated by heating in a rotary kiln to temperature sufficient enough to purge the VOCs from the GAC and the VOCs are destroyed.

In addition to these elements, access and institutional controls would be established as described in Section 5.3.1.

Alternative A-1 Cost

Maintenance of the existing soil cap consists of $2,500 per year in perpetuity. The estimated cost for the one well expansion of the SVE system is based on the actual costs for the IRM installation. It is estimated that this expansion will have a capital cost of $25,000. Operation and maintenance for the expanded SVE system in perpetuity, as an annuity, would be $5,973,956. In addition to the annual O & M costs, this figure includes a complete system replacement every ten years. Detailed costs for this element are found in Table 5-1.

Total Cost for Alternative A-1

Maintenance of Existing Soil Cap	$35,714
Expansion of SVE and O & M	5,918,242
Institute Access and Institutional Controls	20,000
Total	**$5,973,956**

5.3.3.2 ALTERNATIVE A-2

Alternative A-2 consists of the following elements:

- Construct and maintain a Cap on Zone A in compliance with WAC 173-303;
- Expanded SVE; and
- Access and institutional controls.

This alternative implements Alternative A-1, but upgrades the cap on the zone to an engineered cap per WAC 173-303.

Zone A Cap

The upgraded cap will be installed over the present position of Zone A and will extend past the existing zone dimensions a distance equal to the zone depth to prevent lateral infiltration.

Therefore, the total cap area proposed for this conceptual design is 1.89 acres (82,464 square feet). A conceptual design including a discussion of the design components of the proposed cap is included in this section of the feasibility study.

Zone A will require clearing and grubbing prior to installation of a cap. The row of tree stumps adjacent and bordering the west side of Zone A will be removed. The cap will extend west beyond the present location of the tree stumps to prevent any preferential infiltration caused by the tree roots. The 2-5% slope on the sides of the cap would then be tapered into the 5-15% slope that exists to the west of the trees.

The area surrounding Zone A will be filled and graded according to the cap grading plan. Run-on and Run-off controls will be incorporated into the grading plan. It is expected that the cap will be built on top of the present cover. Because of the unknown condition of the drums within the zone, mechanical compaction of the waste will not be considered prior to installing the cap. Instead, subsidence will be addressed in the O&M plan and the cap will be replaced every 40 years.

Zone A Cap - Conceptual Design

This conceptual design has been prepared in accordance with WAC 173-303-351 and WAC 173-303-665. It should be noted that this conceptual design was completed for the purpose of comparing remedial alternatives. Exact specifications of the design should be revisited during the formal design stage if this alternative is chosen. Specifications made in this FS should not limit the choices of the design engineer during the formal design stage. During the formal design stage all relevant and appropriate regulation and guidance documents will be followed.

A cap for land disposal units is comprised of several overlying layers. Design of the Zone A cap will take into consideration health and safety, aesthetics, and site usage following closure. The cap will be designed and constructed to provide long-term minimization of migration of liquids through the landfill cap, operate with minimal maintenance, function to control drainage, minimize erosion and minimize settling.

The cap final design will take into account site conditions including topography, precipitation or drought, freezing and thawing, soil types, waste characterization, settlement/subsidence, slope stability, erosion potential, and the cap system elements.

The service life for the landfill cap is assumed to be 40 years. Replacing the Zone A cap every 40 years will address any degradation in the cap liner and provide an opportunity to address any subsidence that may occur within a zone.

The conceptual design of the Zone A cap is shown in Figure 5-1 and will include the following:

- Surface Water Collection and Removal Systems
- Vegetative Cover
- Vegetative Support Layer
- Geotextile Filter
- Drainage Layer
- Flexible Geomembrane Barrier Layer
- Low Permeability Soil Layer

Each of the cap layers is described in more detail in the paragraphs below.

Surface Water Collection and Removal Systems

The Zone A cap is designed to shed water prior to infiltration. Therefore, it is necessary to manage water generated as a result. Run-on waters are also taken into consideration as part of this design component. Due to the arid climate at the site, potentially accumulated volumes may be less than in most areas, however, above or below grade storm water detention basins will be constructed as part of the cap construction.

Vegetative Cover

The upper most layer of a cover system is the vegetative cover. Generally natural shallow rooted self-sustaining grasses or legumes are selected for this purpose. The vegetative cover will include low and spreading plants with rapid seed generation and development. Plants will be resistant to disease, insects and fire and will act to a small degree as a thermal barrier. The vegetative cover will promote evapo-transpiration to help minimize the infiltration of surface water and potential for leachate generation. A good cover can ultimately help prevent erosion caused by wind and precipitation and aid in slope stability. Recommended planting/seeding schedules should be performed in accordance with vender specifications and will be defined by the final design engineer. Species should be selected based on their suitability to climate and soils at the site. Planting by hydroseeding has been selected for this conceptual design and cost estimating purposes.

Vegetative Support Layer

A two feet thick vegetative topsoil layer will be installed to protect the other cover layers from the natural elements and provide a good base for the vegetative cover. Important criteria considered for selecting the vegetative topsoil include available nutrients (nitrogen, phosphorus, potassium, and organic matter), pH level (6.5), seed germination timing, and water holding capacity. Soil from on-site will be used for this layer.

Geotextile Filter

A geotextile filter will be installed between the vegetative topsoil layer and drainage layer. The geotextile filter minimizes the movement of fines from the vegetative support layer to the drainage layer during natural settling and during water percolation. It is important to prevent this movement since fines are needed in the vegetative support layer to maintain the field capacity of the soil. In addition, the movement of fines into the drainage layer can fill the voids in that layer and prevent horizontal flow.

The geotextile used as part of a cover application must have properties that provide a high degree of permeability as well as resistance to punctures, rips and the effects of heating or freezing. A Layfield Plastics Typar geotextile 3801 woven polypropylene liner has been used for this concept design and cost estimating purposes. The Typar 3801 has a 74 micon (200 sieve) opening. Heat bonded non-woven geotextiles are generally used for drainage applications and are good for sub-grade stabilization and applications requiring strength.

Drainage Layer

A one foot thick drainage layer is located below the geotextile filter and serves to remove moisture that has penetrated these layers. Constructing this layer with a proper grade (2% or greater) will allow gravity to move moisture horizontally along the barrier layer, into edge drains that flow into a retention basin at the site. Removal of liquids from above the barrier layer reduces hydraulic loading on the Zone and the potential for structural failures. In addition, the removal of liquids from the drainage layer reduces the effects of freezing and thawing within the Zone cover.

A poorly sorted medium to course grained sand with a hydraulic conductivity (k) greater than or equal to 10^{-3} cm/sec was used for this concept design and cost estimating purposes. Due to the arid climate of this region, conveyance enhancement systems (such as piping) are not required to help move water through the drainage layer.

Flexible Geomembrane Barrier Layer

The barrier layer is the main "impenetrable" boundary constructed as part of the cover that prevents liquid percolation into the Zone. The barrier layer can be constructed of low permeable soils such as clay, or synthetic materials (geomembranes).

The barrier layer liner must be constructed to accommodate chemical compatibility with the landfill waste. The liner must have sufficient strength and thickness to prevent failure due to pressure gradients including static head or gases, and external hydrogeologic forces. The liner must also accommodate climatic conditions, the stress of installation, and the stress of daily operation.

The barrier layer used for this conceptual design is a 40 mil HDPE that will provide a significant safety factor meeting all of the design criteria listed above.

Low Permeability Soil Layer

The second portion of the barrier layer will be constructed of low permeable soils. A two foot thick layer of clay will be placed over the top of the existing materials. This layer will act as base layer for placement the geomembrane, a back-up for the geomembrane, and a foundation for the completed cover system. The layer will be composed of native soils mixed with bentonite using an on-site pugmill so that the hydraulic conductivity of the mixture is lowered to less than or equal to 10^{-7} cm/sec.

HELP Model - Cap

The Hydrologic Evaluation of Landfill Performance (HELP) model was executed to verify that the preliminary design of the landfill caps provided sufficient protection from infiltration. This model was developed by the U.S. Army Corps of Engineers for the EPA to evaluate water balance analysis of landfills, landfill caps, and disposal containment cells. HELP Version 3.07 was used in the estimation of percolation/leakage through the waste. The reader may refer to a discussion of this model and assumptions used related to the input parameters in the "Pasco Sanitary Landfill Closure Plan," prepared by Woodward-Clyde (Seattle, WA) for Philip Environmental Services Corporation (Renton, WA) dated October 3, 1995.

The following additional assumptions were applied to the input parameters of the model:

- The model was executed over 40 years (the life of the landfill cap) using synthetically generated evapotranspiration, precipitation, and temperature data from Yakima, WA (Woodward-Clyde, 1995).

- The area of each landfill was assumed to be the design area of each landfill cap calculated previously.
- The landfill area was modeled with an average slope of 2% and a maximum slope length of half of the longest dimension of each zone. The SCS curve number was computed from these values and assuming a poor stand of grass.
- The flexible membrane layers were assumed to contain a pinhole density of 1 hole/acre (conservative), installation defect density of 4 holes/acre (fair/good), and "good" (average) placement quality.
- The native top-soil was assumed to be type SM (silty sand) with a saturated hydraulic conductivity of 5.2 x 10^{-4} cm/sec.
- The lateral drainage layer was assumed to be soil type SW (well-graded sand) with a saturated hydraulic conductivity of 5.8 x 10^{-3} cm/sec.
- For Zones A and B, the layer of waste was assumed to have the characteristics of municipal waste with channeling.
- For Zones C/D and E, the layer of waste was assumed to have the characteristics of municipal waste without channeling.

Using these assumptions, modeling results for all the zones indicate that the majority (86.5%) of the average total annual precipitation is converted by evapotranspiration. The modeling results for the landfill cap design for all the zones indicate that the average percolation/leakage through the waste over a 40-year period is less than 1 x 10^{-4} inches per month. Output of this application of the HELP model can be found in Appendix A.

Zone A Cap Operation & Maintenance Plan

In further consideration for public safety, protection to human health and the environment and in order to provide long term care for the landfill cap, a Landfill Operation and Maintenance Plan will be prepared. The contents of this plan will include but not be limited to the following.

Zone Inspections

Cover system inspections will be performed by qualified personnel on a routine basis or following a storm event. The inspector will:

- Inspect deterioration, malfunctions, or improper operation of the landfill cover, run-on, and run-off control systems;

- Inspect for the presence of burrowing animals or non-designed (deep-rooted) vegetation.
- Perform a site survey periodically with fixed survey benchmarks to assess the potential for landfill subsidence.

Recordkeeping

Landfill owners/operators/inspectors shall keep a written operating record at the facility. Records will include all information related to the design, construction, waste types, operations and maintenance plans, emergency plans, and inspections.

Landfill owners/operators/inspectors shall keep detailed records regarding landfill operations and maintenance including landfill inspections. For record keeping consistency, an inspection form will be completed during the course of each inspection (see Landfill Inspections). Reports shall be kept documenting the use of any landfill contingency plans, or any other landfill incidents.

In addition to the cap element, expansion of the SVE system as would be included as described in Section 5.3.3.1, and access and institutional controls would be established as described in section 5.3.1.

Alternative A-2 Costs

The estimated costs for the installation of a cap over Zone A based on this conceptual design is summarized in Table 5-2. Earthwork and labor costs were derived from unit cost data estimated by Wilder Construction (Everett, WA) and Jan-Car, Inc. (El Paso, TX). Flexible membrane liner and geotextile filter installation and testing unit costs were provided by Layfield Plastics (Bellevue, WA), and bentonite cost estimates for the on-site mixing of a barrier soil layer were provided by Wyo-Ben, Inc. (Billings, MT). The bentonite costs are based on the use of 3.5 lbs. of bentonite per square foot of surface area per six-inch lift of soil-bentonite mixture.

The estimated costs are segregated into engineering, installation, construction management, and operation and maintenance costs. Engineering and construction management costs were estimated to be approximately 10% of the installation cost, and a 15% contingency is applied to the subtotal.

The vegetation support layer is assumed to consist of on-site native soils. Unit costs associated with the mixing and application of the barrier soil layer (10^{-7} requirement) are estimated assuming that no natural clay is available and must be mixed on-site using bentonite, water, and natural loess soil. Water is assumed to be readily available and in close proximity with the landfill cells.

Operation and maintenance of the cap is assumed to be $2,500 per year in perpetuity with cap replacement every 40 years. Cap replacement includes the removal of the vegetation layer, vegetation support layer, geotextile filter, and drainage layer from the top of the cap. After removal of these layers, the remaining cap will be prepared as needed to accept a new flexible membrane layer, and the vegetation layer, vegetation support layer, geotextile filter, and drainage layer will be rebuilt. Costs are included for excavation of on-site borrow soils, and construction management.

Total Cost for Alternative A-2

Zone A Cap Construction and O & M	$399,155
Expansion of SVE and O & M	5,918,242
Institute Access and Institutional Controls	20,000
Total	**$6,337,397**

5.3.3.3 ALTERNATIVE A-3

Alternative A-3 consists of the following elements:

- Drum removal with off-site disposal;
- Construct and maintain a cap in compliance with WAC 173-303 on the remaining soils;
- Expanded SVE; and
- Institute access and institutional controls.

This alternative implements Alternative A-2 with the addition of the removal of the drummed waste from the zone, and placing the cap over the underlying soils.

Drum Removal, and Off-site Incineration

The drums in Zone A will need to be removed individually due to the variety of waste streams in the drums, differing treatment and regulatory requirements for each potential waste stream, and the potential incompatibility of these waste streams.

Procedures to implement this element would include:

- Slope and fill materials excavation;
- Drum inspection, containment and removal;
- Waste sampling and inventory;
- Waste characterization and analysis;
- Waste consolidation, transportation and disposal;
- Potential rerouting of the existing landfill access road; and
- Implementation of significant site and public health and safety procedures.

Drum Removal Procedures

Prior to drum removal, the remediation site will be staged. Exclusion zones, support zones, decontamination zones, materials handling areas, equipment storage space, administrative support trailers, laboratory trailer, etc. will be put in place. Potentially, the access road to the landfill will be rerouted to limit public proximity.

<u>Slope and Fill Materials Excavation</u>

The landfill slope face will be excavated to the outermost columns of drums, which will be inspected for integrity, leaks and potential contents identification. Fill material in between the columns will be excavated. Excavated soil and fill material will be removed from the drum removal area, placed on liners, and covered. As drums are removed, surface soils and inter-drum fill material will be removed.

<u>Drum Inspection, Containment and Removal</u>

As each column of drums is uncovered, the drums will be inspected for corrosion, leakage and waste identification. Each drum will be placed into an overpack drum, to prevent product release from probable corrosion, and delivered to a staging area for assessment. It is certain that a significant percentage of drums will be sufficiently corroded as to require special handling, through a variety of means, to minimize product release.

<u>Waste Sampling and Inventory</u>

Each drum will be sampled for identification. Qualitative, on-site analysis will be performed to determine the fundamental nature of the waste stream, such as hazard class, reactivity, physical state, etc. This qualitative analysis will be used to direct quantitative analysis. Each drum will be labeled, inventoried (total quantity, percent liquid versus solid, drum condition and type, color, phases, qualitative analysis results) and stored with other drums of similar type or hazard class.

Waste Characterization and Analysis

To properly identify waste streams for disposal, an on-site testing facility will be used for quantitative analysis. As necessary, drum samples may also be delivered to an off-site testing laboratory. To the extent possible, drums will be grouped by type and hazard class, and a composite analysis will be conducted. To be cost effective, a waste disposal strategy will be developed to maximize consolidation for disposal by waste type, hazard class, physical state, treatment technology, regulatory requirements, and transportation mode. When the waste streams have been successfully identified and characterized, they will be profiled for treatment and disposal at a permitted hazardous waste treatment, storage and disposal facility (TSDF).

Waste Consolidation, Transportation and Disposal

When disposal approval has been obtained, the drum contents will be consolidated as characterized; for example, drums containing liquid solvents, acids, bases, biocides or oils may be pumped for bulk transport and disposal. Solids may be removed from drums and placed in containers for bulk shipments. Empty drums would be either triple rinsed on site or crushed and consolidated with bulk solids disposal. Some drums would be shipped without bulking; economics, regulatory and technical considerations will drive the consolidation strategy.

The wastes will be properly labeled, manifested, transported and disposed of at a rate equal to removal from the landfill. It is anticipated, based on the RI site history, that the majority of waste removed from Zone A will require incineration. The nearest permitted incinerator is located in Aragonite, Utah which is 660 miles from the site.

Release Prevention and Engineering Control

Release prevention engineering controls will include:

1) the installation of portable shelters,
2) carbon filtration of potential air contaminants, and
3) the staging of portable spill containment.

The portable shelter will be a galvanized tubular steel frame structure, with translucent white vinyl flame retardant fabric. The shelter will be approximately 133' x 200' in size, and will be positioned over the area of current excavation. The shelter will be fully enclosed, and prevent the migration of air contaminants from potential release. A 36,000 pound, 28,000 cfm carbon adsorption air filtration unit will be connected to the shelter, and will filter potential airborne organic contaminants from the air. Inside the shelter, a series of portable, inflatable, chemical resistant spill containment berms will be deployed. The berms will be positioned along the open face of drums, to collect potential product that may leak from drums during removal.

Site Maintenance

Significant effort will be needed to maintain a stable slope face, implement spill containment and emergency response preparedness, manage surface water runoff and leachate, manage excavated materials stockpiles, and coordinate the timely turn-around of wastes to prevent site drum accumulation.

Alternative A-3 Cost

Cost estimates for drum removal are based on the following assumptions:

- Approximately 35,000 drums requiring removal,
- A 100% rate of drum corrosion (i.e., no drums will meet D.O.T. specifications after being buried for 26 years),
- An average of 40 drums contained, removed, characterized, and transported off-site per work day,
- A project duration of four years,
- Average analytical costs of $300/drum,
- Average transportation and disposal costs of $500/drum,
- A 25% contingency margin for unforeseen costs.

The total cost for the drum removal and incineration element of alternative A-3 is estimated to be $50,674,531. This cost is presented in detail in Table 5-3.

Total Cost for Alternative A-3

Drum Removal and Incineration	$53,475,860
Zone A Cap Construction and O & M	339,155
Expansion of SVE and O & M	5,918,242
Institute Access and Institutional Controls	20,000
Total	**$59,753,257**

5.3.3.4 ALTERNATIVE A-4

Alternative A-4 is composed of the following elements:

- Drum removal with off-site disposal; and
- Removal of impacted soil and off-site disposal at a RCRA TSD;
- Access and institutional controls.

This alternative implements A-3, but instead of treating the underlying soil in-situ with SVE, it relies on excavation of soils and off-site disposal to meet clean-up criteria. While it is assumed that soil beneath Zone A is impacted by contaminants of concern, the amount of impacted soil is not known. Because of the groundwater beneath Zone A is impacted by VOCs above cleanup levels it is assumed that the entire soil column beneath Zone A is impacted above soil cleanup levels protective of groundwater.

Soil Removal Procedures

After drummed waste is removed from the zone soil excavation can begin. Prior to excavation a significant design effort will be required. The excavation could be as deep as 45 feet if it must extend to the groundwater surface to meet cleanup levels. Stabilizing an excavation of this depth would require a major effort in terracing, tie-back walls and/or sheet piling. This fact plus the fact that Zone A is surrounded by a balefill, burn trench, and construction debris fill present a sizeable implementation effort for this alternative. Provisions for a haul road out of the excavation would be included to accommodate truck traffic. Alternatively, a crane and clam-shovel could be used from the surface. This would slow the excavation rate substantially compared to the use of excavators and trucks in the excavation.

This alternative assumes that the majority of soil removed from beneath Zone A would require incineration. A testing program would be implemented that would evaluate the level of contamination of the soil to properly characterize the waste and determine how it could be most cost-effectively treated. It is assumed that the soil would be manifested and shipped in bulk to an incineration facility. The nearest incinerator is in Aragonite, Utah, which is 660 miles from the site.

Total Cost for Alternative A-4

Drum Removal and Incineration	$53,475,860
Soil Removal and Incineration	128,432,000
Institute Access and Institutional Controls	20,000
Total	**$181,927,860**

5.3.3.5 ALTERNATIVE A-5

This alternative consists of the following elements:

- Drum and soil removal;
- Consolidation and containment in an on-site lined cell; and
- Access and Institutional controls.

Alternative A-5 implements Alternative A-4, but places the drummed waste and excavated soil in an on-site lined cell constructed in compliance with WAC 173-303-646. Drum and soil removal will be implemented in the same way as Alternative A-4, but costs for off-site transport and disposal will not apply to dry non-reactive waste.

After excavation, waste and soil will be sorted according to reactivity and physical state. Wastes or soils containing free liquids will require off-site incineration or on-site stabilization prior to disposal in the on-site lined cell. Wastes that appear reactive would require off-site disposal. This alternative may not be implementable because of uncertainties associated with waste or soil handling. In addition, given the impacts of Zone A to groundwater, the amount of wastes and soil requiring off-site disposal may approach the amount removed in A-4. For purposes of this FS it is assumed that up to 10% of the COC's by mass will be in a free liquid or reactive state and require off-site incineration.

Zone A On-Site Lined Cell

The on-site lined cell will be installed in a level area east of the present location of Zone A. Based on the surface area and depth of Zone A and the thickness of the various containment systems/layers outlined below, a total excavation volume of 48,145 cubic yards of soil will be required to construct the cell. A conceptual design including a discussion of the design components of the on-site lined cell is included below.

On-Site Lined Cell Conceptual Design

This conceptual design has been prepared in accordance with WAC 173-303-665. It should be noted that this conceptual design was completed for the purpose of comparing remedial alternatives. Exact specifications of the design should be revisited during the formal design stage if this alternative is chosen. Specifications made in this FS should not limit the choices of the design engineer during the formal design stage.

Disposal of wastes from Zones A through E into on-site lined cells is considered in this FS. The concept design includes a dedicated lined cell for waste from each zone, located in close proximity to the existing zone. As with the cap, we have proposed a single cell for Zones C & D because the zones are close together and have similar wastes.

An alternative to this approach is to construct a single partitioned landfill cell for all wastes in Zones A through Zone E or at least reduce the number of cells by consolidating compatible wastes into a single cell. A single cell could be easily sited at the property and may reduce costs and add to the ease of instituting engineering and institutional controls. If the on-site lined cell alternative is chosen as the preferred remedy for more than one Zone, consolidation of the wastes into a single cell should be considered during design.

Cell design will take into consideration health and safety, aesthetics, and site usage following closure. The landfill cell will be designed and constructed to provide long-term management of liquids in the landfill cell, operate with minimal maintenance, and minimize settling.

The on-site lined cell conceptual design for all zones is presented in Figure 5-2. The cell consists of three major components as follows:

- A cover system as described and defined in Section 5.3.3.2 above;
- The waste; and
- A liner and leachate collection system.

Cell design will take into account site conditions including topography, precipitation or drought, freezing and thawing, soil types, waste characterization, settlement/subsidence, slope stability, erosion potential, and the cover system elements. Implementation of this alternative will require completion of the following tasks:

- Design and construction of an on-site lined cell.
- Removal and redisposal of wastes.

- Site restoration of the waste excavation area.
- Construction of the landfill cap (See Alternative A-2)

For this preliminary design the service life for the landfill cap is assumed to be 40 years. Therefore, every 40 years the landfill cap will be replaced.

Design and Construction of the On-site Lined Cell

Starting from directly beneath the wastes in the cell, the lined cell is composed of the following systems/layers:

- Filter Media Layer;
- Geotextile Filter Layer;
- Primary Leachate Collection System;
- Primary Flexible Membrane Liner Layer;
- Secondary Leachate Collection and Leak Detection System;
- Secondary Flexible Membrane Liner Layer;
- Low Permeability Layer; and
- Foundation Layer/Native Soil Layer.

Each of these systems/layers is described in some detail below.

Filter Media Layer

Landfill waste will be placed directly on the filter media layer. This layer will be a one foot layer of gravel with a minimum hydraulic conductivity of 1 cm/sec. If leachate is produced within the waste, this media will allow for free drainage into the primary leachate collection system. Although synthetic drainage materials can also be used for this layer, an advantage of using natural material is that it protects the underlying materials by more effectively spreading the loads from the overlying wastes.

Geotextile Filter Layer

A geotextile filter will be installed between the filter media layer and the primary leachate collection system (PLCS). The geotextile filter minimizes the movement of fines from the filter media layer into the PLCS during natural settling and during leachate percolation. It is important to prevent this movement since fines in the PLCS can fill the voids in that system and reduce drainage capacity.

The geotextile used as part of this layer must have properties that provide a high degree of strength as well as resistance to punctures, compatibility with wastes and permeability to leachate. Woven geotextiles are generally used for separation and reinforcement and provide filtration of fines that may settle out from waste products. A Layfield Plastics LP 300 woven geotextile polypropylene liner has been used for this concept design and cost estimating purposes. This liner should meet or exceed design specifications for this layer.

Primary Leachate Collection System

The primary leachate collection system (PLCS) is located just below the filter media and lays on top of the flexible membrane liner. This system provides horizontal transport by gravity drainage of moisture that has percolated through the filter media. Removal of leachate from above the flexible membrane liner reduces hydraulic loading on the landfill and the potential for structural failure.

The PLCS will be a one-foot thick layer of coarse sand and gravel with a hydraulic conductivity of 0.01 cm/sec and will be installed with a slope of greater than or equal to 2% to promote drainage. A single perforated pipe is located in this system to facilitate gravity flow into a sump that will be located at the lowest point of the system. Depending on the final design the sump may be emptied through the use of pumps installed and located in the sump, above ground or mounted on a truck (vactruck). For the purpose of this conceptual design the more expensive alternative of pumps located within the sump is assumed.

Sumps may be simply extensions of the PLCS or pipe trenches. Pumps used to remove leachate from the sumps should be sized to ensure removal of leachate at the expected rate of generation and must have a sufficient operating head to lift the leachate the required height, from the sump to the access port. Pumps and piping should be capable of handling solids without clogging. Pipe diameters will be designed with minimum velocities to avoid particulate settling and maximum velocities to prohibit pipe thrust and hammer. Pipe and pump materials shall be chemically compatible to the waste leachate that is capable of being generated in the landfill cell.

This design meets or exceeds the following design criteria:

- the primary system should be capable of maintaining a leachate head of less than 30 cm (one foot);

- the system should have at least a 12-inch thick granular drainage layer that is chemically resistant to the waste and leachate, with a hydraulic conductivity not less than 1×10^{-2} cm/sec, and with a minimum bottom slope of two percent; and
- primary systems should have a drainage system of pipes to efficiently collect leachate; the pipes should have sufficient strength and chemical resistance to perform under landfill loadings.

Primary Flexible Membrane Liner

The primary flexible membrane liner (PFML) is positioned below the PLCS. Flexible membrane liners are designed, constructed, and installed to prevent migration of wastes out of the cell into adjacent subsurface soil or groundwater or surface water during the life of the landfill. Liners are selected to accommodate chemical compatibility with waste and have strength and thickness to support landfill waste, cover, construction and operations during waste loading. Liner compatibility with waste and leachate is essential to assure maximum liner integrity. Liner material selection can be made through discussions with liner manufacturers.

The membrane liner used for this conceptual design is a 60 mil HDPE.

Secondary Leachate Collection And Leak Detection System

A secondary leachate collection system (SLCS) will be installed just below the top membrane liner. The SLCS will be constructed with similar specifications to the primary leachate collection system and will also incorporate a leak detection system.

Secondary Flexible Membrane Liner

The secondary flexible membrane liner (SFML) is located beneath the SLCS and acts as a secondary barrier to loss of leachate. Similar to the PFML the SFML is selected to accommodate chemical compatibility with waste and have strength and thickness to support landfill waste, cover, construction and operations during waste loading.

The membrane liner used for this conceptual design is a 60 mil HDPE.

Low Permeability Layer

A three feet clay soil liner will be installed beneath the SFML. This layer is proposed for added protection against leachate loss from the liners. The layer will be composed of native soils mixed with bentonite using an on-site pugmill so that the hydraulic conductivity of the mixture is lowered to less than or equal to 10^{-7} cm/sec.

Foundation/Native Soil Layer

Native soil located beneath the landfill cell will be prepared as a foundation layer for the low permeability layer and the rest of the cell. The design engineer will characterize the subsurface soils and prepare a compaction specification suitable to function under the forces of the cell.

HELP Model – On-Site Lined Cell

The Hydrologic Evaluation of Landfill Performance (HELP) model was executed to verify that the preliminary design of the on-site lined cells provided sufficient protection from infiltration. This model was developed by the U.S. Army Corps of Engineers for the EPA to evaluate water balance analysis of landfills, landfill caps, and disposal containment cells. Version 3.07 was used in the estimation of percolation/leakage through the bottom barrier soil layer of the cells. The reader may refer to a discussion of this model and assumptions used related to the input parameters in the "Pasco Sanitary Landfill Closure Plan," prepared by Woodward-Clyde (Seattle, WA) for Philip Environmental Services Corporation (Renton, WA) dated October 3, 1995.

The following additional assumptions were applied to the input parameters of the model:

- The model was executed over 40 years (the life of the landfill cap) using synthetically generated evapotranspiration, precipitation, and temperature data from Yakima, WA (Woodward-Clyde, 1995).
- The area of each landfill was assumed to be the design area of each landfill cap calculated previously.
- The landfill area was modeled with an average slope of 2% and a maximum slope length of half of the longest dimension of each zone. The SCS curve number was computed from these values and assuming a poor stand of grass.
- The flexible membrane layers were assumed to contain a pinhole density of 1 hole/acre (conservative), installation defect density of 4 holes/acre (fair/good), and "good" (average) placement quality.
- The native top-soil was assumed to be type SM (silty sand) with a saturated hydraulic conductivity of 5.2×10^{-4} cm/sec.
- The lateral drainage layer in the cap was assumed to be soil type SW (well-graded sand) with a saturated hydraulic conductivity of 5.8×10^{-3} cm/sec.

- The lateral drainage layers in the primary and secondary leachate collection systems in the on-site lined cell were assumed to be soil type SP with a saturated hydraulic conductivity of 1.0×10^{-2} cm/sec.
- The barrier soil layers were assumed to be high density soils with a saturated hydraulic conductivity of 1.0×10^{-7} cm/sec.
- The filter media layer was assumed to be gravel with a saturated hydraulic conductivity of 0.3 cm/sec.
- For Zones A and B, the layer of waste was assumed to have the characteristics of municipal waste with channeling.
- For Zones C/D and E, the layer of waste was assumed to have the characteristics of municipal waste without channeling.

Using these assumptions, modeling results for all the zones indicate that the majority (86.5%) of the average total annual precipitation is converted by evapotranspiration. The modeling results for the on-site lined cell design for all the zones indicate that the average percolation/leakage through the bottom barrier soil layer over a 40-year period is less than 1×10^{-4} inches per month.

<u>On-Site Cell Operation & Maintenance Plan</u>

In further consideration for public safety, protection to human health and the environment and in order to provide long term care for the on-site cell, an On-Site Cell Operation and Maintenance Plan shall be prepared. The contents of this plan will include but not be limited to the following:

<u>On-Site Cell Inspections</u>

On-site cell inspections will be performed by qualified personnel on a routine basis or following a storm event. The inspector will:

- Inspect deterioration, malfunctions, or improper operation of the on-site cell cover, run-on, and run-off control systems;
- Inspect for the presence of burrowing animals or non-designed (deep-rooted) vegetation.
- Record the volume collected leachate in hold devices and the on-site cell sump;
- Inspect the leachate collection and removal system.

- Perform a site survey with fixed survey benchmarks (bi-annually) to assess the potential for on-site cell subsidence.

Recordkeeping

On-site cell owners/operators/inspectors shall keep a written operating record at the facility. Records will include all information related to the design, construction, waste types, operations and maintenance plans, emergency plans, and inspections.

On-site cell owners/operators/inspectors shall keep detailed records regarding cell operations and maintenance including landfill inspections. For record keeping consistency, an inspection form will be completed during the course of each inspection (see On-site Cell Inspections). Reports shall be kept documenting the use of any on-site cell contingency plans, or any other incidents.

Zone A On-Site Lined Cell Estimated Costs

The estimated costs for the installation of a lined cell for disposal of waste from Zone A are summarized in Table 5-5. Earthwork and labor costs were derived from unit cost data estimated by Wilder Construction (Everett, WA) and Jan-Car, Inc. (El Paso, TX). Flexible membrane liner and geotextile filter installation and testing unit costs were provided by Layfield Plastics (Bellevue, WA), and bentonite cost estimates for the on-site mixing of a barrier soil layer were provided by Wyo-Ben, Inc. (Billings, MT). The bentonite costs are based on the use of 3.5 lbs. of bentonite per square foot of surface area per six-inch lift of soil-bentonite mixture.

The estimated costs are segregated into engineering, installation, construction management, and operation and maintenance costs. Engineering and construction management costs were estimated to be approximately 10% of the installation cost, and a 15% contingency is applied to the subtotal.

The vegetation support layer is assumed to consist of on-site native soils. Unit costs associated with the mixing and application of the barrier soil layer (10^{-7} requirement) are estimated assuming that no natural clay is available and must be mixed on-site using bentonite, water, and natural loess soil. Water is assumed to be readily available and in close proximity with the landfill cells. It is also assumed that the new cell is constructed in a location near the current location of Zone A.

Drum removal costs are the same as those described in alternative A-4, with only 4000 drums (10 percent) requiring incineration.

Operation and maintenance of the on-site lined cell is assumed to be $2,500 per year in perpetuity with cap replacement every 40 years. Cap replacement includes the removal of the vegetation layer, vegetation support layer, geotextile filter, and drainage layer from the top of the cap. After removal of these layers, the remaining cap will be prepared as needed to accept a new flexible membrane layer, and the vegetation layer, vegetation support layer, geotextile filter, and drainage layer will be rebuilt. Costs are included for excavation of on-site borrow soils, and construction management. The lined bottom of the cell will never be replaced. Annual leachate collection and treatment costs were estimated at $10,000/year

Total Costs for Alternative A-5

Drum Removal	$30,739,375
Soil Removal	4,815,000
On-site Lined Cell with Cap	1,549,513
Institute Access and Institutional Controls	20,000
Total	**$37,123,888**

5.3.4 ZONE B

The following sections describe the remedial alternatives for the waste/soil media at Zone B.

5.3.4.1 ALTERNATIVE B-1

Alternative B-1 includes the following elements:

- Maintain existing soil cap; and
- Implement access and institutional controls.

The existing native soil cover over the drums of Zone B has, to date, prevented direct human contact with wastes contained in the zone. However, the native soils cap has recently begun to show some evidence of subsidence. Where appropriate, areas have been filled or patched. This alternative would include periodic inspections of the cover, and provide for repair if failures occur in the future.

In addition, access and institutional controls would be established as described in Section 5.3.1. There is currently a six-foot high chain link fence with a barbed wire top, surrounding Zone B.

Total Cost for Alternative B-1

Maintain existing Zone B soil cap	$35,714
Implement access and institutional controls	5,000
Total	**$40,714**

5.3.4.2 ALTERNATIVE B-2

Alternative B-2 includes the following elements:

- Construct and maintain a cap on Zone B in compliance with WAC 173-303; and
- Implement access and institutional controls.

A new Zone B cap, in compliance with WAC 173-303, will be installed over the present position of the Zone. To prevent lateral infiltration, it will extend beyond the existing zone boundaries a distance equal to the zone depth, approximately 15 feet. The total Zone B cap area proposed under this conceptual design is 0.26 acres (11,440 square feet). The "RCRA" cap conceptual design is described in Section 4.3.1.2.2.

The surface of Zone B will require significant re-grading as part of the cap construction. Native soil will be added to the west, south, and east sides of the zone to attain a 2% to 5% slope. A trench will be added to the north side of the zone to prevent run-on and conduct surface water around the cap. It is expected that the existing cover material will remain over the waste. Because of the unknown condition of the drums within the zone, mechanical compaction of the waste will not be considered prior to installing the cap. Instead, potential future subsidence will be addressed in the O&M plan and the cap will be replaced every 40 years.

The estimated costs for the installation of a cap at Zone B are summarized in Table 5-6. The assumptions made are consistent with those discussed in Section 5.3.3.2. In addition to a new Zone B cap, access and institutional controls would be established as described in section 5.3.1. There is currently a six-foot high chain link fence, with a barbed wire top, surrounding Zone B.

Total Cost for Alternative B-2

Construct new Zone B cap	$117,117
Implement access and institutional controls	5,000
Total	**$122,117**

5.3.4.3 ALTERNATIVE B-3

Alternative B-3 includes the following elements:

- Construct and maintain a cap on Zone B in compliance with WAC 173-303
- Construct horizontal subsurface barriers
- Implement access and institutional controls

In addition to the Zone B cap described in Section 5.3.3.2 above, a horizontal barrier will be constructed beneath the zone and will tie in with the cap.

The horizontal barrier system would provide full containment of the waste cell using an 'inverted pyramid ' configuration for the bottom along with the impermeable cap for the top. Conventional unguided angle drilling would be used to deliver a grouting material into the subsurface at a preset angle to the horizontal. As the drill auger is extracted from the boring, grout material is injected through two nozzles set at 160°. A cross sectional view of the resulting grout/soil mixture shows a rectangular shape with a bend from the middle, referred to as a thin diaphragm wall. The next panel of the thin diaphragm wall is placed so that panels overlap. This is in contrast to the somewhat circular cross section left by permeation grouting behind the auger. The diaphragm wall allows for better overlap and connection with the previous group panel. This procedure is repeated along each side of the cell. The panels intersect with the adjoining panel to form the edge of the 'pyramid' All four sides of the containment meet at the deepest point forming the 'inverted pyramid'. It is estimated that the nose of the cone would be approximately 35 feet BGS for Zone B. Figure 5-3 shows a conceptual diagram of this barrier. The diaphragm wall grouting technology is more widely used than the permeation grouting and is considered to be somewhat more reliable.

Thin diaphragm walls technology injects the grout into the soil voids, creating turbulence that mixes soil and grout to form a relative consistent barrier material. The injection rate is typically adjusted to minimize the production of tailings or excess grout.

The grout material is chosen based on the geology of the site and chemical properties of the waste. The variety of wastes in Zone B may require extensive laboratory grout testing to define the grout composition. The least expensive grouting material would be a bentonite/portland cement or bentonite/polymer grout. The most costly grout would be a mixture of Montan Wax and additives.

The following steps would be required as part of the implementation of this alternative:

1. Laboratory Grout Testing to determine the grout mixture best suited for the Zone B (i.e., maintain structural integrity in the subsurface geology beneath the Zone and withstand potential exposure to Zone contaminants).
2. Field Testing - This would involve the installation of a test section in an uncontaminated area followed by excavation to evaluate and confirm that the construction parameters and grout behavior is adequate for the site. . Field testing in an uncontaminated area allows full excavation to evaluate the true behavior of the grout material and construction techniques with little or no potential for release of contamination to the environment.
3. Final Design including borehole placement, injection rate, grout recipe and confirmation testing.
4. Installation of the thin diaphragm walls using unguided conventional drilling with jet grouting.
5. Excess soil/grout disposal (expected to be minimal)
6. Curing or setting of the grout (time will vary depending on grout characteristics and site geology)
7. Confirmation Testing using gas phase tracers.
8. Placement of the Zone B cap tied into the horizontal barriers.

The estimated costs for the installation of a horizontal barrier beneath Zone B are summarized in Table 5-7. Applied Geotechnical Engineering and Construction Incorporated (AGEC) in Richland, Washington provided design and cost information. Engineering and construction management costs were estimated to be approximately 10% of the installation cost, and a 15% contingency has been applied to the subtotal.

The estimated costs for the new Zone B cap are as described above. Access and institutional controls would be established as described in Section 5.3.1. There is currently a six-foot high chain link fence, with a barbed wire top, surrounding Zone B.

Total Cost for Alternative B-3

Construct new Zone B cap	$117,117
Construct horizontal barrier	1,184,627
Implement access and institutional controls	5,000
Total	**1,306,744**

5.3.4.4 ALTERNATIVE B-4

Alternative B-4 includes the following elements:

- Drum removal with off-site disposal;
- Construct and maintain a cap in compliance with WAC 173-303 on the remaining soils; and
- Implement access and institutional controls.

The following is a conceptual procedure for executing a drum removal action at Zone B. Prior to actual drum removal, the area surrounding Zone B will be staged. Exclusion zones, support zones, decontamination zones, materials handling areas, equipment storage areas, administrative support trailers, laboratory trailer, etc. will be put in place.

The southern slope of the zone will be excavated to the outermost columns of drums. As each column of drums is uncovered, the drums will be inspected for integrity, leaks, and content identification. The drums will then be removed and placed into overpack drums, to prevent waste release due to probable drum corrosion. The overpacked drums will then be delivered to a staging area for assessment. It is likely that a percentage of drums will be sufficiently corroded and will therefore require special handling, through a variety of means. As drums are removed, the fill material between the drum columns will be excavated. Excavated fill material and incidental soils will be removed from the drum removal area, placed on liners, and covered.

Each drum will be sampled for identification. Qualitative, on-site analysis will be performed to determine the fundamental nature of the waste stream, such as hazard class, reactivity, physical state, etc. This qualitative analysis will be used to direct quantitative analysis as necessary. Each drum will be labeled, inventoried (drum condition and type, waste quantity, waste color, waste phases, qualitative analysis results) and stored with other drums of similar type or hazard class.

To properly identify waste streams for disposal, an on-site testing facility will be used for quantitative analysis. Drum samples may also be delivered to an off-site testing laboratory, as necessary. To the extent possible, drums will be grouped by type and hazard class, and a composite analysis will be conducted. To be cost effective, a waste disposal strategy will be developed to maximize consolidation for disposal by waste type, hazard class, physical state, regulatory requirements, required treatment technology, and transportation mode. When the waste streams have been successfully identified and characterized, they will be profiled for treatment and disposal at a permitted hazardous waste incinerator. While disposal options other than incineration may be feasible, this element assumes incineration as the off-site disposal method.

When disposal approval has been obtained, the drum contents will be consolidated as characterized. Solids may be removed from drums and placed in containers for bulk shipments. Empty drums would be either triple rinsed on site or crushed and consolidated with bulk solids disposal. Many drums would likely be shipped without bulking. Technical, regulatory and economic considerations will drive the consolidation strategy. All wastes will be properly labeled, manifested, transported and disposed of at a rate equal to the removal of the drums from the Zone.

Significant effort will be needed to maintain a stable slope face, implement spill containment and emergency response preparedness, manage surface water runoff, manage excavated materials stockpiles, and coordinate the timely turn-around of wastes to prevent drum accumulation at the site. Site specific health and safety procedures will be required to be developed to address concerns resulting from the probability that the drums will be in an advanced stage of corrosion, and lack structural integrity.

The estimated costs for the removal and off-site disposal of the Zone B drums are summarized in Table 5-8. This cost estimate is based on the following assumptions:

- Approximately 5,000 drums requiring removal.
- No drums will meet D.O.T. specifications after being buried for 26 years.
- An average of 40 drums contained, removed, characterized, and transported off-site per workday.
- A project duration of 30 weeks.
- Average analytical costs of $300/ drum.

- Average transportation and disposal costs of $500/ drum.
- A 25% contingency for unforeseen costs.

After removing the drums, fill material, and incidental soils from within the Zone, the remaining soils beneath the Zone footprint will be capped as described previously. The estimated costs for the Zone B cap are as described above. Access and institutional controls would be established as described in Section 5.3.1. There is currently a six-foot high chain link fence, with a barbed wire top, surrounding Zone B.

Total Cost for Alternative B-4

Drum removal with off-site disposal	$7,239,219
Construct new Zone B cap	117,117
Implement access and institutional controls	5,000
Total	**$7,361,336**

5.3.4.5 ALTERNATIVE B-5

- Drum removal with off-site disposal
- Soil removal with off-site disposal

Alternative B-5 includes the drum removal action as in Alternative B-4, but adds soil removal in lieu of a cap over the former footprint of the zone. During the RI, soil samples collected immediately adjacent to Zone B detected 21 dioxin congeners above calculated background levels. As determined by the RA/CLA, none of these dioxin congeners exceeded the MTCA Method C cleanup level. No dioxins were detected in groundwater samples during the RI. No herbicides were detected in either soil or groundwater samples collected during the RI.

Due to the relative lack of mobility of dioxins in soil, it is estimated that Method C soil levels for dioxin would be met after excavating soil 10 feet beneath the footprint of the excavated drums, (estimated at 2,550 cubic yards). The excavated soil would be staged in roll-off boxes prior to leaving the site for off-site disposal. It is assumed that a source of clean backfill soils is available on site. Detailed costs for this soil removal are found in Table 5-9.

Total Cost for Alternative B-5

Drum removal with off-site disposal	$7,239,219
Soil removal 10 feet below drums and off-site disposal	4,436,470
Implement access and institutional controls	5,000
Total	**$11,680,689**

5.3.4.6 ALTERNATIVE B-6

- Drum and soil removal with consolidation and disposal in an on-site lined cell
- Institute access and institutional controls

Alternative B-6 includes the drum and soil removal as in Alternative B-5, but substitutes on-site disposal in a new lined cell as opposed to off-site disposal. After excavation, waste and soil will be sorted according to reactivity and physical state. Wastes or soils containing free liquids will require off-site incineration or on-site stabilization prior to disposal in the on-site lined cell. Wastes that appear reactive would require off-site disposal. This alternative may not be implementable because of the uncertainties associated with waste or soil handling. For the purposes of this FS it is assumed that 500 drums (10 percent) will require off-site disposal. Clean backfill for the soil excavation could be supplied by the soil excavated during the cell construction.

The on-site lined cell would be constructed in a level area adjacent to the present location of Zone B. Based on the surface area and depth of Zone B and the thickness of the various containment systems/layers outlined in Section 5.3.3.5, a total excavation volume of 5,610 cubic yards of soil would be required to construct the cell. A conceptual design, including a discussion of the design components of an on-site lined cell, is included in Section 5.3.3.5.

The estimated costs for the installation of an on-site cell for disposal of waste from Zone B based on the conceptual design in Figure 5-2 are summarized in Table 5-10. The assumptions made are consistent with those discussed in Section 5.3.3.5.

It should be noted the costs shown for the excavation of the drums and soil includes the handling costs associated with the transfer of the waste and soil to the new cell. The same methods employed to prevent contamination from spreading during operations associated with off-site disposal are used to prevent spreading contamination during the transfer of material to an on-site cell.

Total Cost for Alternative B-6

Drum and soil removal	$4,167,935
On-site waste disposal	383,490
Institute access and institutional controls	5,000
Total	**$4,556,425**

5.3.5 ZONES C AND D

The following sections describe the remedial alternatives for the waste/soil media at Zones C and D.

5.3.5.1 ALTERNATIVE CD-1

Alternative CD-1 includes the following elements:

- Maintain existing soil caps
- Implement access and institutional controls

The existing native soil cover over Zones C and D have prevented direct human contact with the wastes contained in the zone. This alternative would include periodic inspections of the cover, and provide for repair as needed.

In addition, access and institutional controls would be established as described in Section 5.3.1.

Total Cost for Alternative CD-1

Maintain existing soil caps	$35,714
Implement access and institutional controls	10,000
Total	**$45,714**

5.3.5.2 ALTERNATIVE CD-2

Alternative CD-2 includes the following elements:

- Construct and maintain a cap in compliance with WAC 173-303,
- Implement access and institutional controls

A new cap in compliance with WAC 173-303 will be installed over the present position of Zones C and D. Due to the geographical relationship of the Zones, placement of a cap would most easily be performed by constructing a single cap over both zones. To prevent lateral infiltration, the cap will extend beyond the existing zone boundaries a distance equal to the depth of Zone D (the deeper of the two zones), approximately 9 feet. The total Zone C-D cap area proposed under this conceptual design is 0.71 acres (30,952 square feet). The 'RCRA' cap conceptual design is described in Section 4.3.1.2.2.

Minimal re-grading is necessary to prepare the zones for cap construction. It is expected that the existing cover material will remain over the waste. Mechanical compaction of the waste will be considered at the time of final design after geotechnical criteria are specified. It is not anticipated that mechanical compaction of Zone C-D waste will be needed due to the solid nature of the wastes as observed during the bulk waste characterization study performed during the RI. The estimated costs for the installation of a cap over Zones C and D are summarized in Table 5-11. The assumptions made are consistent with those discussed in Section 5.3.3.2.

In addition to a new single cap covering Zones C and D, access and institutional controls would be established as described in Section 5.3.1.

Total Cost for Alternative CD-2

Construct new Zone C-D cap	$198,429
Implement access and institutional controls	10,000
Total	**$208,429**

5.3.5.3 ALTERNATIVE CD-3

Alternative CD-3 includes the following elements:

- Construct and maintain a cap in compliance with WAC 173-303;
- Install a SVE system to treat impacted soil; and
- Implement access and institutional controls.

In addition to the new Zone C-D cap described in Section 5.3.4.2 above, a SVE system will be installed to treat vadose zone soils beneath the zones. Based on the operating experience of the SVE system at Zone A, it is anticipated that a single vapor extraction well centered between Zones C and D would be sufficient. The vapor extraction well would be completed approximately 10 feet above the water table, with a 15-foot screen section. The acetone VOCs present beneath Zones C and D will be subject to physical removal from the soils via vapor extraction. As the vadose zone oxygen levels increase as a result of SVE, these compounds will also be subject to destruction via aerobic biodegradation.

The estimated costs associated with a single well SVE system were based on experience with the existing SVE system at Zone A (Table 5-12). Operation and maintenance costs are for five years of operation. This assumption was based on the compounds present in the soils beneath the zone and the physical condition of the waste as observed during the RI. The estimated costs for the new Zone C-D cap are as described above. Access and institutional controls would be established as described in Section 5.3.1.

Total Cost for Alternative CD-3

Construct new Zone C-D cap	$198,429
Install SVE system, 5 year O&M	874,409
Implement access and institutional controls	10,000
Total	**$1,082,838**

5.3.5.4 ALTERNATIVE CD-4

Alternative CD-4 includes the following elements:

- Remove the waste from Zones C and D;
- Off-site disposal;
- Install a SVE system to treat impacted soil; and
- Implement access and institutional controls.

The following is a conceptual procedure for executing a waste removal action at Zones C and D. Prior to actual waste removal, the area surrounding the Zones will be staged. Exclusion zones, support zones, decontamination zones, materials handling areas, equipment storage areas, administrative support trailers, laboratory trailer, etc. will be put in place.

The zones will be excavated using a trackhoe and an excavator. The soil overburden will be removed and set aside for use as backfill material. Waste material from the zones will be excavated and placed directly into dump trucks or end dumps, or stockpiled short term, for logistical convenience, prior to loading into the trucks. A small amount of soil from directly beneath the waste will be excavated along with the waste. The remaining soil will be treated in-situ using a SVE system as described above.

A workplan will be prepared to address issues such as waste containment and emergency response preparedness, surface water run-on/run-off, the management of excavated materials stockpiles, and the coordination and timely turn-around of wastes to prevent accumulation at the site. Site specific health and safety procedures will be developed.

The findings of the bulk waste characterizations were used to develop disposal cost scenarios for the waste contents from the Zones. Zone C waste samples did not designate as either a characteristic RCRA hazardous waste or a Washington Dangerous Waste. The cost for the disposal of Zone C waste is based on a Subtitle C hazardous waste landfill, though it meets regulatory standards for disposal in a Subtitle D non-hazardous landfill.

The Zone D waste samples had detected levels of three VOCs following the TCLP extraction procedure. One of these three, 1,2-DCA was at a level that would cause the waste to designate as both a characteristic RCRA waste (D028) as well as a Washington Dangerous Waste. The cost for the disposal of Zone D waste is based on incineration at a permitted hazardous waste incinerator, as the waste exceeds regulatory levels for disposal in a Subtitle C landfill.

The estimated costs for the removal and off-site disposal of Zone C and D waste are summarized in Table 5-13. The estimated costs for the Zone C-D SVE system are as described above. Access and institutional controls would be established as described in section 5.3.1.

Total Cost for Alternative CD-4

Remove the waste from Zones C and D	$126,063
Off-site waste disposal	4,665,780
Install SVE system, 5 year O&M	874,409
Implement access and institutional controls	10,000
Total	**$5,676,252**

5.3.5.5 ALTERNATIVE CD-5

Alternative CD-5 includes the following elements:

- Removal of waste;
- containment in an on-site lined cell;
- Install an SVE system to treat impacted soil; and
- Implement access and institutional controls.

Alternative CD-5 includes the waste removal and in-situ soil treatment with SVE as in Alternative CD-4, but substitutes on-site disposal in a new lined cell as opposed to off-site disposal.

Due to the similarity of wastes contained in Zones C and D and the co-location of the zones, a single lined cell is proposed for the on-site disposal of the wastes from both zones. The on-site lined cell will be installed in a level area adjacent to the present location of Zones C and D. Based on the surface area and depth of Zones C and D and the thickness of the various containment systems/layers outlined in Section 5.3.3.5. A total excavation volume of 15,160 cubic yards of soil will be required to construct the cell. A conceptual design including a discussion of the design components of the on-site lined cell is included in Section 5.3.3.5.

The estimated costs for the installation of an on-site cell for disposal of waste from Zones C and D based on the conceptual design in Figure 5-2 are summarized in Table 5-14. The assumptions made are consistent with those discussed in Section 5.3.3.5.

It should be noted the costs shown for the excavation of the wastes includes the handling costs associated with the transfer of the waste and soil to the new cell. The same methods employed to prevent contamination from spreading during operations associated with off-site disposal are used to prevent spreading contamination during the transfer of material to an on-site cell.

Total Cost for Alternative CD-5

Remove the waste from Zones C and D	$126,063
On-site waste disposal	591,200
Install SVE system, 5 year O&M	874,409
Implement access and institutional controls	10,000
Total	**$1,601,672**

5.3.6 ZONE E

The following sections describe the remedial alternatives for the waste/soil media at Zone E.

5.3.6.1 ALTERNATIVE E-1

Alternative E-1 includes the following elements:

- Maintain existing soil cap and plastic liner; and
- Institute access and institutional controls.

The existing native soil cover and liner over Zone E has prevented direct human contact with the wastes contained in the zone. This alternative would include periodic inspections of the cover, and provide for repair as needed.

In addition, access and institutional controls would be established as described in Section 5.3.1.

Total Cost for Alternative E-1

Maintain existing soil caps	$35,714
Implement access and institutional controls	10,000
Total	**$45,714**

5.3.6.2 ALTERNATIVE E-2

Alternative E-2 includes the following elements:

- Construct and maintain a cap in compliance with WAC 173-303;
- Institute access and institutional controls.

A new cap in compliance with WAC 173-303 will be installed over the present position of Zone E. To prevent lateral infiltration, the cap will extend beyond the existing zone boundaries a distance equal to the depth of Zone E, approximately 10 feet. The total Zone E cap area proposed under this conceptual design is 0.92 acres (40170 square feet). The 'RCRA' cap conceptual design is described in Section 5.3.3.2.

Minimal re-grading is necessary to prepare the zone for cap construction. It is expected that the existing cover material will remain over the waste. Mechanical compaction of the waste will be considered at the time of final design after geotechnical criteria are specified. It is not anticipated that mechanical compaction of Zone E waste will be needed due to the solid nature of the wastes as observed during the bulk waste characterization study performed during the RI. The estimated costs for the installation of a cap over Zone E are summarized in Table 5-15. The assumptions made are consistent with those discussed in Section 5.3.3.2.

In addition to a new cap over Zone E, access and institutional controls would be established as described in Section 5.3.1.

Total Cost for Alternative E-2

Construct new Zone E cap	$232,447
Implement access and institutional controls	10,000
Total	**$242,447**

5.3.6.3 ALTERNATIVE E-3

Alternative E-3 includes the following elements:

- Waste removal
- Disposal off-site
- Institute access and institutional controls.

The conceptual procedure for executing a waste removal action at Zone E is similar to that described for Zones C and D in Section 5.3.5.4.

The findings of the bulk waste characterizations were used to develop disposal cost scenarios for the waste contents from Zone E. The Zone E waste samples did not designate as either a characteristic RCRA hazardous waste or a Washington Dangerous Waste; however, RCRA-listed waste code K071 may apply to the material. Therefore, the cost for the disposal of Zone E waste is based on a Subtitle C hazardous waste landfill.

Given the type of waste in Zone E and the lack of corresponding contaminants in groundwater down gradient of the zone, for the purposes of this FS, it is assumed that no more than 10 feet of soil beneath the footprint of the Zone may potentially require remediation. It is assumed that a source of clean backfill soils is available on site.

The estimated costs for the removal and off-site disposal of Zone E waste are summarized in Table 5-16.

Total Cost for Alternative E-3

Waste Removal	$482,241
Disposal Off-site	2,161,770
Implement access and institutional controls	10,000
Total	**$2,654,011**

5.3.6.4 ALTERNATIVE E-4

Alternative E-4 includes the following elements

- Waste removal;
- consolidation and containment on site in a lined cell; and
- institute access and institutional controls.

Alternative E-4 includes the waste as in Alternative E-3, but substitutes on-site disposal in a new lined cell as opposed to off-site disposal. Clean backfill for the soil excavation could be supplied by the soil excavated during the cell construction.

The on-site lined cell will be installed in a level area adjacent to the present location of Zone E. Based on the surface area and depth of Zone E and the thickness of the various containment systems/layers outlined in Section 5.3.3.5 a total excavation volume of 20,985 cubic yards of soil will be required to construct the cell. A conceptual design of the on-site lined cell is included in Section 5.3.3.5.

The estimated costs for the installation of an on-site cell for disposal of waste from Zone E based on the conceptual design in Figure 5-2 are summarized in Table 5-17. The assumptions made are consistent with those discussed in Section 5.3.3.5.

It should be noted the costs shown for the excavation of the waste and soil includes the handling costs associated with the transfer of the waste and soil to the new cell. The same methods employed to prevent contamination from spreading during operations associated with off-site disposal are used to prevent spreading contamination during the transfer of material to an on-site cell.

Total Cost for Alternative E-4

Waste removal	$482,241
On-site disposal cell	737,754
Institute access and institutional controls	10,000
Total	**$1,229,995**

5.3.7 GROUNDWATER

As stated in Section 2, the Municipal Solid Waste Landfill and Zone A are the sources of contaminants of concern to groundwater at the Pasco Landfill site. All remedial alternatives for the groundwater media rely on some level of source control to reduce the loading of contaminants. In the case of the Landfill, implementation of the closure plan is expected to reduce the release of VOCs to the groundwater to meet cleanup standards. For Zone A, all alternatives address source removal either by SVE or waste removal. Capping Zone A will minimize leachate production at the Zone, further reducing contaminant release.

Since May of 1997 interim remedial measures have been operating at Zone A. As stated previously these measures include SVE of the soil underlying Zone A. Also included in these IRMs is the treatment of groundwater downgradient of Zone A. This treatment consists of two NoVOCs™, in-well air stripping, recirculating wells placed downgradient of well EE-3. These wells were placed to remove VOCs from the center of the VOC plume emanating from the Zone, forming a treatment zone in which contaminated groundwater would be captured, treated and released.

To date groundwater treatment using this technology has been highly effective. Combined with the removal of contaminants from the vadose zone by the SVE system, the NoVOCs™ wells have dramatically reduced the amount of VOCs in the groundwater within, and downgradient of their treatment zone. This reduction in dissolved VOCs has resulted in the elimination of the off-site migration of contaminants above cleanup standards in wells directly downgradient of the system (MW-10S). Figures 5-4 through 5-9 are time versus concentration graphs of six VOCs that were found to be migrating off site in the RI. Each graph has concentrations found in wells EE-3, NVM-01, MW-12S, and MW-10S. These wells are on the approximate axis of the contaminant plume emanating from Zone A. Well EE-3 is upgradient of the NoVOCs™ system and is used as a pre-treatment reference.

As can be seen on these graphs, all wells show a downward trend in the concentrations of VOCs. The temporary increases seen in wells NVM-01, and MW-12S around August 1997, and June 1998 are a result of the NoVOCs™ system being down due to an electrical problem. This problem was permanently fixed by replacement of the main electrical panel in September 1998. The notable decrease in concentrations of PCE, TCE, cis-1,2-DCE, 1,1-DCE, and 1,2-DCA in December 1997 and September 1998 reflect the restart and sustained operation of the NoVOCs™ system. These reductions illustrate the effectiveness of this technology for use in groundwater treatment at the Pasco Landfill site.

Three of the groundwater alternatives discussed below employ the NoVOCs™ recirculating well technology in some form. Two of these alternatives rely on this technology to treat groundwater proximal to a source, with attenuation of the remaining downgradient plume by the migrating treated water. Because of this, a discussion of advective contaminant transport of groundwater is appropriate.

Advective Contaminant Transport

Advective transport considers only the action of clean groundwater being flushed through the existing contaminant plume. In the absence of an ongoing source this action will eventually flush the remaining dissolved-phase contaminants from the plume. This section evaluates the groundwater monitoring data available for the entire plume and assesses the amount of time that is required to flush one pore volume of water through the dissolved-phase contaminant plume.

This section considers dissolved-phase contaminant migration only through advective transport. This approach presents the most conservative estimate of contaminant fate since it does not consider the effects of dilution, volatilization, biological degradation, abiotic chemical transformation, or hydrodynamic dispersion; all of which would serve to further attenuate the detected dissolved phase contaminant concentrations.

The path of groundwater and dissolved-phase contaminants is most clearly reflected in the shape and orientation of the dissolved-phase plume. The centerline axis of the plume is the route of migration least affected by dispersion or other attenuative mechanisms. The shape and orientation of the contaminant plume has been very stable over time and the July 1996 dissolved

PCE plume has been selected as being representative of the average plume orientation (Figure 5-9).

In order to estimate the groundwater travel time along this centerline axis a set of wells has been selected to represent a surrogate centerline. The straight line path between wells NW-5, MW-16S, MW-17SR, MW-24S, MW-11S, MW-29S, MW-35S, MW-38S, MW-41S, and MS-42S constitute the nine individual segments that have been chosen as the surrogate centerline axis of the contaminant plume (*Note: data for MW-35 are absent after July 1996 and the surrogate centerline has been adjusted accordingly*).

The travel times for groundwater migration between these wells has been calculated and the resulting travel times have been corrected to the centerline path travel time. These data have then been distance weighted to account for the non-uniformity of the segment length and time-weighted to account for the non-uniformity of the sampling rounds.

Travel times along the surrogate centerline have been calculated for each of the five groundwater elevation data sets available for the entire known length of the plume (i.e., July 1996, September 1996, December 1996, February 1997, and June 1997). These data represent a full annual cycle of water level and gradient variations. Using these data, the hydraulic gradient has been calculated between each of the wells for each monitoring event.

The hydraulic gradient data were then used to calculate the Darcy seepage velocity along each segment of the surrogate centerline axis using the following formula:

$$V = \frac{K \times i}{\eta}$$

Where:

V = Seepage Velocity (cm/s)

K = Hydraulic Permeability (cm/s)

i = Hydraulic Gradient (dimensionless)

η = Effective Porosity (dimensionless)

The hydraulic permeability of the water table aquifer soils (i.e., Pasco Gravels) has been previously calculated during the Phase I RI to be about 0.43 cm/s and the effective porosity has been assumed to be about 0.30. Based upon the observed consistency of the shallow aquifer materials, only minor spatial variations in the hydraulic permeability or the effective porosity are expected.

From the groundwater elevation contour data it is clear that the groundwater velocity varies significantly over the length of the dissolved-phase plume. This is manifested most clearly in the variations in the hydraulic gradient. The calculated seepage velocities along the centerline axis of the dissolved-phase plume varied between 19.2 feet per day between NW-5 and MW-16S in January 1997 and a low of 0.039 feet per day between MW-38S and MW-41S in December 1996.

Dividing the distance between wells by the seepage velocity results in a travel time for the individual segments of the surrogate centerline axis. This travel time is then corrected to the travel time along the actual centerline axis of the dissolved-phase plume using the angle between the surrogate and actual centerline axes.

Table 5-18 presents a summary of these calculated travel times through the individual segments of the dissolved-phase plume for each of the five groundwater monitoring events. These calculated travel times range from a low of 5,038 days (i.e., 13.8 years) in June of 1997 to a high of 29,396 days (i.e., 80.5 years) in December 1996.

The seepage velocities for the individual segments of the surrogate axis were distance-weighted and averaged to take into account the varying lengths of each segment. Table 5-18 presents a summary of the calculated distance weighted seepage velocities. This analysis was performed for each of the five groundwater monitoring events. The distance weighted seepage velocity for the portion of the site between the up-gradient (i.e., NW-5) and the down-gradient and property boundaries (i.e., MW-11S) ranges between 8.9 feet per day in February 1997 and 6.3 feet per day in July 1996. The distance-weighted seepage velocity for the portion of the site between the down-gradient property boundary and the down-gradient portion of the plume (i.e., MW-42S) ranges between 1.8 feet per day in February and June 1997 and 0.039 feet per day in December 1996.

Since the five sampling monitoring events were not evenly spaced throughout the year it is not appropriate to average these rates in order to determine the average annual seepage rates. The distance-weighted seepage rates were therefore converted to time-weighted seepage rates to take into account the temporal differences in the five monitoring periods and to represent an average annual seepage rate for the dissolved-phase plume. These time-weighted seepage rates are presented in Table 5-18, which also presents the resulting anticipated travel times for groundwater migration from the site to the known extent of the plume, from the up-gradient site boundary to the down-gradient site boundary, and from the down-gradient site boundary to the known extent of the plume. The data indicate that the average amount of time required for groundwater to migrate from the up-gradient property boundary to the down-gradient property boundary is about 1.6 years and that the average amount of time required for groundwater to migrate from the down-gradient property boundary to the known down-gradient extent of the plume is about 18.5 years.

Conclusions

The analysis of groundwater seepage velocities presented above supports the following conclusions.

Ground water seepage rates beneath the Municipal Landfill are relatively rapid with distance-weighted seepage velocities that range from 8.9 to 6.3 feet per day. This seepage velocity results in the flux of one pore volume of groundwater flushing though this portion of the site once every 512 to 724 days.

Ground water seepage rates become more variable down-gradient of the southern site boundary and decrease significantly relative to the area beneath the Municipal Landfill. The distance-weighted seepage velocities down-gradient of the site range from 1.8 to 0.039 feet per day.

The time-weighted seepage velocities provide an indication of the annual average seepage velocity of groundwater beneath and down-gradient of the site. These seepage velocities indicate that about 1.6 years is required to flush one pore volume of groundwater through the shallow aquifer beneath the site. An additional 18.5 years is required to flush one pore volume of groundwater from the down-gradient boundary of the site to the known down-gradient extent of the dissolved-phase plume.

The derived time-weighted seepage velocities result in travel times consistent with the site history. The Phase I RI stated that the earliest releases at the site occurred in about 1974, or about 22 years prior to collection of the data analyzed herein. The calculated 18.5 years required for dissolved-phase contaminants to reach MW-42S is consistent with a historic release in 1974 given the uncertainties in geological data and spatial variability in these data. The difference between the calculated 18.5 years and a 1974 release can also be attributed to changes in land use or longer term weather patterns that cannot be observed in a one year data window.

5.3.7.1 Alternative GW-1

Alternative GW-1 consists of the following elements:

- Groundwater Monitoring,
- Provide Alternate Water Supply to Affected Drinking Water Well Users, and
- Establish institutional controls on the domestic use of groundwater exceeding MCLs.

This alternative would consist of implementing and maintaining the source control measures taken at the Landfill and Zone A, continuation of long-term groundwater monitoring and alternate water supplies as described in Section 5.3.1, and the establishment of institutional controls restricting the domestic use of groundwater exceeding MCLs on the landfill property and intervening properties overlying the identified contaminant plume. During long-term groundwater monitoring, domestic wells identified as being impacted by the contaminant plume will continue to be closed for domestic use, and an alternate supply of water will be provided. Monitoring of the residential wells still in use in the area will continue in order detect any unexpected changes in the extent of the plume.

Alternative GW-1 Cost

The cost of long-term groundwater monitoring is based on the following assumptions:

- Quarterly sampling would be implemented,
- The current 35 well network would be used,
- Semi-annual monitoring of the current six domestic wells,
- The current analyte list would be used,

- Current usage of City water will remain the same.

Based on the current monitoring, reporting, and well maintenance costs, an estimate of $320,000 per year was used in this FS. As a conservative measure and because actual duration is not known, annual costs for groundwater monitoring and water supply are presented as the present value of an annuity to provide funding in perpetuity. Costs of institutional controls on the intervening properties were assumed to be for drafting documents and negotiating with property owners.

Total Cost for Alternative GW-1

Institutional controls	$100,000
Long-term Groundwater Monitoring	4,674,825
Provide Alternate Water Supply	648,078
Total	**$5,422,903**

5.3.7.2 ALTERNATIVE GW-2

- NoVOCs™ Recirculating Well Groundwater Treatment Proximal to Zone A;
- Alternate Receptor Water Supply;
- Groundwater Monitoring, and
- Establish institutional controls on the domestic use of groundwater exceeding MCLs.

This alternative implements alternative GW-1, and adds treatment of the groundwater plume emanating from Zone A. This treatment consists of continued operation and expansion of the two-well NoVOCs™ system currently operating as part of the IRM at the site.

NoVOCs™ in-well air stripping, recirculating wells are an in-situ physical treatment process used to remove volatile COCs from the groundwater. Each well is screened at two depths: within the groundwater plume, and within the vadose zone at a specified height above the water table. Air is injected at a point just above the lower screen to produce a continuous stream of bubbles. This stream of bubbles serves two purposes. The pressure differential causes water to be lifted, or pumped upward. In addition, the bubbles allow dissolved VOCs to be transferred from the groundwater to the vapor phase within the bubbles. The water is pumped upward within the well casing until it is forced against a packer. At this point, the bubbles are broken up, allowing the vapor phase to be drawn off with vacuum, and the treated water is allowed to percolate down through the vadose zone to the groundwater table. The system is designed to allow multiple passes of contaminated water through the system before it moves downgradient of the treatment zone.

Based on the operational data collected since system startup in May of 1997, expansion of the existing NoVOCs™ treatment zone is needed to treat the contaminant plume coming from the northern part of Zone A. This is based on the data collected at MW-13S and MW-11S. Two additional NoVOCs™ wells would be installed on a line to the northwest of the existing system to treat this area of the plume from Zone A. The four treatment wells would be on 90-foot centers to allow for overlapping treatment zones. This assures that contaminated groundwater will not pass between the individual well treatment zones.

The objective of this alternative is to prevent future migration of contaminants from Zone A via groundwater by removing them at a location as close to the zone as practicable. The NoVOCs™ treatment of the groundwater, operating in conjunction with the SVE removal of volatile contaminants from the vadose zone, act as a form of dynamic containment, preventing further downgradient migration by actively removing and destroying COCs as they originate from Zone A. Based on data collected during operation of the SVE and NoVOCs™ system since May 1997 this combination of technologies has demonstrated that groundwater cleanup levels can be attained within and downgradient of the treatment zone. These elements of a remedial action would have to operate for an unknown amount of time if wastes remain at Zone A as a source to groundwater contamination.

While treated water migrates downgradient, receptors within the plume will be provided with an alternate source of water. Long-term groundwater monitoring will be implemented to assess the performance of the treatment system, and the cleanup of the downgradient plume.

Total Cost for Alternative GW-2

Institutional Controls	$100,000
Expand NoVOCs™ at Zone A and O&M	3,127,578
Long-term Groundwater Monitoring	4,674,825
Provide Alternate Water Supply	648,078
Total	**$8,550,481**

5.3.7.3 ALTERNATIVE GW-3

- Recirculating Well groundwater treatment proximal to Zone A and the Municipal Solid Waste Landfill;
- Alternate Receptor Water Supply;
- Groundwater Monitoring; and
- Establish institutional controls on the domestic use of groundwater exceeding MCLs.

Alternative GW-3 implements alternative GW-2, and also treats the groundwater plume emanating from the solid waste landfill above cleanup levels for PCE. Up to eighteen additional NoVOCs™ recirculating wells would be installed in addition to the four-well system proposed in alternative GW-2. These additional wells would form a treatment zone across the low-level VOC plume from the solid waste landfill.

Data from the RI show that the concentrations in the plume of COCs attributed to releases from the landfill fall rapidly as it moves away from the landfill. Since June 1995 well MW-22S has exceeded cleanup levels for only one compound, PCE. The highest level of PCE found in MW-22S since June 1995 was 1.5 ug/L in September and December 1995. The cleanup level for PCE specified the RA/CLA in 0.8 ug/L. Since June 1995 well MW-24S has also exceeded cleanup levels for only one compound, PCE. The highest level of PCE detected in this well was 5.3 ug/L in July 1996. By comparison wells MW-16S, #4, #5 and #6 at the margin of the landfill have had maximum detected concentrations of PCE of 7.8 ug/l, 20 ug/l, 8.95 ug/l and 4.7 ug/l respectively. MW-23S, located downgradient of MW-16S, has had a maximum concentration for PCE of 10.8 ug/l. Given this level of natural decline, GW-3 may only have a minimal impact on restorative time frame compared to GW-2.

The objective of this alternative is the same as GW-2, to prevent future migration of COCs from Zone A and the solid waste landfill via groundwater by removing them at a location as close to their source as practicable. The NoVOCs™ treatment of the groundwater, operating in conjunction with the SVE removal of volatile contaminants from the vadose zone, and the active landfill gas extraction act as a form of dynamic containment, preventing further downgradient migration.

While treated water migrates downgradient, receptors within the plume will be provided with an alternate source of water. Long-term groundwater monitoring will be implemented to assess the performance of the treatment system, and progress of the cleanup of the downgradient plume due to implementation of remedial actions at Zone A and the solid waste landfill.

Total Cost for Alternative GW-3

Institutional Controls	$100,000
Expanded NoVOCs™ at Zone A and the Landfill and O&M	19,881,768
Long-term Groundwater Monitoring	4,674,825
Provide Alternate Water Supply	648,078
Total	**$25,304,671**

5.3.7.4 ALTERNATIVE GW-4

- Recirculating Well groundwater treatment proximal to Zone A and the Municipal Solid Waste Landfill; and
- Recirculating Well groundwater treatment of the Distal Groundwater Plume.

This alternative implements alternative GW-3, and in addition uses an array of up to 300 recirculating NoVOCs™ wells to treat the entire off-site plume to below cleanup standards. These wells would be arranged across the plume in rows of 18, perpendicular to the groundwater flow direction. It is estimated that 17 rows spaced approximately 750 feet apart would be required to treat the 9000 foot plume of water containing COCs above clean up levels. Figure 5-11 shows the conceptual layout of wells required for this alternative. It should be noted that it is unknown how long it would take to implement this remedy. A significant effort would be required to attain access agreements. Piping and electrical supply installations would adversely affect the agricultural land use so that land would have to be leased or bought. For these reasons, this alternative presents numerous implementation difficulties. In any case, costs associated with site access or leasing or time required to implement the remedy are not included below. Treatment of one pore volume of the entire plume is anticipated to take 18 months using this approach.

Total Cost for Alternative GW-4

Expand NoVOCs™ and O&M at Zone A and the Solid Waste Landfill	$19,881,768
Install an additional 300 NoVOCs™ wells throughout the entire plume and operate for 18 months	51,267,000
Total	**$71,148,768**

TABLE 5-1
ESTIMATED COSTS FOR
EXPANDED SVE AT ZONE A

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$2,540
INSTALLATION			
Well Installation	$7500 per well	1	7,500
Piping and Trenching	$11 per linear foot	900	9,900
System Modifications	$8000 each	1	8000
Installation Subtotal			25,400
CONSTRUCTION MANAGEMENT	10% of install cost		2,540
OPERATION & MAINTENANCE [1]	$350,000 per year in perpetuity, $5000 every 5 years for major maintenance, and $100,000 every 10 years for well and equipment replacement.		5,115,817
Subtotal			5,146,297
15% Contingency			771,945
ESTIMATED TOTAL COST			**$5,918,242**

[1] Calculated as an annuity yielding a cash flow required to operate and maintain the SVE system in perpetuity using a real rate of return of 7%.

TABLE 5-2
ESTIMATED COSTS FOR CAPPING ZONE A

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 24,500
INSTALLATION			
Site Preparation	$1/sq. Yd.	9,165 sq. Yd.	9,165
Vegetation Support Layer (2')			
Load, haul, and place	$1.25/cu. Yd.	6,110 cu. Yd.	7,640
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter			
Installation	$0.08/sq. ft.	82,464 sq. ft.	6,600
Drainage Layer (1')			
Load, haul, and place	$3/cu. Yd.	3,055 cu. Yd.	9,170
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Flexible Geomembrane Barrier Layer			
Installation	$0.25/sq. ft.	82,464 sq. ft.	20,620
QA/QC testing	$1,500/test	5 tests	7,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	82,464 sq. ft	63,500
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. Yd.	6,110 cu. Yd.	85,540
Excavation of On-Site Soils	$3/cu. Yd.	6,110 cu. Yd.	18,330
Hydroseed (Vegetation Layer)	$1,000/acre	1.89 acres	1,890
INSTALLATION SUBTOTAL			244,855
CONSTRUCTION MANAGEMENT	10% of install cost		24,500
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years		53,236
Subtotal			347,091
15% Contingency			52,064
ESTIMATED TOTAL COST			**$ 399,155**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-3
ESTIMATED COSTS FOR ZONE A DRUM REMOVAL

CATEGORY	DESCRIPTION	COST
Mobilization	Planning, Site Prep., Health & Safety, Permitting	$56,875
Site Overhead	Trailers, Fencing, Utilities, Supplies, Staging Areas, Improvements	962,500
Labor	Project Manager, H&S Officer, Equipment Operators, Field Technicians + Per Diem	8,268,750
Heavy Equipment	Excavator, Loader, Truck + Maintenance	374,500
Misc. Equipment	Overpacks, Sampling, Tools, Miscellaneous	2,800,000
Sample Analysis	Estimated at $300.00/ drum	10,528,875
Transportation + Disposal	Estimated @ $500.00/ drum	17,548,125
Air Containment Bldg.	133 ft. x 200 ft. Portable Building	442,750
Air Treatment System	GAC Units and HVAC Systems	116,150
Spill Containment Sys.	Inflatable Spill Containment Units	67,563
Annual Containment Operation Costs	4 years at 403,650	1,614,600
Total Estimate		**42,780,688**
Contingency, 25%	Unforeseen Expenses	
Total w/ Contingency		**$53,475,860**

TABLE 5-4
ESTIMATED COSTS FOR ZONE A SOIL REMOVAL

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of excavation/backfill cost		$440,000
SOIL EXCAVATION AND DISPOSAL			
Soil Excavation	$25 per cubic yard	110,000	2,750,000
Transportation and Disposal	$760/ton	140,000	106,400,000
Backfill	$15/cubic yard	110,000	1,650,000
Subtotal			110,800,000
CONSTRUCTION MANAGEMENT	10% of excavation/backfill cost		440,000
Subtotal			111,680,000
15% Contingency			16,752,000
ESTIMATED TOTAL COST			**$128,432,000**

TABLE 5-5
ESTIMATED COSTS FOR CONSTRUCTING AN ON-SITE LINED CELL FOR ZONE A

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 95,950
INSTALLATION			
Site Preparation	$1/sq. Yd.	9,165 sq. Yd.	9,165
Vegetation Support Layer (cap, 2')			
Load, haul, and place	$1.25/cu. Yd.	6,110 cu. Yd.	7,640
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter (cap)			
Installation	$0.08/sq. ft.	82,464 sq. ft.	6,600
Drainage Layer (cap, 1')			
Load, haul, and place	$3/cu. Yd.	3,055 cu. Yd.	9,170
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Flexible Geomembrane Barrier Layer (cap)			
Installation	$0.25/sq. ft.	82,464 sq. ft.	20,620
QA/QC testing	$1,500/test	5 tests	7,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (cap, 2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	82,464 sq. ft	63,500
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. Yd.	6,110 cu. Yd.	85,540
Excavation of On-Site Soils	$3/cu. Yd.	6,110 cu. Yd.	18,330
Hydroseed (Vegetation Layer)	$1,000/acre	1.89 acres	1,890
Excavation of Cell			
Trackhoe	$4.20/cu. Yd.	48,145 cu. Yd.	202,210
Mobilization/demobilization	$2,000	1	2,000
Subbase preparation of foundation layer	$1/sq. Yd.	9,165 sq. Yd.	9,165
Filter Media Layer (cell, 1')			
Load, haul, and place	$1.25/cu. Yd.	3,055 cu. Yd.	3,820
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter (cell)			
Installation	$0.08/sq. ft.	82,464 sq. ft.	6,600

TABLE 5-5
ESTIMATED COSTS FOR CONSTRUCTING AN ON-SITE LINED CELL FOR ZONE A
(continued)

Primary and Secondary Drainage Layers (cell, 1' each)			
Load, haul, and place	$1.25/cu. Yd.	6,110 cu. Yd.	7,640
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Primary and Secondary Flexible Membrane Liners (cell)			
Installation	$1.25/sq. ft.	164,928 sq. ft.	206,160
QA/QC testing	$1,500/test	10 tests	15,000
Friction angle testing	$500/test	2 tests	1,000
Compatibility testing	$3,000/test	2 tests	6,000
Secondary Leachate Collection and Leak Detection System	$20,000/cell	1	20,000
Low Permeability Soil Layer (cell, 3')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	82,464 sq. ft	95,250
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. Yd.	9,165 cu. Yd.	128,310
Installation Subtotal			959,410
CONSTRUCTION MANAGEMENT	10% of install cost		95,950
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years. $10,000/year Leachate Collection and Treatment		196,093
Subtotal			1,347,403
15% Contingency			202,110
ESTIMATED TOTAL COST			**$ 1,549,513**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-6
ESTIMATED COSTS FOR CAPPING ZONE B

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 5,000
INSTALLATION			
Site Preparation	$1/sq. yd.	1,275 sq. yd.	1,275
Vegetation Support Layer (2')			
Load, haul, and place	$1.25/cu. yd.	850 cu. yd.	1,060
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Geotextile Filter			
Installation	$0.08/sq. ft.	11,440 sq. ft.	915
Drainage Layer (1')			
Load, haul, and place	$3/cu. yd.	425 cu. yd.	1,280
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Flexible Geomembrane Barrier Layer			
Installation	$0.25/sq. ft.	11,440 sq. ft.	2,860
QA/QC testing	$1,500/test	3 tests	4,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	11,440 sq. ft	8,810
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	850 cu. yd.	11,900
Excavation of On-Site Soils	$3/cu. yd.	850 cu. yd.	2,550
Hydroseed (Vegetation Layer)	$1,000/acre	0.26 acres	260
Installation Subtotal			49,610
Construction Management	10% of install cost		5,000
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years		39,622
Subtotal			99,232
15% Contingency			17,885
ESTIMATED TOTAL COST			**$ 117,117**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-7
ESTIMATED COSTS FOR ZONE B HORIZONTAL SUBSURFACE BARRIER

CATEGORY	UNIT COST	QUANTITY	COST
DESIGN	10% of install cost		$79,090
ENGINEERING/CONSTRUCTION MGT.	10% of install cost		79,090
Mobilization/Demobilization	Lump Sum	1	8,800
Grout Testing	Lump Sum	1	14,800
Field Testing/Field Trial	Lump Sum	1	3,400
Installation	$335/Cubic Meter	2234 cu. meter	748,390
Confirmation Testing	Lump Sum	1	5,515
Leachate monitoring system			10,000
Installation Subtotal			790,905
OTHER COSTS (5% OF INSTALL.)	Lump Sum		39,545
Operation and Maintenance[1]	$5000/year leachate collection and treatment	In perpetuity	71,429
15% Contingency (on install.)			124,568
ESTIMATED TOTAL COST			**$1,184,627**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-8
ESTIMATED COSTS FOR ZONE B DRUM REMOVAL

CATEGORY	DESCRIPTION	COST
Mobilization	Planning, Site Preparation, Health & Safety, Permitting	$8,125
Site Overhead	Trailers, Fencing, Utilities, Supplies, Staging Areas, Improvements	137,500
Labor	Project Manager, H&S Officer, Equipment Operators, Field Technicians + Per Diem	1,181,250
Heavy Equipment	Excavator, Loader, Truck + Maintenance	53,500
Misc. Equipment	Overpacks, Sampling, Tools, Miscellaneous	400,000
Sample Analysis	Estimated at $300.00/ drum	1,504,125
Transportation + Disposal	Estimated @ $500.00/ drum	2,506,875
Subtotal		**5,791,375**
Contingency, 25%		1,447,844
ESTIMATED TOTAL COSTS		**$7,239,219**

TABLE 5-9
ESTIMATED COSTS FOR ZONE B SOIL REMOVAL

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of excavation/backfill cost		$10,200
SOIL EXCAVATION AND DISPOSAL			
Soil Excavation	$25 per cubic yard	2550	63,750
Transportation and Disposal	$760/ton	4915	3,735,400
Backfill	$15/cubic yard	2550	38,250
Subtotal			3,847,600
CONSTRUCTION MANAGEMENT	10% of excavation/backfill cost		10,200
Subtotal			3,857,800
15% Contingency			578,670
ESTIMATED TOTAL COST			**$4,436,470**

TABLE 5-10
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONE B

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 18,540
INSTALLATION			
Site Preparation	$1/sq. yd.	1,275 sq. yd.	1,275
Vegetation Support Layer (cap, 2')			
Load, haul, and place	$1.25/cu. yd.	850 cu. yd.	1,060
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Geotextile Filter (cap)			
Installation	$0.08/sq. ft.	11,440 sq. ft.	915
Drainage Layer (cap, 1')			
Load, haul, and place	$3/cu. yd.	425 cu. yd.	1,280
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Flexible Geomembrane Barrier Layer (cap)			
Installation	$0.25/sq. ft.	11,440 sq. ft.	2,860
QA/QC testing	$1,500/test	3 tests	4,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (cap, 2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	11,440 sq. ft	8,810
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	850 cu. yd.	11,900
Excavation of On-Site Soils	$3/cu. yd.	850 cu. yd.	2,550
Hydroseed (Vegetation Layer)	$1,000/acre	0.26 acres	260
Excavation of Cell			
Trackhoe	$4.20/cu. yd.	5,610 cu. yd.	23,570
Mobilization/demobilization	$2,000	1	2,000
Subbase preparation of foundation layer	$1/sq. yd.	1,275 sq. yd.	1,275
Filter Media Layer (cell, 1')			
Load, haul, and place	$1.25/cu. yd.	425 cu. yd.	530
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Geotextile Filter (cell)			
Installation	$0.08/sq. ft.	11,440 sq. ft.	915

TABLE 5-10
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONE B
(continued)

Primary and Secondary Drainage Layers (cell, 1' each)			
Load, haul, and place	$1.25/cu. yd..	850 cu. yd.	1,070
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	1 day	350
Primary and Secondary Flexible Membrane Liners (cell)			
Installation	$1.25/sq. ft.	22,880 sq. ft.	28,600
QA/QC testing	$1,500/test	6 tests	9,000
Friction angle testing	$500/test	2 tests	1,000
Compatibility testing	$3,000/test	2 tests	6,000
Secondary Leachate Collection and Leak Detection System	$20,000/cell	1	20,000
Low Permeability Soil Layer (cell, 3')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	11,440 sq. ft	13,220
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	1,275 cu. yd.	17,850
Installation Subtotal			185,340
CONSTRUCTION MANAGEMENT	10% of install cost		18,540
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years. $5000/year leachate collection and treatment.		111,050
Subtotal			333,470
15% Contingency			50,020
ESTIMATED TOTAL COST			**$ 383,490**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-11
ESTIMATED COSTS FOR CAPPING ZONES C AND D

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 10,300
INSTALLATION			
Site Preparation	$1/sq. yd.	3,440 sq. yd.	3,440
Vegetation Support Layer (2')			
Load, haul, and place	$1.25/cu. yd.	2,295 cu. yd.	2,870
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 day	700
Geotextile Filter			
Installation	$0.08/sq. ft.	30,952 sq. ft.	2,500
Drainage Layer (1')			
Load, haul, and place	$3/cu. yd.	1,150 cu. yd.	3,450
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 day	700
Flexible Geomembrane Barrier Layer			
Installation	$0.25/sq. ft.	30,952 sq. ft.	7,740
QA/QC testing	$1,500/test	3 tests	4,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	30,952 sq. ft.	23,840
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	2,295 cu. yd.	32,130
Excavation of On-Site Soils	$3/cu. yd.	2,295 cu. yd.	6,890
Hydroseed (Vegetation Layer)	$1,000/acre	0.71 acres	710
Installation Subtotal			102,970
CONSTRUCTION MANAGEMENT	10% of install cost		10,300
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years.		48,977
Subtotal			172,547
15% Contingency			25,882
ESTIMATED TOTAL COST			**$ 198,429**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-12
ESTIMATED COST FOR EXPANDED SVE AT ZONES C AND D

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		11,135
INSTALLATION			
Well Installation	$7500 per well	1	7,500
Equipment Purchase and Installation	$65,000	1	65,000
Piping and Trenching	$11 per linear foot	1350	14,850
Air Treatment System (GAC)	$3/pound of GAC	8000	24,000
Installation Subtotal			111,350
CONSTRUCTION MANAGEMENT	10% of install cost		11,135
OPERATION & MAINTENANCE [1]	Assume 5 years of operation to meet cleanup level at $125,695/year	5	628,475
Subtotal			762,095
15% Contingency			114,314
ESTIMATED TOTAL COST			**874,409**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-13
ESTIMATED COSTS FOR WASTE REMOVAL AT ZONES C AND D

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of excavation/backfill cost		9,135
WASTE EXCAVATION AND DISPOSAL			
Waste Excavation	$9.50 per cubic yard	6300	59,850
Backfill	$5/cubic yard	6300	31,500
Excavation Subtotal			91,350
Transportation and Disposal for C Wastes	$130/ton	3440	447,200
Transportation and Disposal for D Wastes	$760/ton	4750	3,610,000
Transportation and Disposal Subtotal			4,054,200
CONSTRUCTION MANAGEMENT	10% of excavation/backfill cost		9,135
Subtotal			4,166,820
15% Contingency			625,023
ESTIMATED TOTAL COST			**4,791,843**

TABLE 5-14
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONES C AND D

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 38,760
INSTALLATION			
Site Preparation	$1/sq. yd.	3,440 sq. yd.	3,440
Vegetation Support Layer (cap, 2')			
Load, haul, and place	$1.25/cu. yd.	2,295 cu. yd.	2,870
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 day	700
Geotextile Filter (cap)			
Installation	$0.08/sq. ft.	30,952 sq. ft.	2,500
Drainage Layer (cap, 1')			
Load, haul, and place	$3/cu. yd.	1,150 cu. yd.	3,450
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 day	700
Flexible Geomembrane Barrier Layer (cap)			
Installation	$0.25/sq. ft.	30,952 sq. ft.	7,740
QA/QC testing	$1,500/test	3 tests	4,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (cap, 2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	30,952 sq. ft.	23,840
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	2,295 cu. yd.	32,130
Excavation of On-Site Soils	$3/cu. yd.	2,295 cu. yd.	6,890
Hydroseed (Vegetation Layer)	$1,000/acre	0.71 acres	710
Excavation of Cell			
Trackhoe	$4.20/cu. yd.	15,160 cu. yd.	63,680
Mobilization/demobilization	$2,000	1	2,000
Subbase preparation of foundation layer	$1/sq. yd.	3,440 sq. yd.	3,440
Filter Media Layer (cell, 1')			
Load, haul, and place	$1.25/cu. Yd.	1,150 cu. Yd.	1,440
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter (cell)			
Installation	$0.08/sq. ft.	30,952 sq. ft.	2,500

TABLE 5-14
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONES C AND D
(continued)

Primary and Secondary Drainage Layers (cell, 1' each)			
Load, haul, and place	$1.25/cu. yd.	2,295 cu. yd.	2,870
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Primary and Secondary Flexible Membrane Liners (cell)			
Installation	$1.25/sq. ft.	61,904 sq. ft.	77,380
QA/QC testing	$1,500/test	6 tests	9,000
Friction angle testing	$500/test	2 tests	1,000
Compatibility testing	$3,000/test	2 tests	6,000
Secondary Leachate Collection and Leak Detection System	$20,000/cell	1	20,000
Low Permeability Soil Layer (cell, 3')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	30,952 sq. ft.	35,750
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	3,440 cu. yd.	48,160
Installation Subtotal			387,590
CONSTRUCTION MANAGEMENT	10% of install cost		38,760
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years.		48,977
Subtotal			514,087
15% Contingency			77,113
ESTIMATED TOTAL COST			**$ 591,200**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-15
ESTIMATED COSTS FOR CAPPING ZONE E

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 13,100
INSTALLATION			
Site Preparation	$1/sq. yd.	4,465 sq.yd.	4,470
Vegetation Support Layer (2')			
Load, haul, and place	$1.25/cu. yd.	2,980 cu. yd.	3,730
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter			
Installation	$0.08/sq. ft.	40,170 sq. ft.	3,220
Drainage Layer (1')			
Load, haul, and place	$3/cu. yd.	1,490 cu. yd.	4,470
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Flexible Geomembrane Barrier Layer			
Installation	$0.25/sq. ft.	40,170 sq. ft.	10,050
QA/QC testing	$1,500/test	5 tests	7,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	40,170 sq. ft.	30,930
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	2,980 cu. yd.	41,720
Excavation of On-Site Soils	$3/cu. yd.	2,980 cu. yd.	8,940
Hydroseed (Vegetation Layer)	$1,000/acre	0.92 acres	920
Installation Subtotal			130,850
CONSTRUCTION MANAGEMENT	10% of install cost		13,100
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years.		45,078
Subtotal			202,128
15% Contingency			30,319
ESTIMATED TOTAL COST			**$ 232,447**

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 4%.

TABLE 5-16
ESTIMATED COSTS FOR WASTE REMOVAL FROM ZONE E

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of excavation/backfill cost		$34,945
WASTE EXCAVATION AND DISPOSAL			
Waste Excavation	$9.50 per cubic yard	24,100	228,950
Backfill	$5/cubic yard	24,100	120,500
Excavation Subtotal			349,450
Transportation and Disposal	$60/ton	31,330	1,879,800
CONSTRUCTION MANAGEMENT	10% of excavation/backfill cost		34,945
Subtotal			2,299,140
15% Contingency			344,871
ESTIMATED TOTAL COST			**$ 2,644,011**

TABLE 5-17
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONE E

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 49,700
INSTALLATION			
Site Preparation	$1/sq. yd.	4,465 sq. yd.	4,470
Vegetation Support Layer (cap, 2')			
Load, haul, and place	$1.25/cu. yd.	2,980 cu. yd.	3,730
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Geotextile Filter (cap)			
Installation	$0.08/sq. ft.	40,170 sq. ft.	3,220
Drainage Layer (cap, 1')			
Load, haul, and place	$3/cu. yd.	1,490 cu. yd.	4,470
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Flexible Geomembrane Barrier Layer (cap)			
Installation	$0.25/sq. ft.	40,170 sq. ft.	10,050
QA/QC testing	$1,500/test	5 tests	7,500
Friction angle testing	$500/test	1 test	500
Compatibility testing	$3,000/test	1 test	3,000
Low Permeability Soil Layer (cap, 2')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	40,170 sq. ft.	30,930
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	2,980 cu. yd.	41,720
Excavation of On-Site Soils	$3/cu. yd.	2,980 cu. yd.	8,940
Hydroseed (Vegetation Layer)	$1,000/acre	0.92 acres	920
Excavation of Cell			
Trackhoe	$4.20/cu. yd.	20,985 cu. yd.	88,137
Mobilization/demobilization	$2,000	1	2,000
Subbase preparation of foundation layer	$1/sq. yd.	4,465 sq. yd.	4,465
Filter Media Layer (cell, 1')			
Load, haul, and place	$1.25/cu. yd.	1,490 cu. yd.	1,860
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700

TABLE 5-17
ESTIMATED COSTS FOR CONSTRUCTING ON-SITE LINED CELL FOR ZONE E
(continued)

Geotextile Filter (cell)			
Installation	$0.08/sq. ft.	40,170 sq. ft.	3,220
Primary and Secondary Drainage Layers (cell, 1' each)			
Load, haul, and place	$1.25/cu. yd.	2,980 cu. yd.	3,780
Mobilization/demobilization	$2,000	1	2,000
Compaction testing	$350/day	2 days	700
Primary and Secondary Flexible Membrane Liners (cell)			
Installation	$1.25/sq. ft.	80,340 sq. ft.	100,425
QA/QC testing	$1,500/test	10 tests	15,000
Friction angle testing	$500/test	2 tests	1,000
Compatibility testing	$3,000/test	2 tests	6,000
Secondary Leachate Collection and Leak Detection System	$20,000/cell	1	20,000
Low Permeability Soil Layer (cell, 3')			
Bentonite material/truck transport	$0.385/sq. ft./ft.	40,170 sq. ft.	46,400
Pugmill mob/demob	$6,000/zone	1	6,000
Material handling	$14/cu. yd.	4,465 sq. yd.	62,510
Installation Subtotal			497,047
CONSTRUCTION MANAGEMENT	10% of install cost		49,700
OPERATION & MAINTENANCE [1]	$2,500/year in perpetuity and replace cap every 40 years.		45,078
Subtotal			641,525
15% Contingency			96,229
ESTIMATED TOTAL COST			$ 737,754

[1] Calculated as an annuity yielding a cash flow required to maintain the cap in perpetuity using a real rate of return of 7%.

TABLE 5-18
Summary of Estimated Advective Ground Water Flow Rates along Axis of Dissolved-Phase Contaminant Plume
Pasco Landfill Feasibility Study

July 1996

Segment No.	Segment Upgradient Well (Wi)		Segment Down-Gradient Well (Wo)	Water Level Elevation(a) (ft) Wi	Water Level Elevation(a) (ft) Wo	Δ Water Level (ft)	Distance Wi to Wo (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Permeability(b) (cm/s)	Effective Porosity(b) (percent)	Seepage Velocity (ft/day)	Apparent Travel Time (days)	Correction Angle(c) (θ degrees)	True Travel Time (days)
1	NW-5	to	MW-16S	358.56	351.16	7.40	1698.5	0.0044	0.43	30	17.70	96	15	93
2	MW-16s	to	MW-17SR	351.16	347.88	3.28	917.2	0.0036	0.43	30	14.53	63	21	59
3	MW-17SR	to	MW-24S	347.88	345.58	2.30	993.3	0.0023	0.43	30	9.41	106	4	105
4	MW-24S	to	MW-11S	345.58	345.13	0.45	947.6	0.0005	0.43	30	1.93	491	18	467
5	MW-11S	to	MW-29S	345.13	344.00	1.13	1124.2	0.0010	0.43	30	4.08	275	18	262
6	MW-29S	to	MW-35S	344.00	343.65	0.35	1693.6	0.0002	0.43	30	0.84	2017	6	2006
7	MW-35S	to	MW-38S	343.65	343.31	0.34	1345.5	0.0003	0.43	30	1.03	1310	8	1298
8	MW-38S	to	MW-41S	343.31	342.92	0.39	1023.7	0.0004	0.43	30	1.55	661	1	661
9	MW-41S	to	MW-42S	342.92	339.71	3.21	3024.3	0.0011	0.43	30	4.31	701	12	686
Total Plume Length														
	NW-5	to	MW-42S											5636
Site Boundary to End of Plume														
	MW-11S	to	MW-42S											4912

September 1996

Segment No.	Segment Upgradient Well (Wi)		Segment Down-Gradient Well (Wo)	Water Level Elevation(a) (ft) Wi	Water Level Elevation(a) (ft) Wo	Δ Water Level (ft)	Distance Wi to Wo (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Permeability(b) (cm/s)	Effective Porosity(b) (percent)	Seepage Velocity (ft/day)	Apparent Travel Time (days)	Correction Angle(c) (θ degrees)	True Travel Time (days)
1	NW-5	to	MW-16S	357.14	351.24	5.90	1698.5	0.0035	0.43	30	14.12	120	15	116
2	MW-16s	to	MW-17SR	351.24	347.45	3.79	917.2	0.0041	0.43	30	16.79	55	21	51
3	MW-17SR	to	MW-24S	347.45	345.25	2.20	993.3	0.0022	0.43	30	9.00	110	4	110
4	MW-24S	to	MW-11S	345.25	344.76	0.49	947.6	0.0005	0.43	30	2.10	451	18	429
5	MW-11S	to	MW-29S	344.76	343.81	0.95	1124.2	0.0008	0.43	30	3.43	327	18	311
6	MW-29S	to	MW-38S	343.81	342.93	0.88	3007.8	0.0003	0.43	30	1.19	2530	6	2516
7	MW-38S	to	MW-41S (a)	342.93	342.95	0.02	1023.7	0.00002	0.43	30	0.08	12895	1	12893
8	MW-41S	to	MW-42S	342.95	339.24	3.71	3024.3	0.0012	0.43	30	4.98	607	12	593
Total Plume Length														
	NW-5	to	MW-42S											17020
Site Boundary to End of Plume														
	MW-11S	to	MW-42S											16314

(a) Negative gradient converted to a positive value

TABLE 5-18 (cont'd)
Summary of Estimated Advective Ground Water Flow Rates along Axis of Dissolved-Phase Contaminant Plume
Pasco Landfill Feasibility Study

December 1996

Segment No.	Segment Upgradient Well (Wi)		Segment Down-Gradient Well (Wo)	Water Level Elevation(a) (ft) Wi	Water Level Elevation(a) (ft) Wo	Δ Water Level (ft)	Distance Wi to Wo (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Permeability(b) (cm/s)	Effective Porosity(b) (percent)	Seepage Velocity (ft/day)	Apparent Travel Time (days)	Correction Angle(c) (θ degrees)	True Travel Time (days)
1	NW-5	to	MW-16S	357.91	351.1	6.81	1698.5	0.0040	0.43	30	16.29	104	15	101
2	MW-16s	to	MW-17SR	351.1	347.55	3.55	917.2	0.0039	0.43	30	15.73	58	21	54
3	MW-17SR	to	MW-24S	347.55	345.52	2.03	993.3	0.0020	0.43	30	8.30	120	4	119
4	MW-24S	to	MW-11S	345.52	344.96	0.56	947.6	0.0006	0.43	30	2.40	395	18	375
5	MW-11S	to	MW-29S	344.96	344.13	0.83	1124.2	0.0007	0.43	30	3.00	375	18	356
6	MW-29S	to	MW-38S	344.13	343.03	1.10	3007.8	0.0004	0.43	30	1.49	2024	6	2013
7	MW-38S	to	MW-41S	343.03	343.02	0.01	1023.7	0.00001	0.43	30	0.04	25790	1	25786
8	MW-41S	to	MW-42S	343.02	339.29	3.73	3024.3	0.0012	0.43	30	5.01	603	12	590
Total Plume Length														
	NW-5	to	MW-42S											29396
Site Boundary to End of Plume														
	MW-11S	to	MW-42S											28746

February 1997

Segment No.	Segment Upgradient Well (Wi)		Segment Down-Gradient Well (Wo)	Water Level Elevation(a) (ft) Wi	Water Level Elevation(a) (ft) Wo	Δ Water Level (ft)	Distance Wi to Wo (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Permeability(b) (cm/s)	Effective Porosity(b) (percent)	Seepage Velocity (ft/day)	Apparent Travel Time (days)	Correction Angle(c) (θ degrees)	True Travel Time (days)
1	NW-5	to	MW-16S	359.92	352.29	7.63	1698.5	0.0045	0.43	30	18.25	93	15	90
2	MW-16s	to	MW-17SR	352.29	348.76	3.53	917.2	0.0038	0.43	30	15.64	59	21	55
3	MW-17SR	to	MW-24S	348.76	346.83	1.93	993.3	0.0019	0.43	30	7.90	126	4	125
4	MW-24S	to	MW-11S	346.83	345.96	0.87	947.6	0.0009	0.43	30	3.73	254	18	242
5	MW-11S	to	MW-29S	345.96	344.91	1.05	1124.2	0.0009	0.43	30	3.80	296	18	282
6	MW-29S	to	MW-38S	344.91	343.85	1.06	3007.8	0.0004	0.43	30	1.43	2100	6	2089
7	MW-38S	to	MW-41S (a)	343.85	343.69	0.16	1023.7	0.00016	0.43	30	0.64	1612	1	1612
8	MW-41S	to	MW-42S	343.69	339.97	3.72	3024.3	0.0012	0.43	30	5.00	605	12	592
Total Plume Length														
	NW-5	to	MW-42S											5086
Site Boundary to End of Plume														

	MW-11S to MW-42S		4574

TABLE 5-18 (cont'd)
Summary of Estimated Advective Ground Water Flow Rates along Axis of Dissolved-Phase Contaminant Plume
Pasco Landfill Feasibility Study

June 1997

Segment No.	Segment			Water Level Elevation(a) (ft)		Δ Water Level (ft)	Distance Wi to Wo (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Permeability(b) (cm/s)	Effective Porosity(b) (percent)	Seepage Velocity (ft/day)	Apparent Travel Time (days)	Correction Angle(c) (θ degrees)	True Travel Time (days)
	Upgradient Well (Wi)		Down-Gradient Well (Wo)	Wi	Wo									
1	NW-5	to	MW-16S	360.86	352.84	8.02	1698.5	0.0047	0.43	30	19.19	89	15	86
2	MW-16s	to	MW-17SR	352.84	349.01	3.83	917.2	0.0042	0.43	30	16.97	54	21	50
3	MW-17SR	to	MW-24S	349.01	346.76	2.25	993.3	0.0023	0.43	30	9.20	108	4	108
4	MW-24S	to	MW-11S	346.76	346.08	0.68	947.6	0.0007	0.43	30	2.92	325	18	309
5	MW-11S	to	MW-29S	346.08	345.01	1.07	1124.2	0.0010	0.43	30	3.87	291	18	276
6	MW-29S	to	MW-38S	345.01	344.29	0.72	3007.8	0.0002	0.43	30	0.97	3092	6	3075
7	MW-38S	to	MW-41S (a)	344.29	343.69	0.60	1023.7	0.0006	0.43	30	2.38	430	1	430
8	MW-41S	to	MW-42S	343.69	340.56	3.13	3024.3	0.0010	0.43	30	4.21	719	12	703

Total Plume Length

	NW-5 to MW-42S		5038

Site Boundary to End of Plume

	MW-11S to MW-42S		4485

TABLE 5-19
ESTIMATED COSTS FOR EXPANDED NOVOCS™
AT ZONE A

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 18,200
INSTALLATION			
NoVOCs System Installation	$73,500 per well	2	147,000
Piping and Trenching	$20 per linear foot	475	9,500
Air Treatment System (GAC)	$3 per pound of GAC	8500	25,500
Installation Subtotal			182,000
CONSTRUCTION MANAGEMENT	10% of install cost		18,200
OPERATION & MAINTENANCE [1]	$144,000 per year in perpetuity, $175,000 every 5 years for well and equipment replacement.		2,501,233
Subtotal			2,719,633
15% Contingency			407,945
ESTIMATED TOTAL COST			**$ 3,127,578**

[1] Calculated as an annuity yielding a cash flow required to operate and maintain the NoVOCs system in perpetuity using a real rate of return of 7%.

TABLE 5-20
ESTIMATED COSTS FOR EXPANDED NOVOCS™
AT ZONE A AND THE MUNICIPAL SOLID WASTE LANDFILL

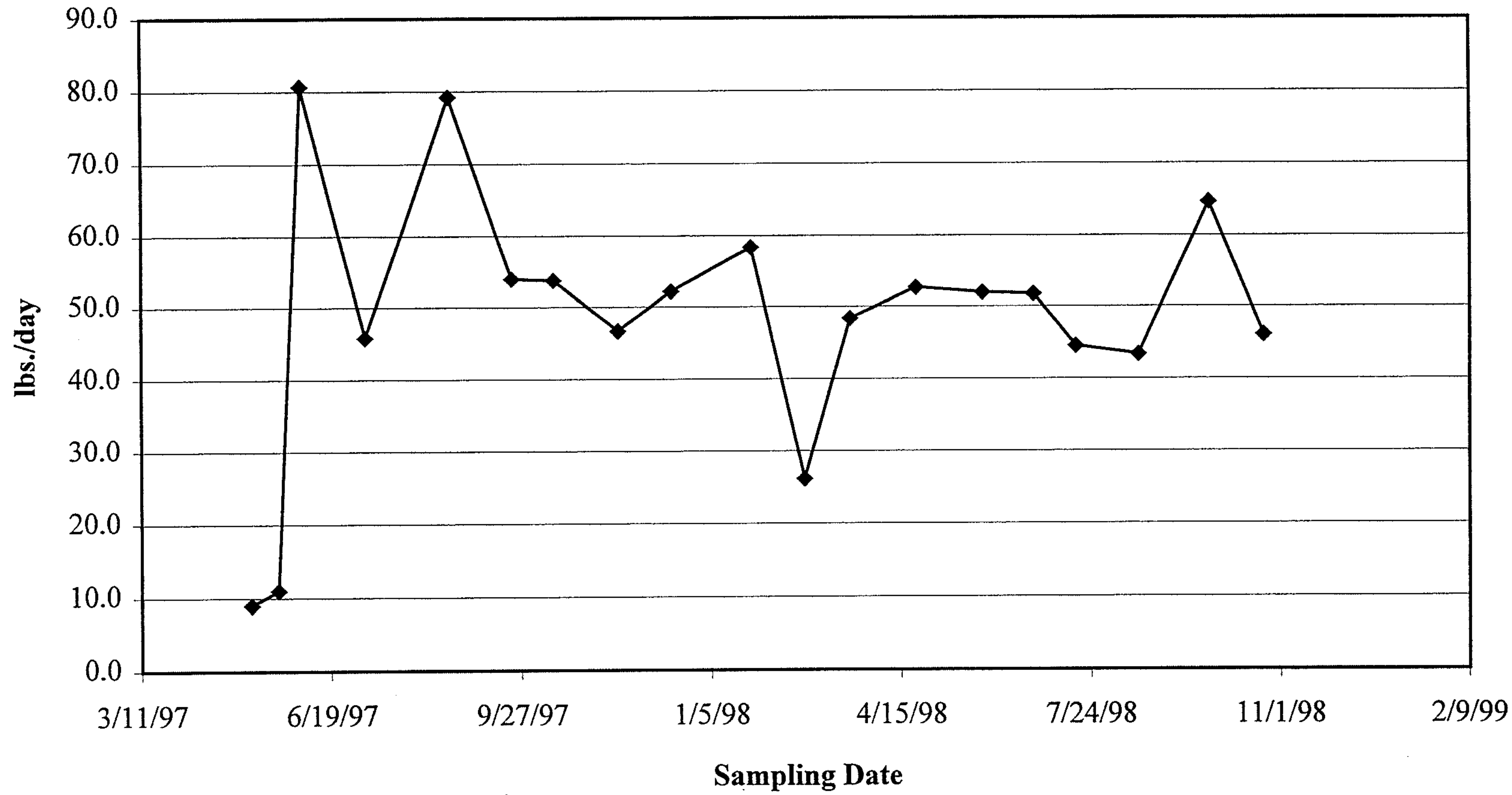
CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 165,850
INSTALLATION			
NoVOCs System Installation	$73,500 per well	20	1,470,000
Piping and Trenching	$20 per linear foot	5000	100,000
Air Treatment System (GAC)	$3 per pound of GAC	29500	88,500
Installation Subtotal			1,658,500
CONSTRUCTION MANAGEMENT	10% of install cost		165,850
OPERATION & MAINTENANCE [1]	$792,000 per year in perpetuity, $1,600,000 every 5 years for well and equipment replacement.		15,298,294
Subtotal			17,288,494
15% Contingency			2,593,274
ESTIMATED TOTAL COST			**$ 19,881,768**

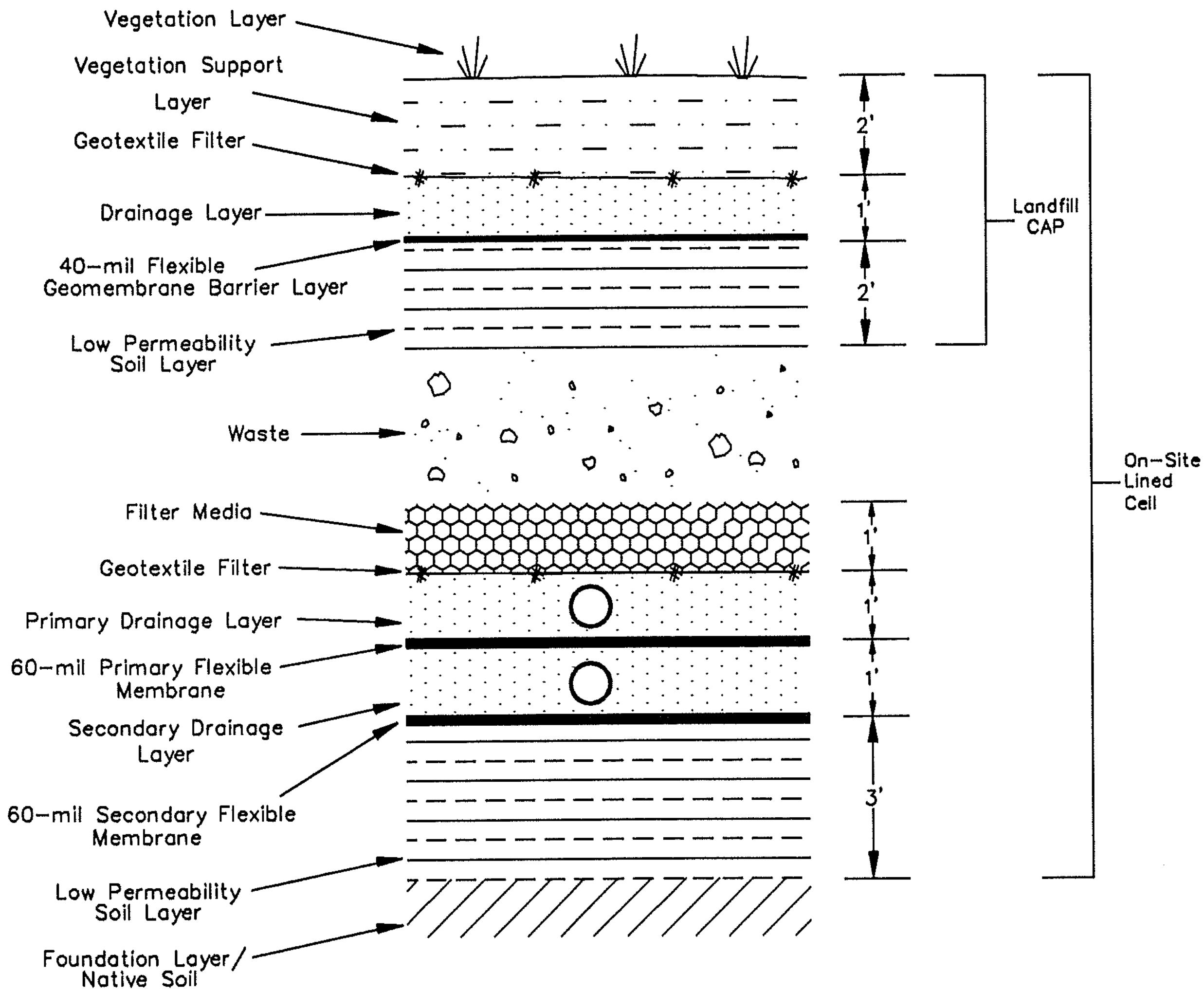
[1] Calculated as an annuity yielding a cash flow required to operate and maintain the NoVOCs™ system in perpetuity using a real rate of return of 7%.

TABLE 5-21
ESTIMATED COSTS FOR EXPANDED NOVOCS™
AT ZONE A, THE MUNICIPAL LANDFILL AND THE OFF-SITE PLUME

CATEGORY	UNIT COST	QUANTITY	COST
ENGINEERING	10% of install cost		$ 2,365,000
INSTALLATION			
NoVOCs System Installation	$73,500 per well	300	22,050,000
Piping and Trenching	$20 per linear foot	20,000	400,000
Air Treatment System (GAC)	$3 per pound of GAC	400,000	1,200,000
Installation Subtotal			23,650,000
CONSTRUCTION MANAGEMENT	10% of install cost		2,365,000
OPERATION & MAINTENANCE	$900,000/month	18	16,200,000
Subtotal			44,580,000
15% Contingency			6,687,000
ESTIMATED TOTAL COST			**$ 51,267,000**

Figure 5-1
Pasco Landfill IRM
SVE Daily Removal Rates





∗ (NOT TO SCALE)

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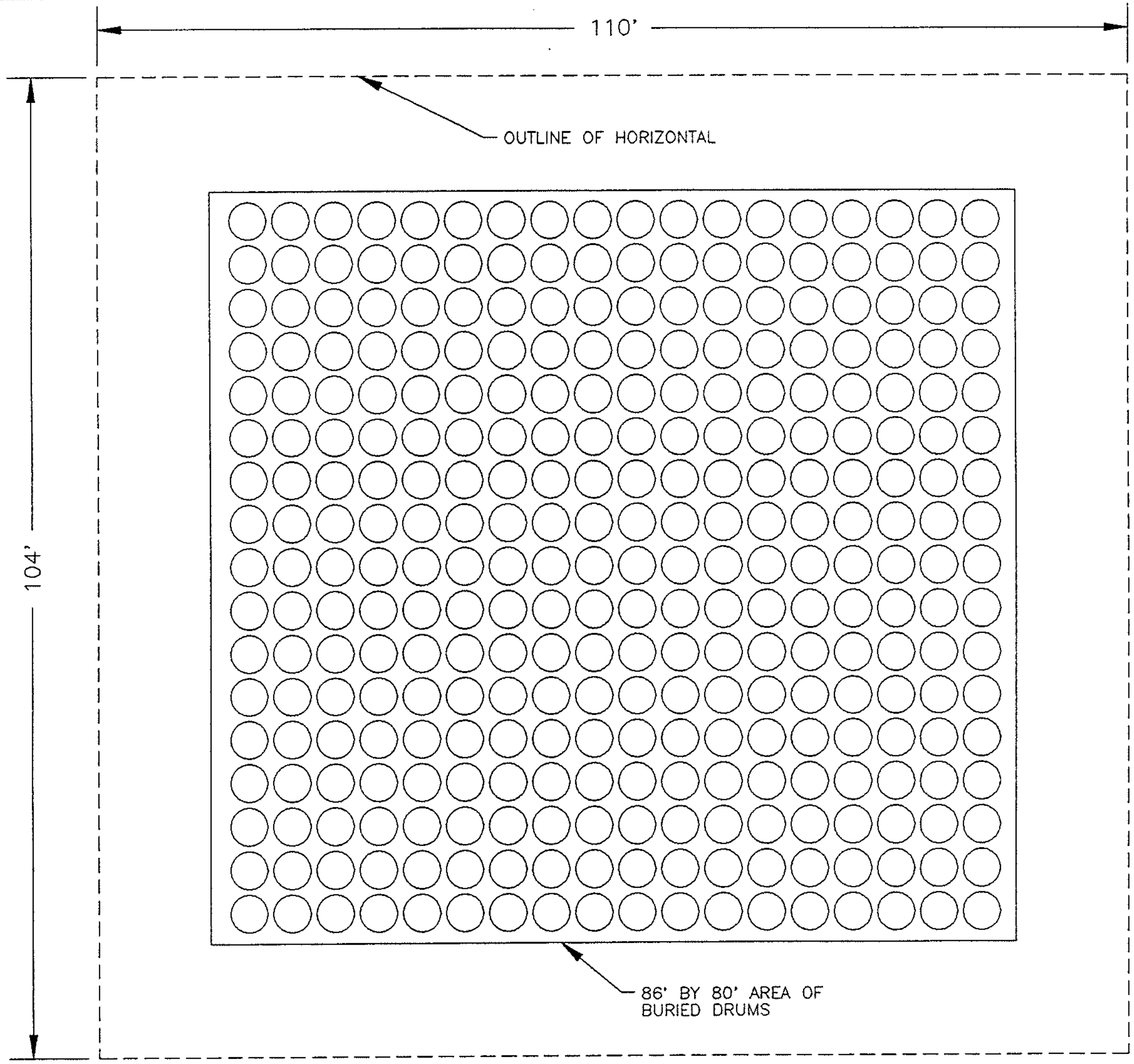
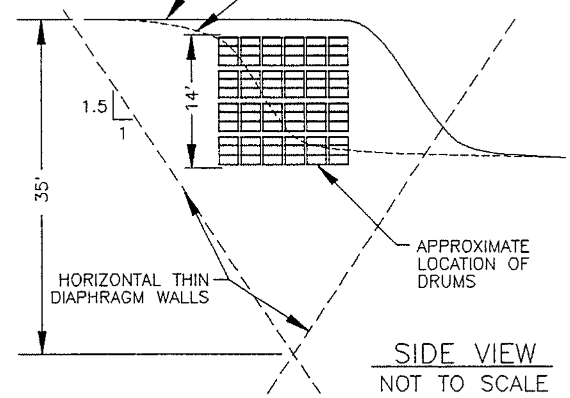
PSC PHILIP SERVICES CORP.

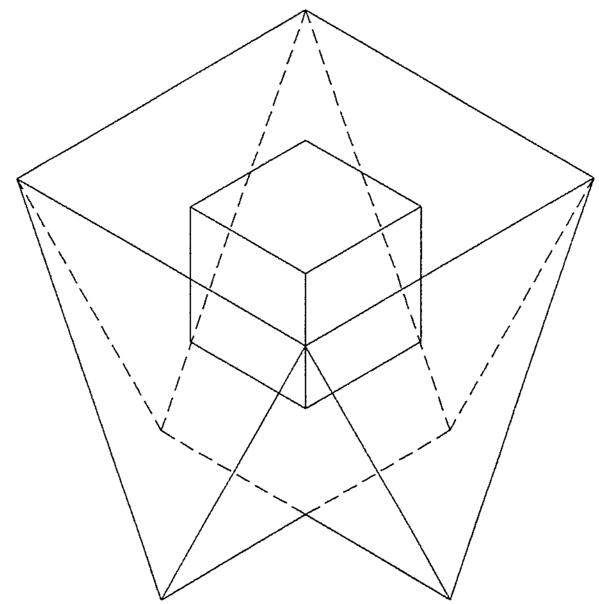
TITLE:	DWN: TS	DES.: TS	PROJECT NO.: 624419
Landfill Cap and On-Site Lined Expanded Cross-Section Pasco Landfill Feasibility Study	CHKD: CH	APPD:	PASCO LANDFILL Pasco WA.
	DATE: 11/11/98	REV.:	Fig. 5-2



PLAN VIEW
1"=20'



SIDE VIEW
NOT TO SCALE



ISOMETRIC VIEW
NOT TO SCALE

PHILIP SERVICES CORP.

TITLE:	DWN:	DES.:	PROJECT NO.: 624419
ZONE B SUBSURFACE BARRIER SCHEMATIC PASCO LANDFILL FEASIBILITY STUDY	TMM/drp	DR	PASCO LANDFILL PASCO WASHINGTON
	CHKD:	APPD:	
	DATE: 04/22/99	REV.: 1	FIGURE 5-3

Figure 5-4
PCE in Plume Axis Wells

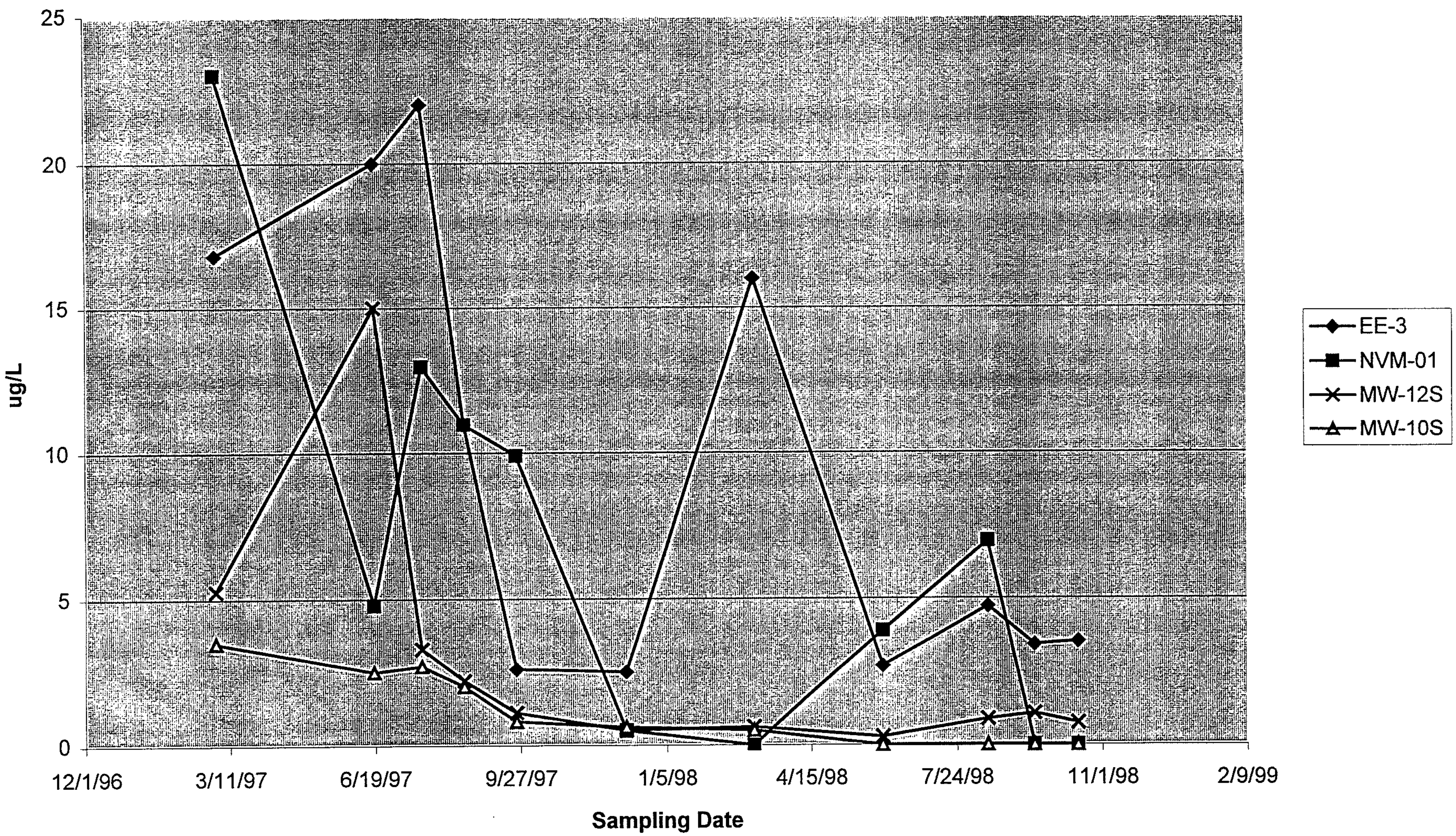


Figure 5-5
TCE in Plume Axis Wells

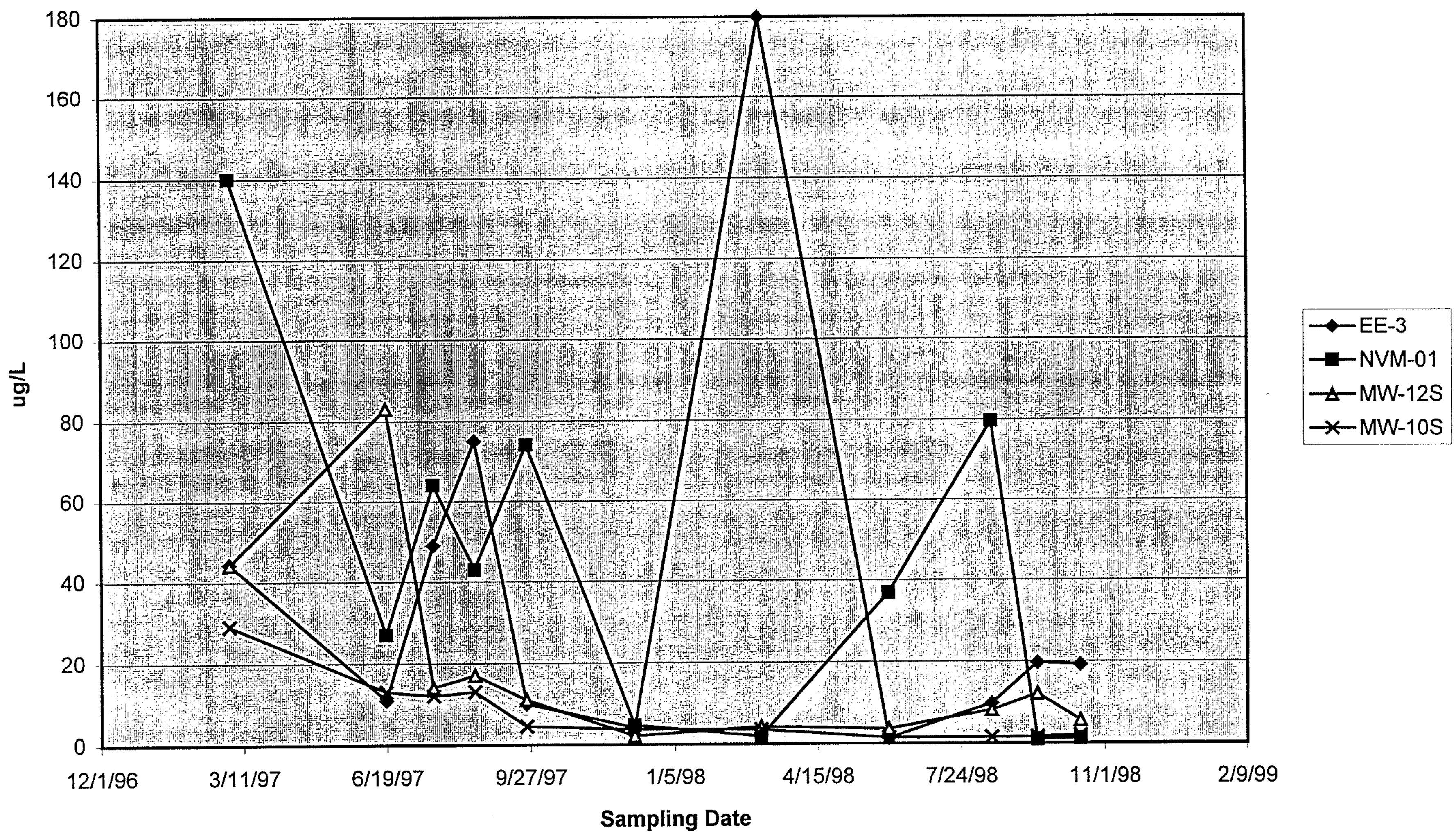


Figure 5-6
cis-1,2-DCE in Plume Axis Wells

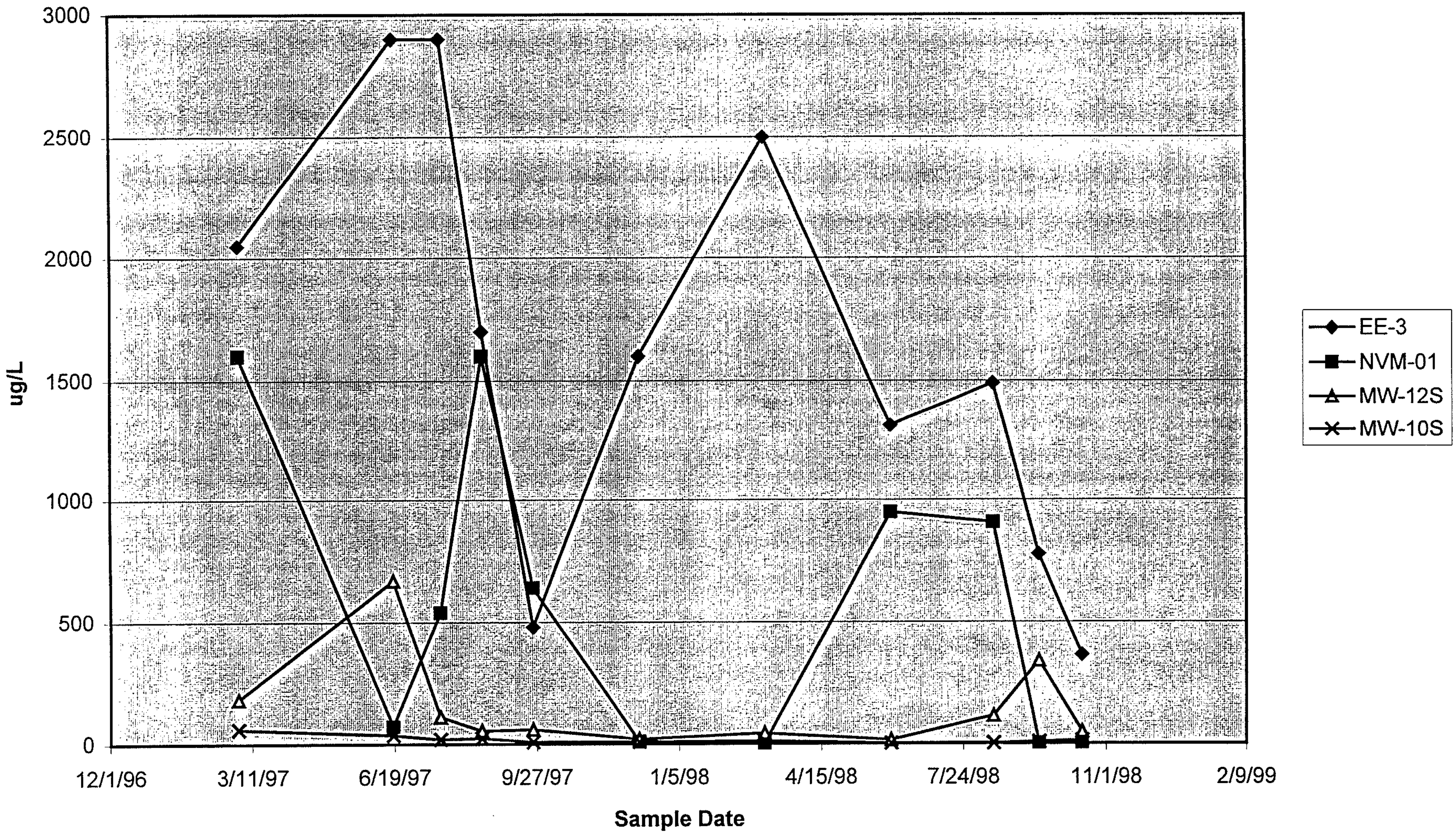


Figure 5-7
Vinyl Chloride in Plume Axis Wells

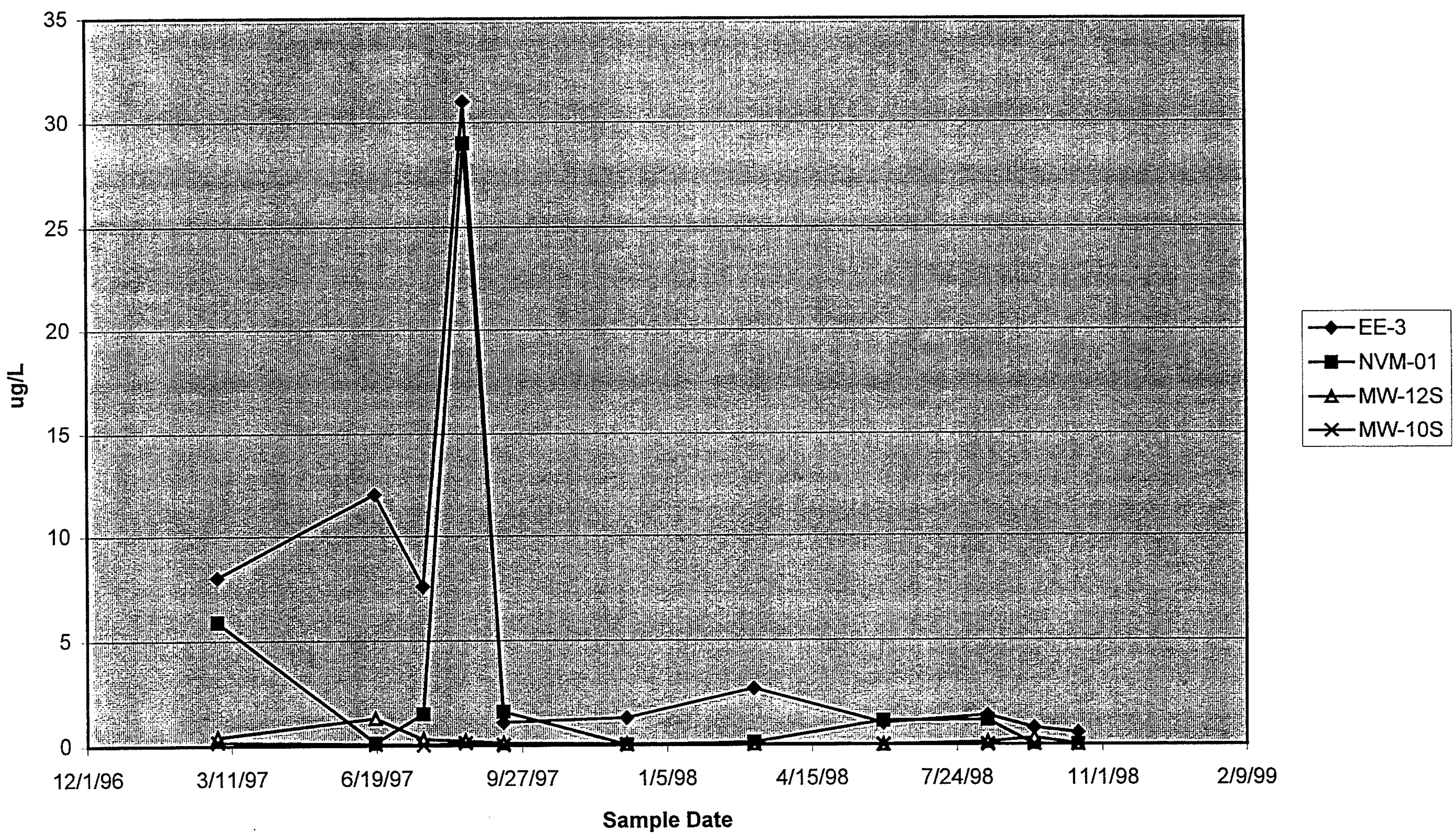


Figure 5-8
1,1-DCE in Plume Axis Wells

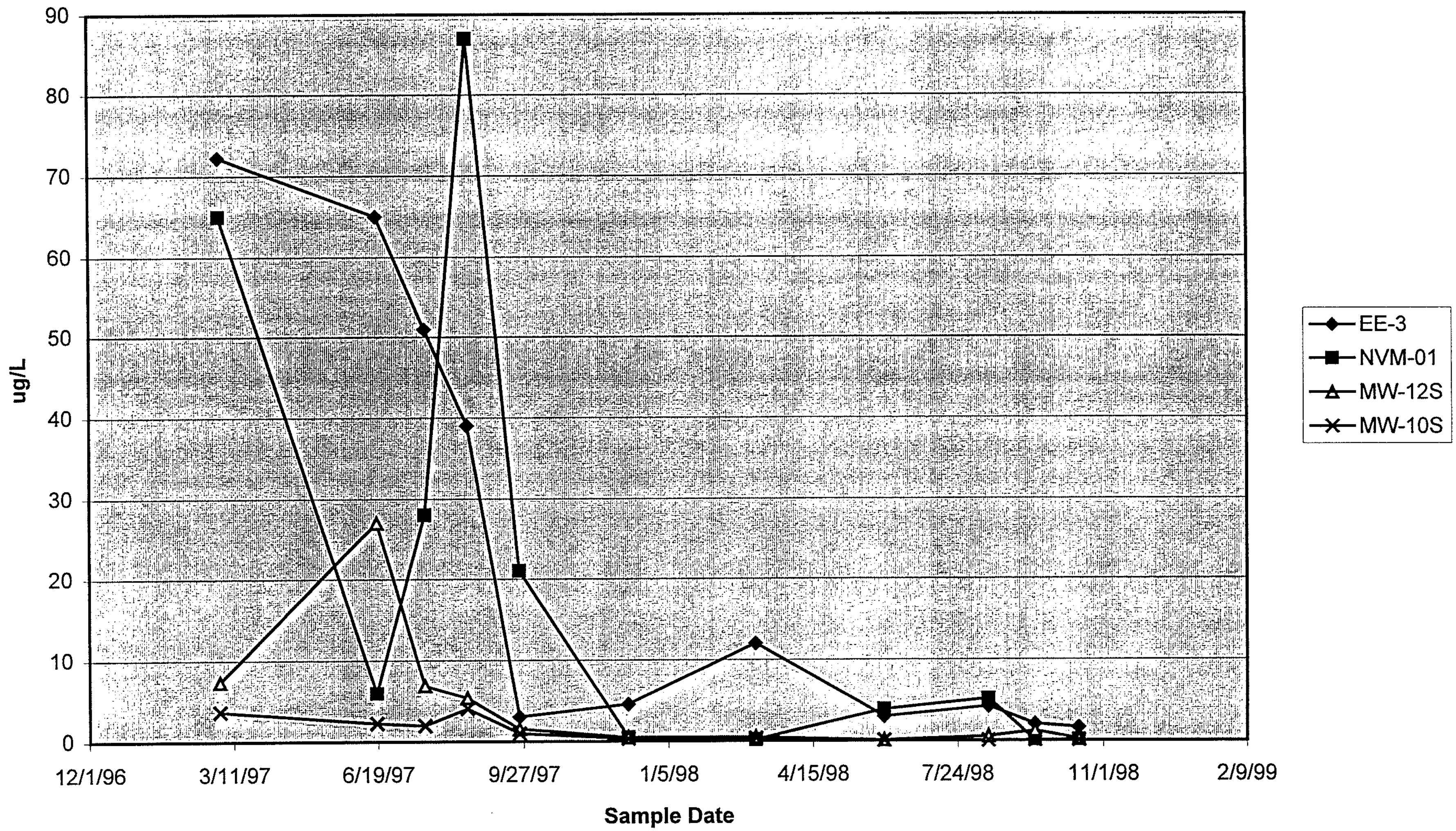
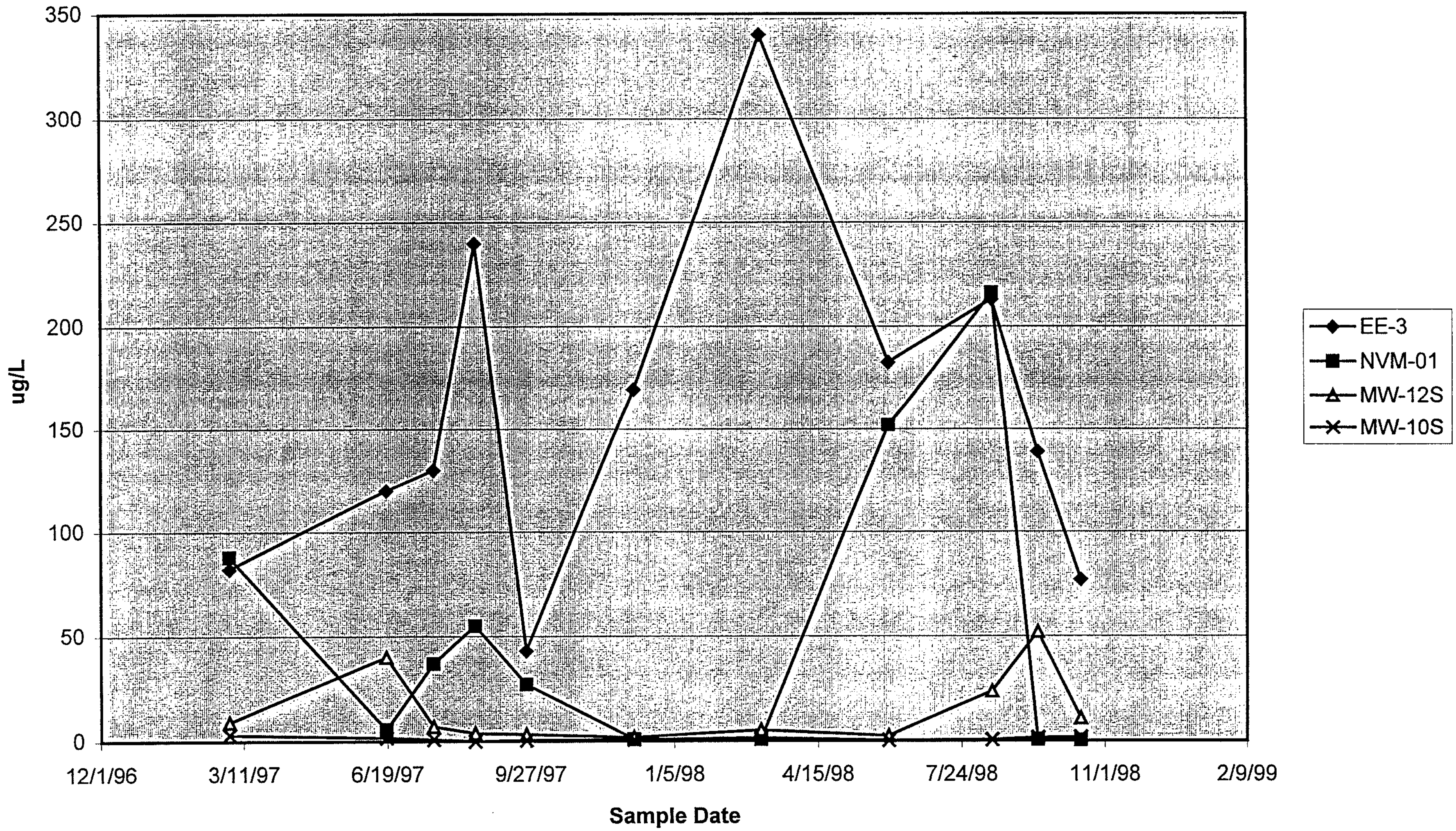
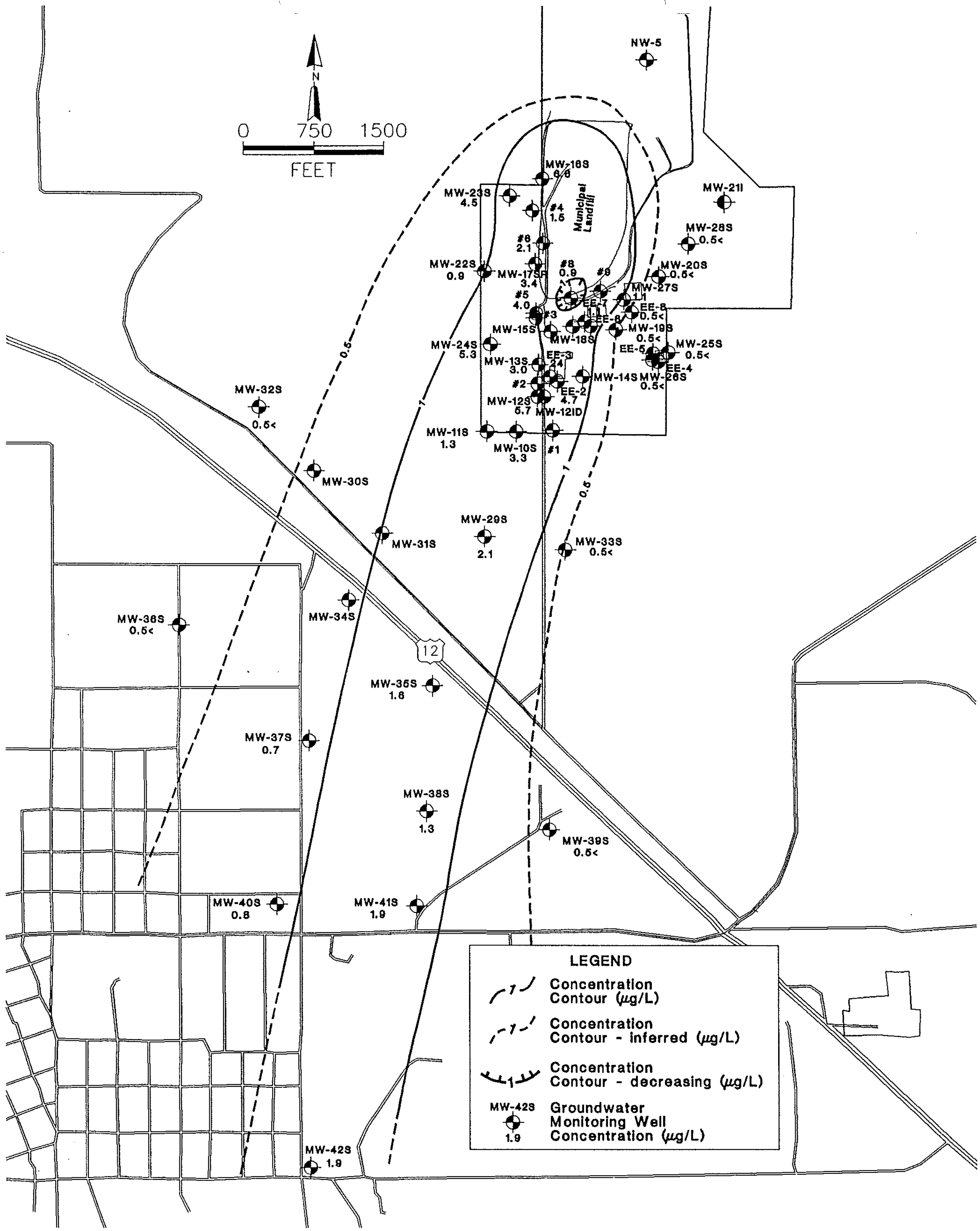


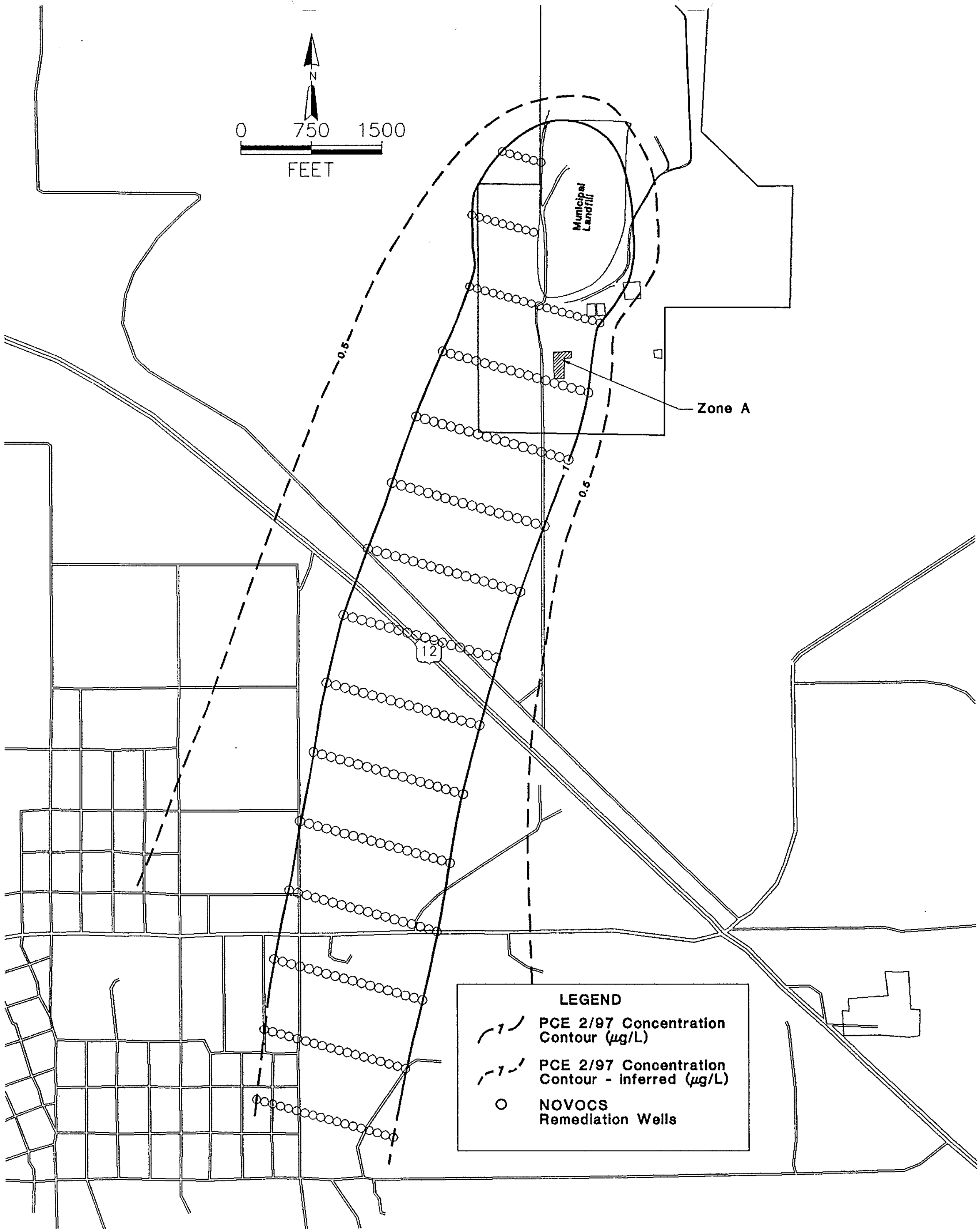
Figure 5-9
1,2-DCA in Plume Axis Wells





PHILIP ENVIRONMENTAL

TITLE:	DWN: brus	DES.: plcsfs26	PROJECT NO.: 624419
PCE in Groundwater July 1996 Pasco Landfill Feasibility Study	CHKD:	APPD:	FIGURE NO.: 5-10
	DATE: 03/10/98	REV.: 8	



PHILIP ENVIRONMENTAL	TITLE: Alternative GW-4 Remediation Well Location Pasco Landfill FS	DWN: brus	DES.: plcfs1	PROJECT NO.: 624419
		CHKD:	APPD:	FIGURE NO.: 5-11
		DATE: 03/17/99	REV.: 8	

6 SELECTION OF CLEANUP ACTIONS

A comparative analysis of the remedial alternatives presented earlier in Section 5 is presented in this section. This section starts by summarizing the Threshold Criteria (Section 6.1), Permanence Criteria (Section 6.2), Restoration Time Frame Criteria (Section 6.3) and Cleanup Technology Hierarchy (Section 6.4) that are presented in WAC 173-340-360. These first four subsections describe all of the criteria which are considered during selection of an appropriate remedial alternative. Methods of Remedial Alternative Analysis (Section 6.5) presents the methods used to evaluate the criteria. The Comparative Analysis Summary is presented in Section 6.6 and includes the selection of the preferred remedy.

All of the alternatives include a comprehensive approach to public outreach as part of the remedial workplan. In addition, an interim approach to address local community concerns prior to acceptance of the workplan is presented as part of the preferred remedy in Section 7.

6.1 THRESHOLD CRITERIA

Under MTCA, remediation alternatives must meet the following threshold evaluation criteria per (WAC 173-340-360(2):

- Compliance with Cleanup Standards
- Compliance with Other Laws and Regulations
- Monitoring for Compliance
- Protectiveness of Human Health and the Environment

These criteria are used as the first four evaluation criteria for each remedial alternative. It should be noted that all of the alternatives include the continued operation of the present SVE system, provision for drinking water to residences with impacted wells and implementation of access and institutional controls. For this reason, all of the alternatives passed the Threshold Requirements.

6.2 PERMANENCE CRITERIA

The permanence criteria used in this analysis are taken from WAC 173-340-360(5)(d)(i-vii) and include the following:

- Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b))
- Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c))
- Overall Protectiveness of Human Health and the Environment (WAC-173-340-360(5)(d)(i))

  Degree to Which Existing Risks are Reduced

  Time Required to Reduce Risk and Attain Cleanup Standards

  On- and Off-site Risks Resulting from Implementing Alternative

  Degree the Action may Perform to Higher Level than Cleanup Standards

  Improvement of Overall Environmental Quality
- Long-Term Effectiveness (WAC 173-340-360(5)(d)(ii))

  Certainty of Success

  Long-term Reliability

  Magnitude of Residual Risk

  Effectiveness of Controls Required to Manage Residual Substances
- Short-Term Effectiveness (WAC 173-340-360(5)(d)(iii))

  Protection of Human Health and the Environment During Construction

  Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards
- Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(d)(iv))

  Adequacy of Alternative in Destroying Hazardous Substances

  Reduction or Elimination of Releases and Sources of Releases

  Degree of Irreversibility of Treatment Process

  Quantity of Treatment Residuals Generated
- Implementability (WAC 173-340-360(5)(d)(v))

  Assessment of Technical Possibility

  Availability of Necessary Off-Site Services and Facilities

  Administrative and Regulatory Requirements

  Project Complexity

Compliance Monitoring Requirements

Access

Integration with Current Facility Operations

- Cleanup Costs
- Community Concerns
-

6.3 RESTORATION TIME FRAME CRITERIA

The restoration time frame criteria used in this analysis are taken from WAC 173-340-360(6)(a)(i-ix) and include the following:

- Restoration Time Frame
- Potential Risks to Human Health and the Environment
- Practicability of Achieving a Shorter Restoration Time Frame
- Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site
- Potential Future Uses of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site
- Availability of Alternative Water Supplies
- Likely Effectiveness and Reliability of Institutional Controls
- Ability to Control and Monitor Migration of Hazardous Substances
- Toxicity of Hazardous Substances Remaining at the Site
- Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site

6.4 CLEANUP TECHNOLOGY HIERARCHY

The cleanup technology hierarchy is described in WAC 173-340-360(4)(a)(i-vii) and is summarized with the most desirable technology first as follows:

- Reuse or Recycling
- Destruction or Detoxification
- Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals

- Immobilization of Hazardous Substances
- On-Site or Off-Site Disposal at an Engineered Facility to Minimize Future Release
- Isolation or Containment with Attendant Engineering Controls
- Institutional Controls and Monitoring

6.5 METHOD OF REMEDIAL ALTERNATIVE ANALYSIS

Choosing a remedy requires weighing differences between criteria. To evaluate and compare the many criteria outlined above, a scoring method was devised. The goal of the scoring method was to provide an objective evaluation of the cleanup actions by closely following the process outlined in WAC 173-340-360. In this way, the total score for an alternative is the best measure of the overall degree of protectiveness of the alternative.

6.5.1 REMEDIAL ALTERNATIVE SCORING METHODS

The Relative Permanence and Restoration Timeframe criteria are scored using a simple ranking technique. Each alternative is scored for each criterion, with the highest score (5) given to the most favorable alternative. The next best alternative is given a 4 and so forth. In some cases, alternatives that were considered essentially the same for a particular criterion are given the same rank. In the case where an evaluation criterion is broken up into several "sub-criteria" in the regulations, each sub-criterion is ranked separately. The score for the evaluation criterion is then calculated as the average of the sub-criteria. The evaluation criteria scores are added together to form the score for the alternative.

The Cleanup Technologies Hierarchy is scored differently from the other tables. The cleanup technologies (i through vi) in WAC 173-340-360-4(a) were each assigned a weighting factor in descending preference. The most preferable technology was given the highest factor of 6 and the least preferable technology was given a factor of 1. Institutional controls and monitoring were given a weighting factor of .5. The percent of waste treated by a particular technology was estimated for each alternative. These estimates were made through the application of professional judgement to the key engineering considerations presented in Section 5. The percent was multiplied by the weighting factor, and the results added to give a total cleanup technology score for each alternative.

The scores for Relative Permanence, Restoration Timeframe and Cleanup Technology are added together to determine the overall score for each alternative, which is presented on

Table 21. These scores are divided by the theoretical perfect score of 101 and rounded to the nearest percent to yield a percent of the perfect score for any alternative.

6.5.2 CONTAINMENT ACTIONS

The preferred remedial alternatives rely on on-site containment of hazardous substances and all of the alternatives include the use of long-term institutional controls to minimize future exposure to hazardous materials in groundwater, in wastes or in soils at the site. The long-term effectiveness, adequacy and reliability of these institutional controls can be an issue. However, the subject site is a large municipal landfill located in a remote area. The site contains an operating sanitary landfill, a closed 40-acre municipal landfill, three burn trench landfills and a balefill. Current laws require that the site will have significant restrictions to future use. These restrictions are compatible with containment remedies in the Industrial Waste Area. Given the collective amount of waste on-site and the restrictions on future use already required by law, the reliability and long-term effectiveness of institutional controls at the Industrial Waste Area is increased.

The MTCA provides regulatory guidance for cleanup actions that rely on containment of hazardous substances (WAC 173-340-360(8)(a-c)). The guidance (italics), is presented below followed by a description of how the remedial alternatives comply:

(a) *A clean up action which relies primarily on on-site disposal, isolation, or containment of hazardous substances shall not be conducted if it is practicable to reuse, destroy, or detoxify those substances in a manner that remaining concentrations are below cleanup levels established under WAC 173-340-700 through 173-340-760.*

The criteria scoring presented in Section 6.6 is used to evaluate the degree of protection and practicability of reusing, destroying, or detoxifying hazardous substances. At Zones B and E the scoring is sufficient to determine practicability. Considering Zone A, Zone CD and the remedial alternatives associated with the Ground Water, additional analysis is required. Although all the alternatives for Zone A, Zone CD and Ground Water result in the destruction of hazardous substances, the rate and total amount of destruction varies between alternatives. To evaluate the relative practicability of these alternatives, cost is compared to the score for each alternative. Since the score is a measure of the "degree of protection" (WAC 173-340-360(5)(vi)) which is achieved by the alternative, comparing the cost to score provides the information needed to determine whether the cost is substantial and disproportionate to the incremental degree of protection for one alternative versus another.

The amount of COCs destroyed is another measure of the degree of protection of an alternative. Unfortunately, the amount of COCs destroyed can only be estimated with reasonable accuracy for the groundwater alternatives. Comparing the cost of the groundwater alternatives to the amount of COCs destroyed provides additional information to determine whether the cost is substantial and disproportionate.

(b) *Long-term monitoring (WAC 173-340-410) and institutional controls (WAC 173-340-440) shall be required if on-site disposal, isolation, or containment is the selected cleanup action for a site or a portion of a site. Such measures shall be required until residual hazardous substance concentrations no longer exceed site cleanup levels established under WAC 173-340-700 through 173-340-760.*

All cleanup alternatives include provisions for institutional controls. This includes restrictions on groundwater use for domestic purposes. In addition, long-term monitoring is included for as long as hazardous substances exceed cleanup standards.

(c) *If the proposed cleanup action involves on-site containment, the draft cleanup action plan shall specify the types, levels, and amounts of hazardous substances remaining on-site and the measures that will be utilized to prevent migration and contact with those substances.*

The types, levels, and amounts of hazardous substances remaining on-site are based on disposal records and are available for inclusion in the cleanup action plan. The preferred remedial alternative is the measure that will be utilized to prevent migration and contact with hazardous substances.

6.6 Comparative Analysis Summary

The comparative analysis summary provides the reasoning for choosing a particular alternative over others. The detailed discussion of each criterion and scoring of the alternatives is presented in tables 6-1 through 6-20. A summary of the results along with additional analysis of substantial and disproportionate arguments is provided below.

6.6.1 Zone A

Tables 6-1 through 6-4 summarize the comparative analysis of remedial alternatives for Zone A. The scores vary from 70% of a perfect score for Alternative A-5 to 79% of a perfect score for Alternative A-4.

Alternatives A-2, A-3 and A-4 received the highest scores and were within 1% of each other. The scores show a trade-off in the potential risks and benefits associated with each of these three alternatives. Implementation of A-3 and A-4 risk the uncontrolled release of hazardous substances during intrusive operations into unknown conditions within the drums of the zone. Implementation of A-2 risks a future release of hazardous substances from a drum or drums that have not leaked to date. Since the IRMs have been successful at treating releases from Zone A, the risks associated with implementing A-2, which provides for a continuation and expansion of presently operating IRMs, are generally characterized as lower than those associated with A-3 and A-4. However, A-3 and A-4 offer quicker remediation of Zone A and will result in the destruction of more hazardous substances within the zone.

The score for each alternative is proportional to the degree of protection that the alternative will provide to workers, the community and the environment. The increase in this protection between A-2, A-3 and A-4 is less than 1%. Subtracting out the effect of cost on the scoring, the difference increases to approximately 3% between A-2 and A-4. However, while A-4 represents an increase in protection of 3%, it costs more than 16 times as much as A-2. In this way, it is clear that the increased cost between A-2 and A-4 is substantial and disproportionate to the increase in the degree of protection provided by A-4. A similar argument is made by comparing the increased protection of A-3 over A-2 (1%) to the increased cost of A-3 (6 times). For this reason, A-2 is selected as the preferred remedial alternative for Zone A.

Table 6-1
Threshold Requirements
(WAC 173-340-360(2))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Compliance with Cleanup Standards		Yes	Yes	Yes	Yes	Yes
Compliance with Other Laws and Regulations	Compliance with Chemical-Specific ARARs	Yes	Yes	Yes	Yes	Yes
	Compliance with Action-Specific ARARs	Yes	Yes	Yes	Yes	Yes
	Compliance with Location-Specific ARARs	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.
	Compliance with Other Criteria, Advisories and Guidance	Yes	Yes	Yes	Yes	Yes
Monitoring(soil)	Compliance	Compliance monitoring is complete since samples taken outside existing cap show compliance.	Compliance monitoring is complete since samples taken outside existing cap show compliance.	Compliance monitoring is complete since samples taken outside existing cap show compliance.	To determine compliance, soil clearance samples will be required after zone excavation.	To determine compliance, soil clearance samples will be required after zone excavation.
	Performance	SVE performance monitoring will be performed until remedy is complete. Cap performance monitoring required by ARARs.	SVE performance monitoring will be performed until remedy is complete. Cap performance monitoring required by ARARs.	SVE performance monitoring will be performed until remedy is complete. Cap performance monitoring required by ARARs.	N/A	Cell performance monitoring required by ARARs.

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b))		Need to run SVE until cleanup standards are met. Need to maintain cap and institutional controls.	Need to run SVE until cleanup standards are met. Need to maintain cap and institutional controls.	Need to run SVE until cleanup standards are met. Need to maintain cap and institutional controls.	Need to maintain institutional controls.	Need to maintain cap and institutional controls.
SCORE:		**2.0**	**2.0**	**3.0**	**5.0**	**4.0**
Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c))		SVE separates COCs from the wastes and soil. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs.	SVE separates COCs from the wastes and soil. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs.	Off-site incineration destroys the COCs. SVE separates COCs from the soil. Carbon collects and recycling the carbon ultimately destroys the COCs.	Off-site incineration destroys the COCs.	Only wastes containing free liquids are incinerated and destroyed off-site.
SCORE:		**3.0**	**3.0**	**4.0**	**5.0**	**2.0**
Overall protectiveness of Human Health and the Environment (WAC 173-340-360(5)(d)(i))	Degree to Which Existing Risks are Reduced	Physical risks from geotechnical failure and risks of a release from rainfall percolation will not be reduced. Risks of a release of some contaminants from drums or soil that is not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Risks of a release of some contaminants from drums or soil that is not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Risks of a release of some contaminants from soil that is not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	All risks addressed to industrial standards.	All risks addressed to industrial standards.
	SCORE:	2.0	3.0	4.0	5.0	5.0
	Time Required to Reduce Risk and Attain Cleanup Standards	Tens of years (Longest) Please note: does not effect time required to clean up off-site ground water.	Tens of years (Shorter than A-1) Please note: does not effect time required to clean up off-site ground water.	Less than ten of years. Please note: uncontrolled releases during intrusive operations may increase time required to cleanup ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time required to cleanup ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time required to cleanup ground water.
	SCORE:	2.0	3.0	4.0	5.0	5.0

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Overall Protectiveness of Human Health and the Environment (continued)	On- and Off-site Risks Resulting from Implementing Alternative	Because this alternative is non-intrusive, the community and workers will not be exposed to increased risks during implementation. Percolation of rain water through cap may create more risks than in A-2. Transport of spent carbon through the community presents a low risk.	Because this alternative is non-intrusive, the community and workers will not be exposed to increased risks during implementation. Transport of spent carbon through the community presents a low risk.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. In addition, transportation of wastes through the community poses additional risk. Transport of spent carbon through the community presents a low risk.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. Deep excavation with possible relocation of the balefill and debrifill increases risks over A-3. In addition, transportation of wastes through the community poses additional risk.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the comunity during intrusive operations. Deep excavation with possible relocation of the balefill and debrifill increases risks over A-3.
	SCORE:	4.0	5.0	3.0	1.0	2.0
	Degree the Action may Perform to Higher Level than Cleanup Standards	SVE will be monitored to confirm successful soil remediation. Concentrations of COCs in soils remaining on-site may be lower than Cleanup Standards.	SVE will be monitored to confirm successful soil remediation. Concentrations of COCs in soils remaining on-site may be lower than Cleanup Standards.	SVE will be monitored to confirm successful soil remediation. Concentrations of COCs in soils remaining on-site may be lower than Cleanup Standards. Incineration of drums may reduce combustible contaminants below Cleanup Levels.	Soil remaining on-site will be at cleanup levels. Incineration of drums and soil off-site may reduce combustible contaminants below Cleanup Levels.	Soil remaining on-site will be at cleanup levels.
	SCORE:	3.0	3.0	5.0	4.0	2.0
	Improvement of Overall Environmental Quality	COCs in soils on-site improved to industrial cleanup levels or better.	COCs in soils on-site improved to industrial cleanup levels or better.	COCs in soils on-site improved to industrial cleanup levels or better.	COCs in soils on-site improved to industrial cleanup levels.	COCs in soils on-site improved to industrial cleanup levels.
	SCORE:	5.0	5.0	5.0	4.0	4.0
AVERAGE SCORE:		**3.2**	**3.8**	**4.2**	**3.8**	**3.6**

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Long-Term Effectiveness (WAC 173-340-360 (5)(d)(ii))	Certainty of Success	Risks exist from geotechnical failure and rainfall infiltration leading to a release. Risks of a release of compounds from drums or soil that are not intercepted by the SVE system prior to reaching the water table is considered small based on data to date. These risks decrease with time as the zone settles and as it becomes less likely that drums containing free liquids are present. Risk of institutional controls failing.	Risks of a release of compounds from drums or soil that are not intercepted by the SVE system prior to reaching the water table is considered small based on data to date. These risks decrease with time as the zone settles and as it becomes less likely that drums containing free liquids are present. Risk of institutional controls failing.	Risk of a release of compounds from soil that is not intercepted by the SVE system prior to reaching the water table is considered very small based on data to date. Risk of institutional controls failing.	Risk of institutional controls failing.	Risks of a release of compounds from the on-site lined cell is considered very small. Risk of institutional controls failing.
	SCORE:	3.0	4.0	5.0	5.0	5.0
	Long-term Reliability	Deed restriction will control future use. Cap will need maintenance program. Care should be taken to monitor the geotechnical stability of the zone. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls..	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. On-site lined cell cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.
	SCORE:	3.0	4.0	4.0	5.0	4.0
	Magnitude of Residual Risk	COCs will remain in on-site soils and wastes at or below industrial cleanup standards.	COCs will remain in on-site soils and wastes at or below industrial cleanup standards.	COCs will remain in on-site soils at or below industrial cleanup standards.	COCs will remain in on-site soils at industrial cleanup standards.	All COCs except those in free liquids will remain on-site.
	SCORE:	3.0	3.0	5.0	4.0	2.0

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Long-Term Effectiveness (continued)	Effectiveness of Controls Required to Manage Residual Substances	Deed restriction will control future use. Cap will need maintenance program. Care should be taken to monitor the geotechnical stability of the zone. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. On-site lined cell cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.
	SCORE:	3.0	4.0	4.0	5.0	4.0
AVERAGE SCORE:		**3.0**	**3.8**	**4.5**	**4.8**	**3.8**
Short-Term Effectiveness (WAC 173-340-360(5)(d)(iii))	Protection of Human Health and the Environment During Construction	Based on the operation of IRMs to date, good short-term effectiveness is expected with the possible exception of physical hazards caused by geotechnical instability.	Based on the operation of IRMs to date, good short-term effectiveness is expected.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason, short-term effective-ness is expected to be poor.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason, short-term effective-ness is expected to be poor.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason short-term effectiveness is expected to be poor.
	SCORE:	4.0	5.0	3.0	2.0	2.0
	Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards	Risks of a release of compounds from drums or soil that are not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Risks of a release of compounds from drums or soil that are not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Risks of an uncontrolled release during intrusive operations into unknown conditions.	Risks of an uncontrolled release during intrusive operations into unknown conditions.	Risks of an uncontrolled release during intrusive operations into unknown conditions.
	SCORE:	5.0	5.0	4.0	4.0	4.0
AVERAGE SCORE:		**3.0**	**5.0**	**4.5**	**3.0**	**3.0**

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Expand SVE*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone A Cap*** ▪ ***Expand SVE*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative A-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(d)(iv))	Adequacy of Alternative in Destroying Hazardous Substances	Adequate. Between 40 and 80 lbs/day of COCs are captured primarily by the SVE system and stored in carbon. These contaminants are subsequently destroyed when the carbon is regenerated.	Adequate. Between 40 and 80 lbs/day of COCs are captured primarily by the SVE system and stored in carbon. These contaminants are subsequently destroyed when the carbon is regenerated.	Adequate. All COCs in wastes will be removed during remediation and subsequently destroyed. The COCs in remaining soils will be removed and destroyed by the SVE system.	Adequate. All COCs in wastes and soils will be removed during remediation and subsequently destroyed.	Adequate. All COCs in wastes and soils containing free liquids will be taken off-site and destroyed during remediation.
	SCORE:	5.0	5.0	5.0	5.0	5.0
	Reduction or Elimination of Releases and Sources of Releases	Sources and releases of COCs will be reduced to industrial cleanup levels over time.	Sources and releases of COCs will be reduced to industrial cleanup levels over time.	The primary source of COCs (drums) will be removed. Releases of COCs from soils will be reduced to industrial cleanup levels over time.	All sources will be removed, minimizing further releases.	All sources except for those contained in free liquids will remain on-site.
	SCORE:	3.0	3.0	4.0	5.0	2.0
	Degree of Irreversibility of Treatment Process	Incineration of COCs in soils is irreversible.	Incineration of COCs in soils is irreversible.	Incineration of drums and COCs in soils is irreversible.	Incineration of drums and soils is irreversible.	Incineration of drums containing free liquids is irreversible.
	SCORE:	3.0	3.0	4.0	5.0	2.0
	Quantity of Treatment Residuals Generated	Minimal amounts of COCs will remain in soils and drums after treatment.	Minimal amounts of COCs will remain in soils and drums after treatment.	Minimal amounts of COCs in soil will remain after treatment.	COCs will remain in soil at industrial cleanup levels.	The most residual will likely remain under this alternative.
	SCORE:	3.0	3.0	5.0	4.0	2.0
AVERAGE SCORE:		**3.5**	**3.5**	**4.5**	**4.8**	**2.8**

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Implementability (WAC 173-340-360(5)(d)(v))	Assessment of Technical Possibility	Minimal technical difficulties expected. Skilled personnel are required to adequately design the SVE expansion. SVE systems appear reliable during IRM phase. Additional data collected during the implementation of the remedial work plan should confirm this result.	Minimal technical difficulties expected. Skilled personnel are required to adequately design the cap and the SVE expansion. SVE systems appear reliable during IRM phase. Additional data collected during the implementation of the remedial work plan should confirm this result.	Intrusive operation, as well as transportation and incineration of waste requires highly skilled personnel. Skilled personnel are required to adequately design the cap and the SVE expansion. Bailfill and construction debrifill may have to be moved to access drums.	Technical difficulties expected. Intrusive operation, as well as transportation and incineration of waste and soils requires highly skilled personnel. Excavation to cleanup levels may not be possible due to depth of contamination or the presence of the water table. Bailfill and construction debrifill may have to be moved to access drums.	Technical difficulties expected. Intrusive operation, and separation of wastes and soils containing free liquids requires highly skilled personnel. Transportation and incineration of waste and soils containing free liquids requires highly skilled personnel. Excavation to cleanup levels may not be possible due to depth of contamination or the presence of the water table. Bailfill and construction debrifill may have to be moved to access drums.
	SCORE:	5.0	5.0	4.0	3.0	3.0
	Availability of Necessary Off-Site Services and Facilities	Availability of carbon is not expected to be a problem.	Availability of carbon is not expected to be a problem.	Availability of transporters and daily capacity of treatment facility may affect duration of the removal but is not expected to be a problem.	Availability of transporters and daily capacity of treatment facility may affect duration of the removal but is not expected to be a problem.	Availability of transporters and daily capacity of treatment facility may affect duration of the removal of wastes containing free liquids but is not expected to be a problem.
	SCORE:	5.0	5.0	5.0	5.0	5.0
	Administrative and Regulatory Requirements	Easily met	Easily met	Easily met	Easily met	RCRA status and movement of waste, and siting requirements of the on-site cell may make administrative and regulatory requirements difficult.
	SCORE:	5.0	5.0	5.0	5.0	4.0
	Project Complexity	Relatively simple. Continue operation of SVE and maintain cap.	Relatively simple. Continue operation of SVE and maintain cap.	Complex. Intrusive operations into unknown conditions.	Most complex. Intrusive operations into unknown conditions and deep excavation to remove drums and soils adjacent to the balefill and debrifill .	Most complex. Intrusive operations into unknown conditions and deep excavation to remove drums and soils adjacent to the balefill and debrifill .
	SCORE:	5.0	5.0	4.0	3.0	3.0
	Monitoring Requirements	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Only protection and performance monitoring required.	Protection, performance and confirmational monitoring required.
	SCORE:	4.0	4.0	4.0	5.0	4.0

Table 6-2
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Implementability (continued)	Access	Readily Available.	Readily Available.	Readily Available.	Readily Available.	Readily Available.
	SCORE:	5.0	5.0	5.0	5.0	5.0
	Integration with Current Facility Operations	Facility is a landfill so integration with current operations is good.	Facility is a landfill so integration with current operations is good.	Facility is a landfill so integration with current operations is good.	Facility is a landfill so integration with current operations is good.	Facility is a landfill so integration with current operations is good.
	SCORE:	5.0	5.0	5.0	5.0	5.0
AVERAGE SCORE:		**4.9**	**4.9**	**4.6**	**4.4**	**4.1**
Cleanup Costs (WAC 173-340-360(5)(d)(vi))		$6,000,000	$6,000,000	$60,000,000	$182,000,000	$37,000,000
SCORE:		**5.0**	**5.0**	**3.0**	**2.0**	**4.0**
Community Concerns (WAC 173-340-360(5)(d)(vii))		Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.
SCORE:		**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
TOTAL PERMANENCE SCORE :		**34.1**	**35.9**	**36.3**	**37.7**	**32.2**

Table 6-3
Restoration Time Frame
(WAC) 173-340-360(6)
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Option	*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Restoration Time Frame	Tens of years (Longest)	Tens of years (Shorter than A-1)	Less than ten years. Please note: uncontrolled releases during intrusive operations may increase time required to clean up ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time required to clean up ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time required to clean up ground water.
SCORE:	2.0	3.0	4.0	5.0	5.0
Potential Risks to Human Health and the Environment (WAC 173-340-360(6)(a)(i))	Physical risks from geotechnical failure and risks of a release from rainfall percolation will not be reduced. Risks of a release of some contaminants from drums or soil that is not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Risks of a release of some contaminants from drums or soil that is not intercepted by the SVE system prior to reaching the water table is considered small based on data to date.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. In addition, transportation of wastes through the community poses additional risk. Transport of spent carbon through the community presents a low risk.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. Deep excavation with possible relocation of the balefill and debrifill increases risks over A-3. In addition, transportation of wastes through the community poses additional risk.	Unknown condition of drums, wastes, physical hazards and potential uncontrolled releases to the environment may create risks to workers and the comunity during intrusive operations. Deep excavation with possible relocation of the balefill and debrifill increases risks over A-3.
SCORE:	4.0	5.0	3.0	1.0	2.0
Practicability of Achieving a Shorter Restoration Time Frame (WAC 173-340-360(6)(a)(ii))	Alternatives A-2 and A-5 offer a practicable alternative for a shorter restoration time frame.	Alternative A-5 offers a practicable alternative approach for a shorter restoration time frame.	No shorter practicable alternative.	No shorter practicable alternative.	No shorter practicable alternative.
SCORE:	4.0	4.0	5.0	5.0	5.0
Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iii))	Agricultural uses of ground water unlikely to be impacted by a release. All other uses protected.	Agricultural uses of ground water unlikely to be impacted by a release. All other uses protected.	Agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected.	Agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected.	Agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected.
SCORE:	5.0	5.0	4.0	4.0	4.0

Table 6-3
Restoration Time Frame
(WAC) 173-340-360(6)
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Option	*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Potential Future Uses of the Site, Surrounding Areas and Associated Resources That are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iv)) SCORE:	Future agricultural uses of ground water unlikely to be impacted by a release. Potential for releases increased due to infiltration of rainfall through existing cap. All other uses protected. 5.0	Future agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected. 4.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected. 4.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other uses protected. 4.0
Availability of Alternative Water Supplies (WAC 173-340-360(6)(a)(v)) SCORE:	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0
Likely Effectiveness and Reliability of Institutional Controls (WAC 173-340-360(6)(a)(vi)) SCORE:	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0
Ability to Control and Monitor Migration of Hazardous Substances (WAC 173-340-360(6)(a)(vii)) SCORE:	Continued monitoring is expected. SVE has proven effective. 5.0	Continued monitoring is expected. SVE has proven effective. 5.0	Continued monitoring is expected. SVE has proven effective but uncontrolled releases may occur during drum removal. 4.0	Continued monitoring is expected. Uncontrolled releases may occur during drum removal. 4.0	Continued monitoring is expected. Uncontrolled releases may occur during drum removal. 4.0
Toxicity of Hazardous Substances Remaining at the Site (WAC 173-340-360(6)(a)(viii)) SCORE:	COCs will remain in on-site soils and wastes at or below industrial cleanup standards. 3.0	COCs will remain in on-site soils and wastes at or below industrial cleanup standards. 3.0	COCs will remain in on-site soils at or below industrial cleanup standards. 4.0	COCs will remain in on-site soils at industrial cleanup standards. 5.0	All COCs except those in free liquids will remain on-site. 2.0
Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site (WAC 173-340-360(6)(a)(ix)) SCORE:	None 0.0	None 0.0	None 0.0	N/A 0.0	None 0.0
TOTAL TIME FRAME SCORE:	**38.0**	**40.0**	**38.0**	**38.0**	**36.0**

Table 6-4
Cleanup Technologies
(WAC 173-340-360(4)(a))
Zone A – Comparative Analysis of Remedial Alternatives

Remedial Option	*Alternative A-1*	*Alternative A-2*	*Alternative A-3*	*Alternative A-4*	*Alternative A-5*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone A Cap* ▪ *Expand SVE* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative A-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Reuse or Recycling (WAC 173-340-360(4)(a)(i)) SCORE: 6	None --	None --	None --	None --	None --
Destruction or Detoxification (WAC 173-340-360(4)(a)(ii)) SCORE: 5	COCs in wastes and soils destroyed to industrial cleanup levels or lower. 0.6	COCs in wastes and soils destroyed to industrial cleanup levels or lower. 0.6	COCs in wastes destroyed, COCs in soils destroyed to industrial cleanup levels or lower. 0.9	COCs in wastes destroyed, COCs in soils destroyed to industrial cleanup levels. 0.85	COCs in wastes and soils containing free liquids destroyed. 0.1
Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals (WAC 173-340-360(4)(a)(iii)) SCORE: 4	None --	None --	None --	None --	None --
Immobilization of Hazardous Substances (WAC 173-340-360(4)(a)(iv)) SCORE: 3	None --	None --	None --	None --	None --
On-Site or Off-Site Disposal at an Engineered Facility to Minimize Future Release (WAC 173-340-360(4)(a)(v)) SCORE: 2	None --	None --	None --	None --	COCs in wastes and soil contained on-site in an engineered facility. 0.75
Isolation or Containment with Attendant Engineering Controls (WAC 173-340-360(4)(a)(vi)) SCORE: 1	COCs below industrial cleanup levels contained in wastes and soils on-site. 0.4	COCs below industrial cleanup levels contained in wastes and soils on-site. 0.4	COCs below industrial cleanup levels contained in soils on-site. 0.1	COCs at industrial cleanup levels contained in soils on-site. 0.15	COCs at industrial cleanup levels contained in soils on-site. 0.15
Institutional Controls and Monitoring (WAC 173-340-360(4)(a)(vii)) SCORE: 1/2	Yes 0.4	Yes 0.4	Yes 0.1	Yes 0.15	Yes 0.9
TOTAL TECHNOLOGIES SCORE:	**3.6**	**3.6**	**4.7**	**4.5**	**2.6**

6.6.2 ZONE B

Tables 6-5 through 6-8 summarize the comparative analysis of remedial alternatives for Zone B. The scores vary from 69% of a perfect score for Alternative B-6 to 80% of a perfect score for Alternative B-2.

Alternatives B-1, B-2 and B-3 received the highest scores and were within 4% of each other. As with Zone A, the scores show a trade-off in the potential risks and benefits associated with each of the alternatives. Implementation of B-4, B-5 and B-6 risk the uncontrolled release of hazardous substances during intrusive operations into unknown conditions within the drums of the zone. Implementation of B-1, B-2 and B-3 risk a future release of hazardous substances from a drum or drums that have not leaked to date. However, the drums have been in place for more than 20 years and there is no evidence of a release from Zone B impacting groundwater. For this reason, the risks associated with leaving drums in place are considered very small compared to disturbing the drums.

Alternative B-1 risks percolation of precipitation through wastes since the present cap installed at the zone is unreliable. In addition, B-1 risks physical hazards due to geotechnical instability at the zone. B-3 will be technically difficult to implement and since wastes within Zone B have not impacted groundwater, completing B-3 may have little or no benefit over completing B-2. For these reasons, B-2 scores the highest and is selected as the preferred remedial alternative at Zone B.

Table 6-5
Threshold Requirements
(WAC 173-340-360(2))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Compliance with Cleanup Standards		Yes	Yes	Yes	Yes	Yes	Yes
Compliance with Other Laws and Regulations	Compliance with Chemical-Specific ARARs	Yes	Yes	Yes	Yes	Yes	Yes
	Compliance with Action-Specific ARARs	Yes	Yes	Yes	Yes	Yes	Yes
	Compliance with Location-Specific ARARs	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.
	Compliance with Other Criteria, Advisories and Guidance	Yes	Yes	Yes	Yes	Yes	Yes
Monitoring (soil)	Compliance	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	To determine compliance, soil clearance samples will be required after zone excavation.	To determine compliance, soil clearance samples will be required after zone excavation.
	Performance	Zone will be monitored as required by ARARs.	Zone will be monitored as required by ARARs.	Zone will be monitored as required by ARARs.	Zone will be monitored as required by ARARs.	N/A	Zone will be monitored as required by ARARs.

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b))		Need to implement monitoring and institutional controls. WAC 173-340-700 (2,C)	Need to implement monitoring and institutional controls. WAC 173-340-700 (2,C)	Need to implement monitoring and institutional controls. WAC 173-340-700 (2,C)	Need to implement monitoring and institutional controls. WAC 173-340-700 (2,C)	Need institutional controls.	Need to implement monitoring and institutional controls. WAC 173-340-700 (2,C)
SCORE:		**4.0**	**4.0**	**4.0**	**4.0**	**5.0**	**4.0**
Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c))		None	None	None	Drum contents will be destroyed. Contaminants in soils will be contained.	All contaminants will be destroyed.	Contaminants in free liquids will be destroyed.
SCORE:		**2.0**	**2.0**	**2.0**	**4.0**	**5.0**	**3.0**
Overall Protectiveness of Human Health and the Environment (WAC 173-340-360(5)(d)(i)) Note: All Remedial Alternatives are Protective Since They All Attain Cleanup Levels and ARARs	Degree to Which Existing Risks are Reduced	Physical risks from geotechnical failure and risks of a release from rainfall percolation will not be reduced. Risks of a release of contaminants from drums or soil are considered small based on ground water data.	Risks of a release of contaminants from drums or soil are considered small based on ground water data.	All risks addressed to industrial standards.	Risk of a release of contaminants from soil is considered small based on ground water data.	All risks addressed to industrial standards.	All risks addressed to industrial standards.
	SCORE:	2.0	3.0	5.0	4.0	5.0	5.0
	Time Required to Reduce Risk and Attain Cleanup Standards	Approximately 1.5 years. Please note: does not effect time required to clean up off-site ground water.	Approximately 1.5 years. Please note: does not effect time required to clean up off-site ground water.	Approximately 2 years. Please note: does not effect time required to clean up off-site ground water.	Approximately 3 years. Please note: uncontrolled releases as a result of intrusive operations may increase time required to clean up ground water.	Approximately 3.5 years. Please note: uncontrolled releases as a result of intrusive operations may increase time required to clean up ground water.	Approximately 3.5 years. Please note: uncontrolled releases as a result of intrusive operations may increase time required to clean up ground water.
	SCORE:	5.0	5.0	4.0	3.0	2.0	2.0

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Overall Protectiveness of Human Health and the Environment (continued)	On- and Off-site Risks Resulting from Implementing Alternative	Because this alternative is non-intrusive, the community and workers will not be exposed to increased risks during implementation. Percolation of rainwater through cap and geophysical instability may create more risks than B-2.	Because this alternative is non-intrusive, the community and workers will not be exposed to increased risks during implementation.	Because this alternative is non-intrusive, the community and workers will not be exposed to increased risks during implementation.	Unknown condition of drums, wastes and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. In addition, transportation of wastes through the community poses additional risk.	Unknown condition of drums, wastes and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations. In addition, transportation of soil and wastes through the community poses additional risk.	Unknown condition of drums, wastes and potential uncontrolled releases to the environment may create risks to workers and the community during intrusive operations.
	SCORE:	4.0	5.0	5.0	3.0	3.0	3.0
	Degree the Action may Perform to Higher Level than Cleanup Standards	Not Applicable.	Not Applicable.	Not Applicable.	Incineration of drummed waste should result in (second best) performance to higher than cleanup levels.	Incineration of drummed waste and soil should result in performance to higher than cleanup levels.	If required, incineration of waste containing free liquid should result in performance to higher than cleanup levels.
	SCORE:	2.0	2.0	2.0	4.0	5.0	3.0
	Improvement of Overall Environmental Quality	Soils on-site improved to industrial cleanup levels.	Soils on-site improved to industrial cleanup levels.	Soils on-site improved to industrial cleanup levels.	Soils on-site improved to industrial cleanup levels. Drums removed.	Soils on-site improved to industrial cleanup levels. Most contaminants removed.	Soils on-site improved to industrial cleanup levels.
	SCORE:	3.0	3.0	3.0	4.0	5.0	3.0
AVERAGE SCORE:		**3.2**	**3.6**	**3.8**	**3.6**	**4.0**	**3.2**

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Long-Term Effectiveness (WAC 173-340-360(5)(d)(ii))	Certainty of Success	Risks from geotechnical failure and rainfall infiltration leading to a release. Risk of a release of compounds from drums or soil reaching the water table is considered small based on ground water data. In the unlikely event that a release occurs, ground water cleanup would be difficult. These risks decrease with time as the zone settles and as it becomes less likely that drums containing free liquids are present. Risk of institutional controls failing.	Risk of a release of compounds from drums or soil reaching the water table is considered very small based on ground water data. In the unlikely event that a release occurs, ground water cleanup would be difficult. This risk decreases with time as it becomes less likely that drums containing free liquids are present. Risk of institutional controls failing.	Risk of a release of compounds from drums or soil is minimized by the installation of the horizontal barrier. In the unlikely event that a release occurs, ground water cleanup would be difficult. This risk decreases with time as it becomes less likely that drums containing free liquids are present. Risk of institutional controls failing.	Risk of a release of compounds from soil reaching the water table is considered very small based on ground water data. In the unlikely event that a release occurs, ground water cleanup would be difficult. Risk of institutional controls failing.	Risk of institutional controls failing.	Risk of a release of compounds from the on-site lined cell is considered very small. Risk of institutional controls failing.
	SCORE:	3.0	4.0	5.0	5.0	5.0	5.0
	Long-term Reliability	Deed restriction will control future use. Cap will need maintenance program. Care should be taken to monitor the geotechnical stability of the zone. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. On-site lined cell cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.
	SCORE:	3.0	4.0	4.0	4.0	5.0	4.0
	Magnitude of Residual Risk	All contamination will remain on-site.	All contamination will remain on-site.	All contamination will remain on-site.	Contaminants will remain in soil on-site.	Contaminants will remain in soil on-site at industrial cleanup standards.	All contamination will remain on-site.
	SCORE:	3.0	3.0	3.0	4.0	5.0	3.0

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Long-Term Effectiveness (continued)	Effectiveness of Controls Required to Manage Residual Substances	Deed restriction will control future use. Cap will need maintenance program. Care should be taken to monitor the geotechnical stability of the zone. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls.
	SCORE:	3.0	4.0	4.0	4.0	5.0	4.0
AVERAGE SCORE:		**3.0**	**3.8**	**4.0**	**4.3**	**5.0**	**4.0**
Short-Term Effectiveness (WAC) 173-340-360(5)(d)(iii))	Protection of Human Health and the Environment During Implementation	Based on the RI data, (i.e., no ground water impact) good short-term effectiveness is expected with the possible exception of physical hazards caused by geotechnical instability.	Based on the RI data, (i.e., no ground water impact) good short-term effective-ness is expected, with the practical elimination of precipitation percolating through the site.	Based on the RI data, (i.e., no ground water impact) good short-term effectiveness is expected with the practical elimination of precipitation percolating through the site.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason short-term effectiveness is unknown.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason short-term effectiveness is unknown.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into unknown conditions. For this reason short-term effectiveness is unknown.
	SCORE:	5.0	5.0	5.0	4.0	4.0	4.0
	Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards	Risks of a release from drums or soil is considered very small based on ground water data.	Risks of a release from drums or soil is considered very small based on ground water data.	Risks of a release from drums or soil is considered very small based on ground water data.	Risks of an uncontrolled release during intrusive operations into unknown conditions.	Risks of an uncontrolled release during intrusive operations into unknown conditions.	Risks of an uncontrolled release during intrusive operations into unknown conditions.
	SCORE:	5.0	5.0	5.0	4.0	4.0	4.0
AVERAGE SCORE:		**5.0**	**5.0**	**5.0**	**4.0**	**4.0**	**4.0**

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(D)(iv))	Adequacy of Alternative in Destroying Hazardous Substances	Not adequate.	Not adequate.	Not adequate.	Adequate. Wastes will be removed during remediation and subsequently destroyed. The contaminants in remaining soils will be treated through containment.	Adequate. Wastes and contaminated soils will be removed during remediation and subsequently destroyed.	Adequate. If present, wastes and soils containing free liquids will be taken off-site and destroyed during remediation. All other materials will be treated through containment.
	SCORE:	4.0	4.0	4.0	5.0	5.0	5.0
	Reduction or Elimination of Releases and Sources of Releases	None Wastes appear highly immobile based upon the RI data.	None Wastes appear highly immobile based upon the RI data.	None Mobility of wastes will be further reduced by the subsurface barriers.	Potential primary source (drums) will be removed.	Potential sources (drums and soil) will be removed.	None Mobility of wastes will be further reduced by the subsurface barriers.
	SCORE:	3.0	3.0	4.0	5.0	5.0	4.0
	Degree of Irreversibility of Treatment Process	Completely reversible.	Completely reversible.	Completely reversible.	Incineration of potential primary source is irreversible.	Incineration of potential source is irreversible.	Completely reversible.
	SCORE:	4.0	4.0	4.0	5.0	5.0	4.0
	Quantity of Treatment Residuals Generated	No treatment, all waste is residual.	No treatment, all waste is residual.	No treatment, all waste is residual.	Residuals will remain in soils.	Residuals will remain in soils at industrial cleanup levels.	No treatment, all waste is residual. Note: wastes containing free liquids will be removed so only solid residuals will remain.
	SCORE:	4.0	4.0	4.0	5.0	5.0	4.0
AVERAGE SCORE:		**3.8**	**3.8**	**4.0**	**5.0**	**5.0**	**4.3**

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Construct Vertical and Horizontal Subsurface Barriers* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative B-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Implementability (WAC 173-340-360(5)(d)(v))	Assessment of Technical Possibility	Minimal technical difficulties expected.	Minimal technical difficulties expected. Skilled personnel required to adequately design and install the new cap.	Minimal technical difficulties expected. Skilled personnel required to adequately design and install the new cap. Installation of horizontal and vertical subsurface barriers will require highly skilled personnel.	Intrusive operation, and transportation and incineration of waste requires highly skilled personnel.	Intrusive operation, and transportation and incineration of waste and soils requires highly skilled personnel. Given the type of waste in Zone B and the lack of contaminants in ground water, compliance levels should be reached with only a minimum of soil removal.	Intrusive operation, and requires highly skilled personnel. Although the data does not indicate the presence of free liquids, separation of wastes and soils containing free liquids may increase technical requirements of personnel. Given the type of waste in Zone B and the lack of contaminants in ground water, compliance levels should be reached with only a minimum of soil removal.
	SCORE:	5.0	5.0	4.0	3.0	3.0	3.0
	Availability of Necessary Off-Site Services and Facilities	Does not apply to this alternative.	Does not apply to this alternative.	Does not apply to this alternative.	Availability of transporters and daily capacity of the disposal facility may affect duration of the removal. Due to the waste characteristics, off-site incineration facilities may not be available.	Availability of transporters and daily capacity of the disposal facility may affect duration of the removal. Due to the waste characteristics, off-site incineration facilities may not be available.	Availability of transporters and daily capacity of the disposal facility may affect duration of the removal of wastes and soils containing free liquids.
	SCORE:	5.0	5.0	5.0	3.0	3.0	4.0
	Administrative and Regulatory Requirements	Easily met.	Easily met.	Easily met.	Presence of dioxins and herbicides in wastes may make administrative and regulatory requirements of incineration difficult or impossible to meet.	Presence of dioxins and herbicides in wastes may make administrative and regulatory requirements of incineration difficult or impossible to meet.	RCRA status and movement of waste, and siting requirements of the on-site cell may make administrative and regulatory requirements difficult.
	SCORE:	5.0	5.0	5.0	3.0	3.0	4.0
	Project Complexity	Relatively simple.	Relatively simple.	Most complex. Installation of horizontal subsurface barrier is technically challenging.	Complex. Intrusive operations into unknown conditions.	Complex. Intrusive operations into unknown conditions.	Complex. Intrusive operations into unknown conditions.
	SCORE:	5.0	5.0	3.0	4.0	4.0	4.0

Table 6-6
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Construct Vertical and Horizontal Subsurface Barriers* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative B-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Implementability (continued)	Monitoring Requirements	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Only protection, and performance monitoring required.	Protection, performance and confirmational monitoring required.
	SCORE:	4.0	4.0	4.0	4.0	5.0	4.0
	Access	Readily Available.	Readily Available.	Readily Available.	Readily Available.	Readily Available.	Readily Available.
	SCORE:	5.0	5.0	5.0	5.0	5.0	5.0
	Integration with Current Facility Operations	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is not common but several vendors are available.	This technology is common and several vendors are available. However, because of dioxin content, incineration facilities may not be available to accept waste from Zone B.	This technology is common and several vendors are available. However, because of dioxin content, incineration facilities may not be available to accept waste from Zone B.	This technology is common and several vendors are available.
	SCORE:	5.0	5.0	3.0	2.0	2.0	4.0
AVERAGE SCORE:		**4.9**	**4.9**	**4.1**	**3.4**	**3.6**	**4.0**
Cleanup Costs (WAC 173-340-360(5)(d)(vi))		$41,000	$122,000	$1,300,000	$7,400,000	$11,700,000	$4,600,000
SCORE:		**5.0**	**5.0**	**4.0**	**2.0**	**1.0**	**3.0**
Community Concerns (WAC 173-340-360(5)(d)(vii))		Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.
SCORE:		**5.0**	**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
TOTAL PERMANENCE SCORE:		**36.0**	**37.0**	**35.9**	**35.3**	**37.6**	**34.7**

Table 6-7
Restoration Time Frame
(WAC 173-340-360(6))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria	▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone B Cap*** ▪ ***Construct Vertical and Horizontal Subsurface Barriers*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum Removal and Off-Site Incineration*** ▪ ***Complete Alternative B-2 on Remaining Soils***	▪ ***Drum and Soil Removal to Cleanup Levels with Off-Site Incineration*** ▪ ***Implement Access and Institutional Controls***	▪ ***Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Restoration Time Frame SCORE:	Approximately 1.5 years. 5.0	Approximately 1.5 years. 5.0	Approximately 2 years. 4.0	Approximately 3 years. 3.0	Approximately 3.5 years. 2.0	Approximately 3.5 years. 2.0
Potential Risks to Human Health and the Environment (WAC 173-340-360(6)(a)(i)) SCORE:	Release of contaminants to ground water has not occurred and is considered unlikely in the future. Geotechnical risks and risks of a release due to rainfall infiltration will require monitoring. 4.0	Release of contaminants to ground water has not occurred and is considered unlikely in the future. 5.0	Release of contaminants to ground water has not occurred and is considered unlikely in the future. In addition, release to ground water is minimized by the horizontal barrier. 5.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 3.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 3.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 3.0
Practicability of Achieving a Shorter Restoration Time Frame (WAC 173-340-360(6)(a)(ii)) SCORE:	None 5.0	None 5.0	Alternatives B-1 or B-2 have a shorter time frame. 4.0	Alternatives B-1 or B-2 have a shorter time frame. 4.0	Alternatives B-1 or B-2 have a shorter time frame. 4.0	Alternatives B-1 or B-2 have a shorter time frame. 4.0
Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iii)) SCORE:	Agricultural uses of ground water could be impacted by an unlikely release. Potential percolation of rainfall through the zone increases this risk over B-2 or B-3. All other uses protected. 4.0	Agricultural uses of ground water could be impacted by an unlikely release. All other uses protected. 5.0	Agricultural uses of ground water could be impacted by an unlikely release. All other uses protected. 5.0	Agricultural uses of ground water could be impacted by a release during drum removal. All other uses protected. 3.0	Agricultural uses of ground water could be impacted by a release during drum and soil removal. All other uses protected. 3.0	Agricultural uses of ground water could be impacted by a release during drum and soil removal. All other uses protected. 3.0
Potential Future Uses of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iv)) SCORE:	Future agricultural uses of ground water might be impacted by an unlikely release. Potential percolation of rainfall through the zone increases this risk over B-2 or B-3. All other future uses protected. 4.0	Future agricultural uses of ground water might be impacted by an unlikely release. All other future uses protected. 5.0	Future agricultural uses of ground water might be impacted by an unlikely release. All other future uses protected. 5.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other future uses protected. 3.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other future uses protected. 3.0	Future agricultural uses of ground water might be impacted by a release during intrusive operations. All other future uses protected. 3.0

Table 6-8
Cleanup Technologies
(WAC 173-340-360(4)(a))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Option	*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Construct Vertical and Horizontal Subsurface Barriers* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative B-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Reuse or Recycling (WAC 173-340-360(4)(a)(i)) SCORE: 6	None --	None --	None --	None --	None --	None --
Destruction or Detoxification (WAC 173-340-360(4)(a)(ii)) SCORE: 5	None --	None --	None --	All wastes incinerated. 0.5	All wastes and soil incinerated. 0.55	All wastes containing free liquids (if any) incinerated. 0.1
Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals (WAC 173-340-360(4)(a)(iii)) SCORE: 4	None --	None --	None --	None --	None --	None --
Immobilization of Hazardous Substances (WAC 173-340-360(4)(a)(iv)) SCORE: 3	None --	None --	None --	None --	None --	None --
On-Site or Off-Site Disposal at an Engineered Facility to Minimize Future Release (WAC 173-340-360(4)(a)(v)) SCORE: 2	None --	None --	None --	Residual wastes after incineration will be disposed in an engineered cell off-site. 0.4	Residual wastes and soil after incineration will be disposed in an engineered cell off-site. 0.4	All wastes except those containing free liquids will be disposed in an engineered cell on-site. 0.9
Isolation or Containment with Attendant Engineering Controls (WAC 173-340-360(4)(a)(vi)) SCORE: 1	All wastes will be contained on-site. 1.0	All wastes will be contained on-site. 1.0	All wastes will be contained on-site. 1.0	Contaminated soils will be contained on-site 0.1	Soils at industrial cleanup levels will remain on-site. 0.05	None --
Institutional Controls and Monitoring (WAC 173-340-360(4)(a)(vii)) SCORE: 1/2	Yes 1.0	Yes 1.0	Yes 1.0	Yes 0.1	Yes 0.05	Yes 0.9
TOTAL TECHNOLOGIES SCORE:	**1.5**	**1.5**	**1.5**	**3.5**	**3.6**	**2.8**

Table 6-7
Restoration Time Frame
(WAC 173-340-360(6))
Zone B - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative B-1*	*Alternative B-2*	*Alternative B-3*	*Alternative B-4*	*Alternative B-5*	*Alternative B-6*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone B Cap* ▪ *Construct Vertical and Horizontal Subsurface Barriers* ▪ *Implement Access and Institutional Controls*	▪ *Drum Removal and Off-Site Incineration* ▪ *Complete Alternative B-2 on Remaining Soils*	▪ *Drum and Soil Removal to Cleanup Levels with Off-Site Incineration* ▪ *Implement Access and Institutional Controls*	▪ *Drum and Soil Removal to Cleanup Levels with Redisposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Availability of Alternative Water Supplies (WAC 173-340-360(6)(a)(v)) SCORE:	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0
Likely Effectiveness and Reliability of Institutional Controls (WAC 173-340-360(6)(a)(vi)) SCORE:	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0
Ability to Control and Monitor Migration of Hazardous Substances (WAC 173-340-360(6)(a)(vii)) SCORE:	Continued monitoring is expected. Release to ground water is unlikely but would be difficult to control. 5.0	Continued monitoring is expected. Release to ground water is unlikely but would be difficult to control. 5.0	Continued monitoring is expected. Release to ground water is unlikely but would be difficult to control. 5.0	Continued monitoring is expected. Uncontrolled releases may occur during drum removal. 4.0	Continued monitoring is expected. Uncontrolled releases may occur during drum removal. 4.0	Continued monitoring is expected. Uncontrolled releases may occur during drum removal. 4.0
Toxicity of Hazardous Substances Remaining at the Site (WAC 173-340-360(6)(a)(viii)) SCORE:	All contaminants will remain on-site. 2.0	All contaminants will remain on-site. 2.0	All contaminants will remain on-site. 2.0	Contaminants will remain in on-site soils at or below industrial cleanup standards. 4.0	Contaminants will remain in on-site soils at industrial cleanup standards. 5.0	All contaminants except those in free liquids will remain on-site. 3.0
Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site (WAC 173-340-360(6)(a)(ix)) SCORE:	None 0.0	None 0.0	None 0.0	None 0.0	N/A 0.0	None 0.0
TOTAL TIME FRAME SCORE:	**39.0**	**42.0**	**40.0**	**34.0**	**34.0**	**32.0**

6.6.3 Zones C and D

Tables 6-9 through 6-12 summarize the comparative analysis of remedial alternatives for Zones C and D. The scores vary from 79% of a perfect score for Alternative CD-5 to 87% of a perfect score for Alternative CD-3.

Alternatives CD-1, CD-2 and CD-3 received the highest scores and were within 1% of each other. As with Zone A, the scores show a trade-off in the potential risks and benefits associated with each of the alternatives. Implementation of CD-4 and CD-5 risk the uncontrolled release of hazardous dusts and/or vapors during intrusive operations. Implementation of CD-1, CD-2 and CD-3 risk a future release of hazardous substances from wastes. However, the waste has been in place for more than 20 years and there is no evidence of a release from Zones C and D that impacts groundwater. For this reason, the risks associated with leaving wastes in place are considered very small compared to disturbing the wastes.

Alternative CD-1 risks percolation of precipitation through wastes since the present cap installed at the zone is unreliable. The difference in scores between CD-2 and CD-3 is less than 1%. However, CD-3 costs more than four times as much as CD-2 to implement. Although CD-3 will be technically easy to implement, wastes within Zones C and D have not impacted groundwater so that completing CD-3 may have little or no benefit over completing CD-2. In this way, it is clear that the additional cost of completing CD-3 is substantial and disproportionate to the increase in the degree of protection provided by CD-3. For these reasons, CD-2 is selected as the preferred remedial alternative at Zones C and D.

Table 6-9
Threshold Requirements
(WAC 173-340-360(2))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		Alternative CD-1	Alternative CD-2	Alternative CD-3	Alternative CD-4	Alternative CD-5
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Compliance with Cleanup Standards		Yes	Yes	Yes	Yes	Yes
Compliance with Other Laws and Regulations	Compliance with Chemical-Specific ARARs	Yes	Yes	Yes	Yes	Yes
	Compliance with Action-Specific ARARs	Yes	Yes	Yes	Yes	Yes
	Compliance with Location-Specific ARARs	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.
	Compliance with Other Criteria, Advisories and Guidance	Yes	Yes	Yes	Yes	Yes
Monitoring	Compliance	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	To determine compliance, soil clearance samples will be required after SVE is completed.	To determine compliance, soil clearance samples will be required after SVE is completed.
	Performance	Performance of the cap will be monitored with regular inspections.	Performance of the cap will be monitored with regular inspections.	Performance of the cap will be monitored with regular inspections. Performance of SVE will be monitored until remediations are complete.	Performance of SVE will be monitored until remediations are complete.	Performance of SVE will be monitored until remediations are complete.

Table 6-10
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		Alternative CD-1	Alternative CD-2	Alternative CD-3	Alternative CD-4	Alternative CD-5
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b))		No further action required. WAC 173-340-700 (2,C)	No further action required. WAC 173-340-700 (2,C)	No further action required. WAC 173-340-700 (2,C)	No further action required. WAC 173-340-700 (2,C)	No further action required. WAC 173-340-700 (2,C)
SCORE:		**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c))		None. COCs degrade through natural attenuation.	None. COCs degrade through natural attenuation.	SVE separates COCs from the wastes and soil. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. COCs degrade through natural attenuation.	SVE separates COCs from the soil. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. COCs degrade through natural attenuation.	SVE separates COCs from the soil. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. COCs degrade through natural attenuation.
SCORE:		**4.0**	**4.0**	**5.0**	**5.0**	**5.0**
Overall Protectiveness of Human Health and the Environment (WAC 173-340-360(5)(d)(i)) Note: All Remedial Alternatives are Protective Since They All Attain Cleanup Levels and ARARs	Degree to Which Existing Risks are Reduced	Risks of a release from rainfall percolation will not be reduced. Risks of a release of COCs to ground water from soils is considered small but will not be addressed.	Risks of a release of COCs to ground water from soils is considered small but will not be addressed.	All risks addressed.	All risks addressed.	All risks addressed.
	SCORE:	3.0	4.0	5.0	5.0	5.0
	Time Required to Reduce Risk and Attain Cleanup Standards	Approximately 6 months. Please note: does not effect time required to clean up off-site ground water.	Approximately 1 year. Please note: does not effect time required to clean up off-site ground water.	Approximately 5 years. Please note: does not effect time required to clean up off-site ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time to clean up ground water.	Approximately 5 years. Please note: uncontrolled releases during intrusive operations may increase time to clean up ground water.
	SCORE:	5.0	4.0	3.0	3.0	3.0

Table 6-10
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		Alternative CD-1	Alternative CD-2	Alternative CD-3	Alternative CD-4	Alternative CD-5
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Overall Protectiveness of Human Health and the Environment (continued)	On- and Off-site Risks Resulting from Implementing Alternative	Because this alternative is non-intrusive, the community and workers will be protected from uncontrolled release of dusts and vapors during implementation of the remedy.	Because this alternative is non-intrusive, the community and workers will be protected from uncontrolled release of dusts and vapors during implementation of the remedy.	Because this alternative is non-intrusive, the community and workers will be protected from uncontrolled release of dusts and vapors during implementation of the remedy. However, some potentially hazardous vapors and carbons will be released during maintenance of the SVE system and transportation of spent carbons through the community poses risk.	Although best control technologies will be used, excavation will release some dust and vapors to the atmosphere. In addition, transportation of wastes and spent carbon through the community poses risk. Because this alternative is intrusive, workers and the community may be exposed to contaminants within the zones. Although it is considered unlikely, disturbing soils may change the soil matrix and result in a release to ground water. In addition, some potentially hazardous vapors and carbons will be released during maintenance of the SVE system.	Although best control technologies will be used, excavation will release some dust and vapors to the atmosphere. In addition, transportation of wastes and spent carbon through the community poses risk. Because this alternative is intrusive, workers and the community may be exposed to contaminants within the zones. Although it is considered unlikely, disturbing soils may change the soil matrix and result in a release to ground water. In addition, some potentially hazardous vapors and carbons will be released during maintenance of the SVE system.
	SCORE:	5.0	5.0	4.0	3.0	3.0
	Degree the Action may Perform to Higher Level than Cleanup Standards	Not applicable.	Not applicable.	The SVE system may cleanup volatile contaminants in soils to higher than industrial cleanup standards.	The SVE system may cleanup volatile contaminants in soils to higher than industrial cleanup standards.	The SVE system may cleanup volatile contaminants in soils to higher than industrial cleanup standards.
	SCORE:	4.0	4.0	5.0	5.0	5.0
	Improvement of Overall Environmental Quality	Soils on-site improved to industrial standards.	Soils on-site improved to industrial standards.	Soils on-site improved to industrial standards or better.	Soils on-site improved to industrial standards or better.	Soils on-site improved to industrial standards or better.
	SCORE:	4.0	4.0	5.0	5.0	5.0
AVERAGE SCORE:		**4.2**	**4.2**	**4.4**	**4.2**	**4.2**
Long-Term Effectiveness (WAC 173-340-360(5)(d)(ii))	Certainty of Success	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Present data indicates high probability of success. Risks that institutional controls fail.	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Present data indicates high probability of success. Risks that institutional controls fail.	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Present data indicates high probability of success. Risks that institutional controls fail.	Risk that soils will require an additional cap after SVE is completed. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils. Risks that institutional controls fail.	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Risk that soils will require an additional cap after SVE is completed. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils. Risks that institutional controls fail.

Table 6-10
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative CD-1*	*Alternative CD-2*	*Alternative CD-3*	*Alternative CD-4*	*Alternative CD-5*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
	SCORE:	5.0	5.0	5.0	4.0	4.0
	Long-term Reliability	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Location of the zone by a municipal landfill increases the reliability of controls.	Deed restriction will control future use. Lined cell will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls.
	SCORE:	4.0	4.0	4.0	5.0	4.0
	Magnitude of Residual Risk	All wastes remain on-site. COCs degrade through natural attenuation.	All wastes remain on-site. COCs degrade through natural attenuation.	Volatile contaminants in wastes and soils removed by SVE. COCs degrade through natural attenuation.	All wastes taken off-site. Volatile contaminants in soils removed by SVE. COCs in soils degrade through natural attenuation.	All wastes remain on-site. Volatile contaminants in soils removed by SVE. COCs degrade through natural attenuation.
	SCORE:	3.0	3.0	4.0	5.0	4.0
	Effectiveness of Controls Required to Manage Residual Substances	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation.	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation.	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs in soil degrade through natural attenuation.	Deed restriction will control future use. Lined cell will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation.
	SCORE:	4.0	4.0	4.0	5.0	4.0
AVERAGE SCORE		**4.0**	**4.0**	**4.3**	**4.8**	**4.0**
Short-Term Effectiveness (WAC 173-340-360(5)(d)(iii))	Protection of Human Health and the Environment During Construction	Based on the RI data good short-term effectiveness is expected. Effectiveness may be reduced by percolation through the waste.	Based on the RI data and the elimination of precipitation percolating through the waste, good short-term effectiveness is expected.	Based on the RI data and the elimination of precipitation percolating through the waste, good short-term effectiveness is expected.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into waste. For this reason short-term effectiveness is expected to be poor.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into waste. For this reason short-term effectiveness is expected to be poor.
	SCORE:	4.0	5.0	5.0	3.0	3.0
	Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards	Risks of a release from waste and soil is considered very small based on ground water data.	Risks of a release from waste and soil is considered very small based on ground water data.	Risks of a release from waste and soil is considered very small based on ground water data.	Risk of uncontrolled release of dust or vapors during intrusive operations. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils.	Risk of uncontrolled release of dust or vapors during intrusive operations. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils.
	SCORE:	5.0	5.0	5.0	4.0	40
AVERAGE SCORE:		**4.5**	**5.0**	**5.0**	**3.5**	**3.5**

Table 6-10
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		***Alternative CD-1***	***Alternative CD-2***	***Alternative CD-3***	***Alternative CD-4***	***Alternative CD-5***
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone CD Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone CD Cap*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal with Redisposal in an On-Site Lined Cell*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(d)(iv))	Adequacy of Alternative in Destroying Hazardous Substances SCORE:	Not adequate. All materials contained on-site. 3.0	Not adequate. All materials contained on-site. 3.0	Adequate. VOCs in wastes and soil will be removed and subsequently destroyed, all other materials will be contained on-site. 5.0	Adequate. VOCs in soil will be removed and subsequently destroyed, all other materials will be contained off-site. 5.0	Adequate. VOCs in soil will be removed and subsequently destroyed, all other materials will be contained on-site. 5.0
	Reduction or Elimination of Releases and Sources of Releases SCORE:	None Based on RI data wastes are not mobile. 4.0	None Based on RI data wastes are not mobile. 4.0	Little Based on RI data wastes are not mobile. VOCs remaining in wastes and soil will be minimized. 5.0	Little Based on RI data wastes are not mobile. VOCs remaining in soils will be minimized. 5.0	Little Based on RI data wastes are not mobile. VOCs remaining in soils will be minimized. 5.0
	Degree of Irreversibility of Treatment Process SCORE:	Completely reversible. 4.0	Completely reversible. 4.0	Incineration of COCs in soils is irreversible. 5.0	Incineration of COCs in soils is irreversible. 5.0	Incineration of COCs in soils is irreversible. 5.0
Permanent & Significant Reduction in Volume, Toxicity and Mobility of Hazardous Substances (continued)	Quantity of Treatment Residuals Generated SCORE:	No treatment, all waste is residual. 2.0	No treatment, all waste is residual. 2.0	All except VOCs removed from soil and waste by SVE. 4.0	Wastes will be removed. Residuals will include all contaminants in soil that are not removed by SVE. 5.0	All except VOCs removed from soil by SVE. 3.0
AVERAGE SCORE:		**3.3**	**3.3**	**4.8**	**5.0**	**4.5**
Implementability (WAC 173-340-360(5)(d)(v))	Assessment of Technical Possibility SCORE:	Minimal technical difficulties expected. Highly skilled personnel are not required. 5.0	Minimal technical difficulties expected. Skilled personnel are required to properly design and install the cap. 5.0	Minimal technical difficulties expected. Skilled personnel are required to properly design and install the cap and SVE system. 5.0	Excavation will require some dust and vapor control. Minimal technical difficulties expected. Skilled personnel are required to properly design and install the SVE system and transport wastes. 4.0	Excavation will require some dust and vapor control. Minimal technical difficulties expected. Skilled personnel are required to properly design and install the SVE system and lined cell. 4.0
	Availability of Necessary Off-Site Services and Facilities SCORE:	Does not apply to this alternative. 5.0	Does not apply to this alternative. 5.0	The need for disposal of small amounts of carbon is not expected to be a problem. 4.0	Volumes too small to be a concern. The need for disposal of small amounts of carbon is not expected to be a problem. 4.0	The need for small disposal of amounts of carbon is not expected to be a problem. 4.0

Table 6-10
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		Alternative CD-1	Alternative CD-2	Alternative CD-3	Alternative CD-4	Alternative CD-5
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Implementability (continued)	Administrative and Regulatory Requirements	Easily met.	Easily met.	Easily met.	Easily met.	RCRA status and movement of waste, and siting requirements of the on-site cell may make administrative and regulatory requirements difficult.
	SCORE:	5.0	5.0	5.0	5.0	4.0
	Project Complexity	Relatively simple.	Relatively simple.	Relatively simple.	Intrusive operations into wastes.	Intrusive operations into wastes.
	SCORE:	5.0	5.0	5.0	4.0	4.0
	Monitoring Requirements	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Only protection and performance monitoring required.	Protection, performance and confirmational monitoring required.
	SCORE:	4.0	4.0	4.0	5.0	4.0
	Access	Readily Available.	Readily Available.	Readily Available.	Readily Available.	Readily Available.
	SCORE:	5.0	5.0	5.0	5.0	5.0
	Integration with Current Facility Operations	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is common and several vendors are available.
	SCORE:	5.0	5.0	5.0	5.0	5.0
AVERAGE SCORE:		**4.9**	**4.9**	**4.7**	**4.6**	**4.3**
Cleanup Costs (WAC 173-340-360(5)(d)(vi))		$46,000	$208,000	$1,100,000	$5,700,000	$1,600,000
SCORE:		**5.0**	**4.0**	**3.0**	**1.0**	**2.0**
Community Concerns (WAC 173-340-360(5)(d)(vii))		Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.
SCORE:		**5.0**	**5.0**	**5.0**	**5.0**	**5.0**
TOTAL PERMANENCE SCORE:		**39.8**	**39.3**	**41.1**	**38.0**	**37.5**

Table 6-11
Restoration Time Frame
(WAC 173-340-360(6))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative CD-1*	*Alternative CD-2*	*Alternative CD-3*	*Alternative CD-4*	*Alternative CD-5*
Evaluation Criteria	▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone CD Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone CD Cap*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal with Redisposal in an On-Site Lined Cell*** ▪ ***Install SVE System*** ▪ ***Implement Access and Institutional Controls***
Restoration Time Frame SCORE:	Approximately 6 months. 5.0	Approximately 1 year. 4.0	Approximately 5 years. 3.0	Approximately 5 years. 3.0	Approximately 5 years. 3.0
Potential Risks to Human Health and the Environment (WAC 173-340-360(6)(a)(i)) SCORE:	Release of contaminants to ground water has not occurred and is considered unlikely in the future. 3.0	Release of contaminants to ground water has not occurred and is considered unlikely in the future. Maintenance of a new cap further minimizes this risk. 4.0	Release of contaminants to ground water has not occurred and is considered unlikely in the future. Maintenance of a new cap and SVE system further minimizes this risk. 5.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 2.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 2.0
Practicability of Achieving a Shorter Restoration Time Frame (WAC 173-340-360(6)(a)(ii)) SCORE:	None 5.0	Alternative CD-1 has a shorter time frame. 4.0	Alternatives CD-1 or CD-2 have a shorter time frame. 3.0	Alternatives CD-1 or CD-2 have a shorter time frame. 3.0	Alternatives CD-1 or CD-2 have a shorter time frame. 3.0
Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iii)) SCORE:	Agricultural uses of ground water unlikely to be impacted by a release. Potential percolation of precipitation through cap makes a release more likely than CD-2 or CD-3. All other uses protected. 4.0	Agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0	Agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0
Potential Future Uses of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iv)) SCORE:	Future agricultural uses of ground water unlikely to be impacted by a release. Potential percolation of precipitation through cap makes a release more likely than CD-2 or CD-3. All other uses protected. 4.0	Future agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Future agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Future agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0	Future agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0
Availability of Alternative Water Supplies (WAC 173-340-360(6)(a)(v)) SCORE:	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0

Table 6-11
Restoration Time Frame
(WAC 173-340-360(6))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	Alternative CD-1	Alternative CD-2	Alternative CD-3	Alternative CD-4	Alternative CD-5
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Likely Effectiveness and Reliability of Institutional Controls (WAC 173-340-360(6)(a)(vi)) SCORE:	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0
Ability to Control and Monitor Migration of Hazardous Substances (WAC 173-340-360(6)(a)(vii)) SCORE:	Continued monitoring is expected. If detected, migration of expected hazardous substances is easily controlled. 5.0	Continued monitoring is expected. If detected, migration of expected hazardous substances is easily controlled. 5.0	Continued monitoring is expected. If detected, migration of expected hazardous substances is easily controlled. 5.0	Continued monitoring is expected. If detected, migration of expected hazardous substances is easily controlled. 5.0	Continued monitoring is expected. If detected, migration of expected hazardous substances is easily controlled. 5.0
Toxicity of Hazardous Substances Remaining at the Site (WAC 173-340-360(6)(a)(viii)) SCORE:	COCs will remain in on-site soils and wastes at or below industrial cleanup standards. 4.0	COCs will remain in on-site soils and wastes at or below industrial cleanup standards. 4.0	COCs will remain in on-site soils and wastes at or below industrial cleanup standards. 4.0	COCs will remain in on-site soils at or below industrial cleanup standards. 5.0	COCs will remain in on-site soils at or below industrial cleanup standards. All wastes will be contained on-site without treatment. 4.0
Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site (WAC 173-340-360(6)(a)(ix)) SCORE:	Acetone is easily degraded in both soil and ground water. 5.0	Acetone is easily degraded in both soil and ground water. 5.0	Acetone is easily degraded in both soil and ground water. 5.0	Acetone is easily degraded in both soil and ground water. 5.0	Acetone is easily degraded in both soil and ground water. 5.0
TOTAL TIME FRAME SCORE:	**45.0**	**46.0**	**45.0**	**41.0**	**40.0**

Table 6-12
Cleanup Technologies
(WAC 173-340-360(4)(a))
Zone CD - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	***Alternative CD-1***	***Alternative CD-2***	***Alternative CD-3***	***Alternative CD-4***	***Alternative CD-5***
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone CD Cap* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Off-Site Disposal in a RCRA TSD or Solid Waste Landfill* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal with Redisposal in an On-Site Lined Cell* ▪ *Install SVE System* ▪ *Implement Access and Institutional Controls*
Reuse or Recycling (WAC 173-340-360(4)(a)(i)) SCORE: 6	None --	None --	None --	None --	None --
Destruction or Detoxification (WAC 173-340-360(5)(a)(ii)) SCORE: 5	COCs in wastes and soils destroyed through natural attenuation. 0.2	COCs in wastes and soils destroyed through natural attenuation. 0.2	COCs in wastes and soils destroyed. 0.2	COCs in soils destroyed. 0.1	COCs in soils destroyed. 0.1
Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals (WAC 173-340-360(4)(a)(iii)) SCORE: 4	None --	None --	None --	None --	None --
Immobilization of Hazardous Substances (WAC 173-340-360(4)(a)(iv)) SCORE: 3	None --	None --	None --	None --	None --
On-Site or Off-Site disposal at an Engineered Facility to Minimize Future Release (WAC 173-340-360(4)(a)(v)) SCORE: 2	None --	None --	None --	All wastes contained off-site in engineered facility. 0.8	All wastes contained on-site in engineered facility. 0.8
Isolation or Containment with Attendant Engineering Controls (WAC 173-340-360(4)(a)(vi)) SCORE: 1	All non-degradable wastes will be contained on-site. 0.8	All non-degradable wastes will be contained on-site. 0.8	All non-volatile COCs will be contained on-site. 0.8	Non-volatile contaminants will remain in soils. 0.1	Non-volatile contaminants will remain in soils. 0.1
Institutional Controls and Monitoring (WAC 173-340-360(4)(a)(vii)) SCORE: 1/2	Yes 0.8	Yes 0.8	Yes 0.8	Yes 0.1	Yes 0.9
TOTAL TECHNOLOGIES SCORE:	**2.2**	**2.2**	**2.2**	**2.3**	**2.7**

6.6.4 ZONE E

Tables 6-13 through 6-16 summarize the comparative analysis of remedial alternatives for Zone E. The scores vary from 66% of a perfect score for Alternative E-4 to 73% of a perfect score for Alternative E-2.

Alternatives E-1 and E-2 received the highest scores and were within 1% of each other. As with the previous zones, the scores show a trade-off in the potential risks and benefits associated with each of the alternatives. Implementation of E-3 and E-4 risks the uncontrolled release of hazardous dusts and/or vapors during intrusive operations. Implementation of E-1 and E-2 risks a future release of hazardous substances from wastes. However, the waste has been in place for more than 20 years and there is no evidence of a release from Zone E that impacts groundwater. For this reason, the risks associated with leaving wastes in place are considered very small compared to disturbing the wastes.

Alternative E-1 risks percolation of precipitation through wastes since the present cap installed at the zone is unreliable. Alternative E-2 scores the highest and therefore offers the highest degree of protection. For this reason, E-2 is selected as the preferred remedial alternative at Zone E.

Table 6-13
Threshold Requirements
(WAC 173-340-360(2))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Compliance with Cleanup Standards		Yes	Yes	Yes	Yes
Compliance with Other Laws and Regulations	Compliance with Chemical-Specific ARARs	Yes	Yes	Yes	Yes
	Compliance with Action-Specific ARARs	Yes	Yes	Yes	Yes
	Compliance with Location-Specific ARARs	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.
	Compliance with Other Criteria, Advisories and Guidance	Yes	Yes	Yes	Yes
Monitoring	Compliance	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	Compliance monitoring is complete since samples taken outside the existing cap show compliance.	To determine compliance, soil clearance samples will be required after zone excavation.	To determine compliance, soil clearance samples will be required after zone excavation.
	Performance	Performance of the cap will be monitored with regular inspections.	Performance of the cap will be monitored with regular inspections.	None	Performance of the cap will be monitored with regular inspections.

Table 6-14
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		***Alternative E-1***	***Alternative E-2***	***Alternative E-3***	***Alternative E-4***
Evaluation Criteria		▪ ***Maintain Existing Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Construct Zone E Cap*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal and Disposal Off-Site in a RCRA TSD*** ▪ ***Implement Access and Institutional Controls***	▪ ***Waste Removal and Disposal in an On-Site Lined Cell*** ▪ ***Implement Access and Institutional Controls***
Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b)) **SCORE:**		No further action required. WAC 173-340-700 (2,C) **5.0**	No further action required. WAC 173-340-700 (2,C) **5.0**	No further action required. **5.0**	No further action required. WAC 173-340-700 (2,C) **5.0**
Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c)) **SCORE:**		None **0.0**	None **0.0**	None **0.0**	None **0.0**
Overall Protectiveness of Human Health and the Environment (WAC-173-340-360(5)(d)(i)) Note: All Remedial Alternatives are Protective Since They All Attain Cleanup Levels and ARARs	Degree to Which Existing Risks are Reduced SCORE:	Risks of a release from rainfall percolation will not be reduced. Risks of a release of COCs to ground water from soils is considered small but will not be addressed. 3.0	Risks of a release of COCs to ground water from soils is considered small but will not be addressed. 4.0	All risks addressed. 5.0	All risks addressed. 5.0
	Time Required to Reduce Risk and Attain Cleanup Standards SCORE:	Approximately 6 months. Please note: does not effect time required to clean up off-site ground water. 5.0	Approximately 1 year. Please note: does not effect time required to clean up off-site ground water. 4.0	Approximately 1 year. Please note: uncontrolled releases during intrusive operations may increase time required to clean up ground water. 4.0	Approximately 1 year. Please note: uncontrolled releases during intrusive operations may increase time required to clean up ground water. 4.0
	On- and Off-site Risks Resulting from Implementing Alternative SCORE:	Because this alternative is non-intrusive, the community and workers will be protected from uncontrolled release of dusts and vapors during implementation of the remedy. 5.0	Because this alternative is non-intrusive, the community and workers will be protected from uncontrolled release of dusts and vapors during implementation of the remedy. 5.0	Although best control technologies will be used, excavation will release some dust and vapors to the atmosphere. In addition, transportation of wastes through the community poses risk. Because this alternative is intrusive, workers and the community may be exposed to contaminants within the zones. Although it is considered unlikely, disturbing soils may change the soil matrix and result in a release to ground water. 4.0	Although best control technologies will be used, excavation will release some dust and vapors to the atmosphere. Because this alternative is intrusive, workers and the community may be exposed to contaminants within the zones. Although it is considered unlikely, disturbing soils may change the soil matrix and result in a release to ground water. 4.0

Table 6-14
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
	Degree the Action may Perform to Higher Level than Cleanup Standards SCORE:	Not applicable. 0.0	Not applicable. 0.0	Not applicable. 0.0	Not applicable. 0.0
	Improvement of Overall Environmental Quality SCORE:	All wastes and impacted soil (if any) maintained on-site. 4.0	All wastes and impacted soil (if any) maintained on-site. 4.0	All wastes removed. All impacted soil (if any) maintained on-site. 5.0	All wastes and impacted soil (if any) maintained on-site. 4.0
AVERAGE SCORE:		**4.5**	**4.5**	**4.0**	**4.3**
Long-Term Effectiveness (WAC 173-340-360(5)(d)(ii))	Certainty of Success SCORE:	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Present data indicates high probability of success. Risks that institutional controls fail. 5.0	Risks due to direct exposure to wastes will require continued mitigation through maintenance of the cap. Present data indicates high probability of success. Risks that institutional controls fail. 5.0	Risk that soils will require an additional cap after removal is completed. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils. Risks that institutional controls fail. 4.0	Risk that soils will require an additional cap after removal is completed. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils. Risks that institutional controls fail. 4.0
	Long-term Reliability SCORE:	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls. 4.0	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability of controls. 4.0	Deed restriction will control future use. Location of the zone by a municipal landfill increases the reliability of controls. 5.0	Deed restriction will control future use. Location of the zone by a municipal landfill increases the reliability of controls. 5.0
	Magnitude of Residual Risk SCORE:	All wastes remain on-site. COCs degrade through natural attenuation. 4.0	All wastes remain on-site. COCs degrade through natural attenuation. 4.0	All wastes taken off-site. COCs in soils degrade through natural attenuation. 5.0	All wastes remain on-site. COCs degrade through natural attenuation. 4.0
	Effectiveness of Controls Required to Manage Residual Substances SCORE:	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation. 4.0	Deed restriction will control future use. Cap will need maintenance program. Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs degrade through natural attenuation. 4.0	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs in soil degrade through natural attenuation. 5.0	Location of the zone by a municipal landfill increases the reliability and effectiveness of institutional controls. COCs in soil degrade through natural attenuation. 4.0
AVERAGE SCORE:		**4.3**	**4.3**	**4.8**	**4.3**

Table 6-14
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Short-Term Effectiveness (WAC 173-340-360(5)(d)(iii))	Protection of Human Health and the Environment During Construction	Based on the RI data good short-term effectiveness is expected. Possible percolation of precipitation through the waste makes this alternative less reliable than E-2.	Based on the RI data and the elimination of precipitation percolating through the waste, good short-term effectiveness is expected.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into waste. For this reason short-term effectiveness is expected to be poor.	As noted above, increased risks to human health and the environment are expected due to intrusive operations into waste. For this reason short-term effectiveness is expected to be poor.
	SCORE:	4.0	5.0	3.0	3.0
	Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards	Risks of a release from waste and soil is considered very small based on ground water data.	Risks of a release from waste and soil is considered very small based on ground water data.	Risk of uncontrolled release of dust or vapors during intrusive operations. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils.	Risk of uncontrolled release of dust or vapors during intrusive operations. Risk (although small) that changes in the soil matrix may lead to a release of contamination from soils.
	SCORE:	5.0	5.0	4.0	4.0
AVERAGE SCORE:		**4.5**	**5.0**	**3.5**	**3.5**
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(d)(iv))	Adequacy of Alternative in Destroying Hazardous Substances	Not adequate. All materials contained on-site.	Not adequate. All materials contained on-site.	Not adequate. All materials contained off-site.	Not adequate. All materials contained on-site.
	SCORE:	0.0	0.0	0.0	0.0
	Reduction or Elimination of Releases and Sources of Releases	None Based on RI data, wastes are not mobile.	None Based on RI data, wastes are not mobile.	None Based on RI data, wastes are not mobile.	None Based on RI data, wastes are not mobile.
	SCORE:	0.0	0.0	0.0	0.0
	Degree of Irreversibility of Treatment Process	Completely revisable.	Completely revisable.	Completely revisable.	Completely revisable.
	SCORE:	0.0	0.0	0.0	0.0
	Quantity of Treatment Residuals Generated	No treatment, all waste is residual.	No treatment, all waste is residual.	No treatment, all waste is residual.	No treatment, all waste is residual.
	SCORE:	0.0	0.0	0.0	0.0
AVERAGE SCORE:		**0.0**	**0.0**	**0.0**	**0.0**

Table 6-14
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives		*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria		▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Implementability (WAC 173-340-360(5)(d)(v))	Assessment of Technical Possibility	Minimal technical difficulties expected. Highly skilled personnel not required.	Minimal technical difficulties expected. Skilled personnel required to properly design and install the cap.	Excavation may require some dust control. Minimal technical difficulties expected. Skilled personnel are required. Given the type of waste in Zone E and the lack of contaminants in ground water, compliance levels should be reached with only a minimum of soil removal.	Excavation may require some dust control. Minimal technical difficulties expected. Skilled personnel are required. Given the type of waste in Zone E and the lack of contaminants in ground water, compliance levels should be reached with only a minimum of soil removal.
	SCORE:	5.0	5.0	4.0	4.0
	Availability of Necessary Off-Site Services and Facilities	Does not apply to this alternative.	Does not apply to this alternative.	Percent of waste to be stabilized, availability of transporters and daily capacity of the disposal facility may affect duration of the removal.	Does not apply to this alternative.
	SCORE:	5.0	5.0	4.0	5.0
	Administrative and Regulatory Requirements	Easily met.	Easily met.	Easily met.	RCRA status and movement of waste, and siting requirements of the on-site cell may make administrative and regulatory requirements difficult.
	SCORE:	5.0	5.0	5.0	4.0
	Project Complexity	Relatively simple.	Relatively simple.	Intrusive operations into wastes.	Intrusive operations into wastes.
	SCORE:	5.0	5.0	4.0	4.0
	Compliance Monitoring Requirements	Protection, performance and confirmational monitoring required.	Protection, performance and confirmational monitoring required.	Only protection and performance monitoring required.	Protection, performance and confirmational monitoring required.
	SCORE:	4.0	4.0	5.0	4.0
	Access	Readily Available.	Readily Available.	Readily Available.	Readily Available.
	SCORE:	5.0	5.0	5.0	5.0
	Integration with Current Facility Operations	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is common and several vendors are available.	This technology is common and several vendors are available.
	SCORE:	5.0	5.0	5.0	5.0
AVERAGE SCORE:		**4.9**	**4.9**	**4.6**	**4.4**
Cleanup Costs (WAC 173-340-360(5)(d)(vi))		$46,000	$240,000	$2,600,000	$1,200,000
SCORE:		**5.0**	**4.0**	**3.0**	**2.0**

Table 6-14
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Community Concerns (WAC 173-340-360(5)(d)(vii))	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.
SCORE:	**5.0**	**5.0**	**5.0**	**5.0**
TOTAL PERMANENCE SCORE:	**32.0**	**31.5**	**29.4**	**27.6**

Table 6-15
Restoration Time Frame
(WAC 173-340-360(6))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Restoration Time Frame SCORE:	Approximately 6 months. 5.0	Approximately 1 year. 4.0	Approximately 1 year. 4.0	Approximately 1 year. 4.0
Potential Risks to Human Health and the Environment (WAC 173-340-360(6)(a)(i)) SCORE:	Release of contaminants to ground water has not occurred and is considered unlikely in the future. 4.0	Release of contaminants to ground water has not occurred and is considered unlikely in the future. Maintenance of a new cap further minimizes this risk. 5.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 3.0	Intrusive work increases risks to human health and the environment from uncontrolled releases. 3.0
Practicability of Achieving a Shorter Restoration Time Frame (WAC 173-340-360(6)(a)(ii)) SCORE:	None 5.0	Alternative E-1 has a shorter time frame. 4.0	Alternative E-1 has a shorter time frame. 4.0	Alternative E-1 has a shorter time frame. 4.0
Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iii)) SCORE:	Agricultural uses of ground water unlikely to be impacted by a release. Potential percolation of precipitation through cap makes a release more likely than E-2. All other uses protected. 4.0	Agricultural uses of ground water unlikely to be impacted by a release. All other uses protected. 5.0	Agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0	Agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0
Potential Future Uses of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iv)) SCORE:	Future agricultural uses of ground water unlikely to be impacted by a release. Potential percolation of precipitation through cap makes a release more likely than E-2. All other uses protected. 4.0	Future agricultural uses of ground water unlikely to be impacted by a release. All other planned uses protected. 5.0	Future agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0	Future agricultural uses of ground water unlikely to be impacted by a release. Potential for a release is increased because of intrusive operations. All other uses protected. 4.0
Availability of Alternative Water Supplies (WAC 173-340-360(6)(a)(v)) SCORE:	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0	Public water is available. 5.0
Likely Effectiveness and Reliability of Institutional Controls (WAC 173-340-360(6)(a)(vi)) SCORE:	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0	Institutional controls are expected to be highly reliable because the site is a large municipal landfill. 5.0

Table 6-15
Restoration Time Frame
(WAC 173-340-360(6))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	*Alternative E-1*	*Alternative E-2*	*Alternative E-3*	*Alternative E-4*
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Ability to Control and Monitor Migration of Hazardous Substances (WAC 173-340-360(6)(a)(vii)) SCORE:	Continued monitoring is expected. 4.0	Continued monitoring is expected. 4.0	N/A 5.0	Continued monitoring is expected. 4.0
Toxicity of Hazardous Substances Remaining at the Site (WAC 173-340-360(6)(a)(viii)) SCORE:	COCs will remain in on-site soils and wastes at industrial cleanup standards. 4.0	COCs will remain in on-site soils and wastes at industrial cleanup standards. 4.0	COCs will remain in on-site soils at industrial cleanup standards. 5.0	COCs will remain in on-site soils at industrial cleanup standards. All wastes will be contained on-site without treatment. 4.0
Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site (WAC 173-340-360(6)(a)(ix)) SCORE:	None 0.0	None 0.0	None 0.0	None 0.0
TOTAL TIME FRAME SCORE:	**40.0**	**41.0**	**39.0**	**37.0**

Table 6-16
Cleanup Technologies
(WAC 173-340-360(4)(a))
Zone E - Comparative Analysis of Remedial Alternatives

Remedial Alternatives	***Alternative E-1***	***Alternative E-2***	***Alternative E-3***	***Alternative E-4***
Evaluation Criteria	▪ *Maintain Existing Cap* ▪ *Implement Access and Institutional Controls*	▪ *Construct Zone E Cap* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal Off-Site in a RCRA TSD* ▪ *Implement Access and Institutional Controls*	▪ *Waste Removal and Disposal in an On-Site Lined Cell* ▪ *Implement Access and Institutional Controls*
Reuse or Recycling (WAC 173-340-360(4)(a)(i)) SCORE: 6	None --	None --	None --	None --
Destruction or Detoxification (WAC 173-340-360(4)(a)(ii)) SCORE: 5	None --	None --	None --	None --
Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals (WAC 173-340-360(4)()(iii)) SCORE: 4	None --	None --	None --	None --
Immobilization of Hazardous Substances (WAC 173-340-360(4)(a)(iv)) SCORE: 3	None --	None --	Removed waste may be stabilized prior to off-site disposal. 0.5	None --
On-Site or Off-Site Disposal at an Engineered Facility to Minimize Future Release (WAC 173-340-360(4)(a)(v)) SCORE: 2	None --	None --	All waste will be contained in an engineered facility off-site. 0.45	All waste will be contained in an engineered facility on-site. 0.95
Isolation or Containment with Attendant Engineering Controls (WAC 173-340-360(4)(a)(vi)) SCORE: 1	All waste and soils contained on-site. 1.0	All waste and soils contained on-site. 1.0	Contaminants contained in soils. 0.05	Contaminants contained in soils. 0.05
Institutional Controls and Monitoring (WAC 173-340-360(4)(a)(vii)) SCORE: 1/2	Yes 1.0	Yes 1.0	None --	Yes 1.0
TOTAL TECHNOLOGIES SCORE:	**1.5**	**1.5**	**2.5**	**2.5**

6.6.5 MUNICIPAL LANDFILL

The preferred remedy for the Municipal Landfill is described in the Pasco Sanitary Landfill Closure Plan and was accepted by Ecology in 1996. The remedy includes a conceptual cap design and active landfill gas extraction.

6.6.6 GROUND WATER

Tables 6-17 through 6-20 summarize the comparative analysis of remedial alternatives for Ground Water. The scores vary from 83% of a perfect score for Alternative GW-1 to 92% of a perfect score for Alternative GW-3.

Alternatives GW-2, GW-3 and GW-4 received the highest scores and were within 1% of each other. The scores show a trade-off in the potential risks and benefits associated with each of these three alternatives. Implementation of GW-4 risks the disruption of present agricultural or residential activities down-gradient of the Pasco Sanitary Landfill. Implementation of GW-2 risks a longer groundwater restoration period. Implementation of GW-3 and GW-4 offer quicker remediation of the groundwater and will result in the destruction of more hazardous substances.

The score for each alternative is proportional to the degree of protection that the alternative will provide to workers, the community and the environment. The increase in this protection between GW-2, GW-3 and GW-4 is less than 1%. Subtracting out the effect of cost on the scoring, the difference increases to close to 2% between GW-2 and either GW-3 or GW-4. However, while GW-3 represents an increase in protection of 2%, it costs more than three times as much as GW-2. In this way, it is clear that the increased cost between GW-2 and GW-3 is substantial and disproportionate to the increase in the degree of protection provided by GW-3. GW-4 has the same score as GW-3 without consideration of cost. Since GW-4 is more than five times more expensive than GW-2, it's cost is also substantial and disproportionate to the increase in the degree of protection provided by GW-4.

Appendix B presents the calculation of pounds of COCs that are expected to be destroyed in Alternatives GW-2, GW-3 and GW-4. During implementation of GW-2, destruction of one pound of COCs in groundwater will cost approximately $1,200. Implementation of GW-2 will result in destruction of more than 92% of the COCs in groundwater. In comparison, implementation of GW-3 and GW-4 will result in additional destruction of approximately 3%

and 4% of the COCs in groundwater at $7,300 and $6,300 per pound of COCs respectively. For these reasons, GW-2 is selected as the preferred remedial alternative for groundwater.

Table 6-17
Threshold Requirements
(WAC 173-340-360(2))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*
Compliance with Cleanup Standards		Yes	Yes	Yes	Yes
Compliance with Other Laws and Regulations	Compliance with Chemical-Specific ARARs	Yes	Yes	Yes	Yes
	Compliance with Action-Specific ARARs	Yes	Yes	Yes	Yes
	Compliance with Location-Specific ARARs	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.	There are no location-specific ARARs at the site.
	Compliance with Other Criteria, Advisories and Guidance	Yes	Yes	Yes	Yes
Monitoring	Compliance	Ground water monitoring will be required to determine compliance. Compliance will be achieved on-site and off-site as a result of natural attenuation over an extended period of time as the SVE and Landfill Gas collection system removes the source of COCs.	Ground water monitoring will be required to determine compliance. Time to reach compliance is significantly reduced over GW-1 by treating on-site ground water so that ground water leaving the site is either in compliance or close to compliance levels.	Ground water monitoring will be required to determine compliance. Time to reach compliance may be reduced from GW-2 by treating all ground water leaving the site to compliance levels.	Ground water monitoring will be required to determine compliance. Time to reach compliance may be reduced from GW-3 by treating all impacted ground water to compliance levels.
	Performance	Performance monitoring will be performed quarterly or as required until compliance levels are reached.	Performance monitoring will be performed quarterly or as required until compliance levels are reached.	Performance monitoring will be performed quarterly or as required until compliance levels are reached.	Performance monitoring will be performed quarterly or as required until compliance levels are reached.

Table 6-18
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*
Degree to which Cleanup Standards can be met without Further Action being Required (WAC 173-340-360(5)(b))		Cleanup standards will be met after a period (tens of years) of natural attenuation (longer than GW-2).	Cleanup standards will be met in a relatively short period of time (less than 10 years) at the property boundary. Elsewhere cleanup standards will be met after a period (tens of years) of natural attenuation (longer than GW-3).	Cleanup standards will be met in a relatively short period of time (less than 5 years) at the property boundary. Elsewhere cleanup standards will be met after a period (tens of years) of natural attenuation (longer than GW-4).	Cleanup standards will be met in the shortest period of time (less than 10 years).
SCORE:		**2.0**	**3.0**	**4.0**	**5.0**
Use of Technologies which Reuse, Recycle, Destroy or Detoxify Hazardous Substances (WAC 173-340-360(5)(c))		Natural fate processes will gradually destroy and dilute the COCs.	NoVOCs removes COCs from the ground water. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. Natural fate process will gradually destroy and dilute the remaining COCs. More than 92% of COC mass destroyed.	NoVOCs removes COCs from more of the ground water than GW-2. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. Natural fate process will gradually destroy and dilute the remaining COCs. Additional mass of COCs destoryed over GW-2 is not significant.	NoVOCs removes COCs from the most ground water. Carbon collects the COCs and recycling the carbon ultimately destroys the COCs. Natural fate process will gradually destroy and dilute the remaining COCs. Additional mass of COCs destoryed over GW-2 is not significant.
SCORE:		**4.0**	**5.0**	**5.0**	**5.0**
Overall Protectiveness of Human Health and the Environment (WAC 173-340-360(5)(d)(i)) Note: All Remedial Alternatives are Protective Since They All Attain Cleanup Levels and ARARs	Degree to Which Existing Risks are Reduced.	Risks are all addressed by exposure pathway elimination and natural attenuation.	Risks are all addressed by removal of COCs from most impacted ground water, exposure pathway elimination, and natural attenuation.	Risks are all addressed by removal of COCs from ground water, exposure pathway elimination, and natural attenuation.	Risks are all addressed by active remediation of all impacted ground water above MCLs and natural attenuation.
	SCORE:	5.0	5.0	5.0	5.0
Overall Protectiveness of Human Health and the Environment	Time Required to Reduce Risk and Attain Cleanup Standards	Tens of years (longest).	Tens of years (shorter than GW-1).	Tens of years (shorter than GW-2).	Less than 10 years (shortest).
(continued)	SCORE:	2.0	3.0	4.0	5.0

Table 6-18
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*
	On- and Off-site Risks Resulting from Implementing Alternative	Households with affected wells have been placed on public water. Low levels of COCs leaving the site are present in water that is used for irrigation. These small amounts of COCs are readily stripped into the atmosphere during irrigation. Because this alternative is non-intrusive, workers will be protected from direct exposure to contaminants in the ground water.	Households with affected wells have been placed on public water. Low levels of COCs leaving the site are present in water that is used for irrigation. These small amounts of COCs are readily stripped into the atmosphere during irrigation. Limited exposures to COCs in vapor or spent carbon may occur during remediation.	Households with affected wells have been placed on public water. Low levels of COCs leaving the site are present in water that is used for irrigation. These small amounts of COCs are readily stripped into the atmosphere during irrigation. Limited exposures to COCs in vapor or spent carbon may occur during remediation.	Households with affected wells have been placed on public water. Low levels of COCs leaving the site are present in water that is used for irrigation. These small amounts of COCs are readily stripped into the atmosphere during irrigation. Limited exposures to COCs in vapor or spent carbon may occur during remediation.
	SCORE:	5.0	4.0	4.0	4.0
	Degree the Action may Perform to Higher Level than Cleanup Standards	Natural attenuation alone has not been shown to be effective at performing to a higher level than cleanup standards at this site.	NoVOCs treatment of the ground water from Zone A may reduce COCs below Cleanup Standards based on data to date.	NoVOCs treatment of the ground water from Zone A and Municipal Solid Waste Landfill may reduce COCs below Cleanup Standards based on data to date.	NoVOCs treatment of the ground water from Zone A, the Municipal Solid Waste Landfill and the off-site ground water plume may reduce COCs below Cleanup Standards based on data to date.
	SCORE:	2.0	3.0	4.0	5.0
	Improvement of Overall Environmental Quality	The most dilution will occur in this alternative resulting in the lowest environmental quality.	Area of impact limited by controlling the plume.	Area of impact limited by controlling the plume.	Best improvement in environmental quality results from treating all ground water plume above MCLs.
	SCORE:	3.0	4.0	4.0	5.0
AVERAGE SCORE:		**3.4**	**3.8**	**4.2**	**4.8**
Long-Term Effectiveness (WAC 173-340-360(5)(d)(ii))	Certainty of Success	Over time, risks from COCs in ground water will be reduced to acceptable levels through natural attenuation as the SVE and Landfill Gas collection systems remove the source of COCs and the Zone caps eliminate precipitation percolating through the waste. Success is less certain without active treatment in GW-2.	Operation of NoVOCs close to Zone A makes this alternative more likely to be successful.	Operation of NoVOCs close to Zone A makes this alternative more likely to be successful. Increase in certainty over GW-2 is not significant.	Operation of NoVOCs close to Zone A makes this alternative more likely to be successful. Increase in certainty over GW-2 is not significant.
	SCORE:	4.0	5.0	5.0	5.0

Table 6-18
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ ***Ground Water Monitoring*** ▪ ***Provide Alternate Receptor Water Supply*** ▪ ***Implement Institutional Controls***	▪ ***NoVOCs Treatment of the Ground Water from Zone A*** ▪ ***Alternative GW-1*** ▪ ***Implement Institutional Controls***	▪ ***NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill*** ▪ ***Alternative GW-1*** ▪ ***Implement Institutional Controls***	▪ ***NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume*** ▪ ***Alternative GW-1*** ▪ ***Implement Institutional Controls***
	Long-term Reliability	Deed restrictions will control future use of the Pasco Sanitary Landfill property. Public water will continue to be supplied to households with impacted wells. Institutional controls will be required for the extent of the impacted ground water.	Deed restrictions will control future use of the Pasco Sanitary Landfill property. Public water will continue to be supplied to households with impacted wells. Institutional controls will be required for the extent of the impacted ground water.	Deed restrictions will control future use of the Pasco Sanitary Landfill property. Public water will continue to be supplied to households with impacted wells. Institutional controls will be required for the extent of the impacted ground water.	Deed restrictions will control future use of the Pasco Sanitary Landfill property. Public water will continue to be supplied to households with impacted wells. Institutional controls will be required for the extent of the impacted ground water.
	SCORE:	5.0	5.0	5.0	5.0
	Magnitude of Residual Risk	At the end of implementation, residual risk will be very small.	At the end of implementation, residual risk will be very small.	At the end of implementation, residual risk will be very small.	At the end of implementation, residual risk will be very small.
	SCORE:	5.0	5.0	5.0	5.0
	Effectiveness of Controls Required to Manage Residual Substances	NA	NA	NA	NA
	SCORE:	5.0	5.0	5.0	5.0
AVERAGE SCORE:		**4.8**	**5.0**	**5.0**	**5.0**

Short-Term Effectiveness (WAC 173-340-360(5)(d)(iii))	Protection of Human Health and the Environment During Construction	Good short-term effectiveness is expected since significant exposure pathways have been eliminated.	Good short-term effectiveness is expected since significant exposure pathways have been eliminated.	Good short-term effectiveness is expected since significant exposure pathways have been eliminated.	Good short-term effectiveness is expected since significant exposure pathways have been eliminated.
	SCORE:	5.0	5.0	5.0	5.0
	Degree of Risk to Human Health and the Environment Prior to Attainment of Cleanup Standards	Significant exposure pathways have been eliminated.	Significant exposure pathways have been eliminated.	Significant exposure pathways have been eliminated.	Significant exposure pathways have been eliminated.
	SCORE:	5.0	5.0	5.0	5.0
AVERAGE SCORE:		**5.0**	**5.0**	**5.0**	**5.0**

Table 6-18
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (WAC 173-340-360(5)(d)(iv))	Adequacy of Alternative in Destroying Hazardous Substances	Less adequate. Dilution instead of destruction may be a significant fate process.	Adequate. Significant portion of COCs will be destroyed.	Adequate. Significant portion of COCs will be destroyed.	Adequate. Significant portion of COCs will be destroyed.
	SCORE:	4.0	5.0	5.0	5.0
	Reduction or Elimination of Releases and Sources of Releases	Releases and sources not affected. These issues are addressed by SVE and capping Zone A and active extraction and capping the Municipal Landfill.	Releases and sources not affected. These issues are addressed by SVE and capping Zone A and active extraction and capping the Municipal Landfill.	Releases and sources not affected. These issues are addressed by SVE and capping Zone A and active extraction and capping the Municipal Landfill.	Releases and sources not affected. These issues are addressed by SVE and capping Zone A and active extraction and capping the Municipal Landfill.
	SCORE:	0.0	0.0	0.0	0.0
	Degree of Irreversibility of Treatment Process	Some COCs will be destroyed through natural processes.	Most COCs will be destroyed by treatment.	Destruction similar to GW-2.	Destruction similar to GW-2.
	SCORE:	4.0	5.0	5.0	5.0
Permanent Reduction of Toxicity, Mobility and Volume of the Hazardous Substances (continued)	Quantity of Treatment Residuals Generated	Given enough time, minimal concentrations of COCs at or below cleanup levels, will probably remain after natural attenuation. However, dilution will not change the mass of the remaining COCs.	Minimal quantities of COCs, below cleanup levels, will remain after natural attenuation and treatment.	Minimal quantities of COCs, below cleanup levels, will remain after natural attenuation and treatment.	Minimal quantities of COCs, below cleanup levels, will remain after natural attenuation and treatment.
	SCORE:	4.0	5.0	5.0	5.0
AVERAGE SCORE:		**3.0**	**3.8**	**3.8**	**3.8**
Implementability (WAC 173-340-360(5)(d)(v))	Assessment of Technical Possibility	Minimal technical difficulties expected. Highly skilled personnel are not required.	Installation and operation of the NoVOCs system requires skilled labor. Availability of carbon is an issue but based upon past experiences availability is expected to be good.	Installation and operation of the NoVOCs system requires skilled labor. Availability of carbon is an issue but based upon past experiences availability is expected to be good.	Installation and operation of the NoVOCs system requires skilled labor. Availability of carbon is an issue but based upon past experiences availability is expected to be good. Installation off-site will disrupt use of a large agricultural area for an extended period of time.
	SCORE:	5.0	4.0	4.0	3.0
	Availability of Necessary Off-Site Services and Facilities	N/A	Availability for spent carbon is expected to be good.	Availability for spent carbon is expected to be good.	Availability for spent carbon is expected to be good.

Table 6-18
Relative Permanence of Alternatives
(WAC 173-340-360(3)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative		*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria		▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1* ▪ *Implement Institutional Controls*
	SCORE:	5.0	5.0	5.0	5.0
Implementability (continued)	Administrative and Regulatory Requirements	Continued releases may pose difficult administrative and regulatory requirements.	Easily met.	Easily met.	Easily met.
	SCORE:	4.0	5.0	5.0	5.0
	Project Complexity	Simplest alternative.	More complex than GW-1.	More complex than GW-2.	Most complex.
	SCORE:	5.0	4.0	3.0	2.0
	Compliance Monitoring Requirements	Protection, performance and confirmation monitoring required.	Protection, performance and confirmation monitoring required.	Protection, performance and confirmation monitoring required.	Protection, performance and confirmation monitoring required.
	SCORE:	5.0	5.0	5.0	5.0
	Access	Readily Available.	Readily Available.	Readily Available.	Difficult or uncertain to obtain.
	SCORE:	5.0	5.0	5.0	4.0
	Integration with Current Facility Operations	Easily integrates with current operations.	Easily integrates with current operations.	Easily integrates with current operations.	May not be compatible with agricultural operations.
	SCORE:	5.0	5.0	5.0	4.0
AVERAGE SCORE:		**4.9**	**4.7**	**4.6**	**4.0**
Cleanup Costs (WAC 173-340-360(5)(d)(vi))		$5,400,000	$8,600,000	$25,000,000	$79,000,000
SCORE:		**5.0**	**4.0**	**3.0**	**2.0**
Community Concerns (WAC 173-340-360(5)(d)(vii))		Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.	Local Community Concerns will be addressed in a comprehensive public participation outreach plan as part of the remedial workplan. Once community concerns are expressed, this criterion will be reevaluated.
SCORE:		**5.0**	**5.0**	**5.0**	**5.0**
TOTAL PERMANENCE SCORE:		**37.0**	**39.3**	**39.5**	**39.6**

Table 6-19
Restoration Time Frame
(WAC 173-340-360(6))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative / *Evaluation Criteria*	*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
	▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1*
Restoration Time Frame SCORE:	Tens of years (longest). 2.0	Tens of years (shorter than GW-1). 3.0	Tens of years (shorter than GW-2). 4.0	Less than 10 years (shortest). 5.0
Potential Risks to Human Health and the Environment (WAC 173-340-360(6)(a)(i)) SCORE:	Risks of a failure of institutional controls during the restoration time frame or that a contaminant may be released that is not readily attenuated is considered unlikely given past data at the site, but is greater than other alternatives. 4.0	Risks of a failure of institutional controls during the restoration time frame or that a contaminant may be released that is not readily attenuated or treated by NoVOCS is considered unlikely given past data at the site. 5.0	Risks of a failure of institutional controls during the restoration time frame or that a contaminant may be released that is not readily attenuated or treated by NoVOCS is considered unlikely given past data at the site. Concentrations leaving the site will be similar to those in GW-2. 5.0	Risks of a failure of institutional controls during the restoration time frame or that a contaminant may be released that is not readily attenuated or treated by NoVOCS is considered unlikely given past data at the site. Concentrations treated off-site will be treated to a level close to those in GW-2. 5.0
Practicability of Achieving a Shorter Restoration Time Frame (WAC 173-340-360(6)(a)(ii)) SCORE:	Alternative A-2 offers a practicable alternative approach to a shorter restoration time frame. 4.0	No shorter practicable alternative. 5.0	No shorter practicable alternative. 5.0	No shorter practicable alternative. 5.0
Current Use of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iii)) SCORE:	Agricultural use of ground water unlikely to be impacted, but risk is greater than GW-2 or GW-3. Drinking water uses protected. 4.0	Agricultural use of ground water less likely to be impacted than in GW-1. Drinking water uses protected. 5.0	Similar to GW-2. 5.0	Access issues and placement of equipment every 750 feet throughout the area of impacted ground water above MCLs will likely affect current agricultural uses of surrounding areas. 3.0
Potential Future Uses of the Site, Surrounding Areas and Associated Resources that are, or may be, Affected by Releases from the Site (WAC 173-340-360(6)(a)(iv)) SCORE:	Future agricultural use of ground water unlikely to be impacted, but risk is greater than other alternatives. Drinking water uses protected. 4.0	Future agricultural use of ground water less likely to be impacted than in GW-1. Drinking water uses protected. 5.0	Similar to GW-2. 5.0	Similar to GW-2. 5.0
Availability of Alternative Water Supplies (WAC 173-340-360(6)(a)(v)) SCORE:	Drinking water is available. 5.0	Drinking water is available. 5.0	Drinking water is available. 5.0	Drinking water is available. 5.0

Table 6-19
Restoration Time Frame
(WAC 173-340-360(6))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative	*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria	▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1*
Likely Effectiveness and Reliability of Institutional Controls (WAC 173-340-360(6)(a)(vi)) SCORE:	Relatively small impacted area and past experiences indicate good effectiveness. 5.0	Relatively small impacted area and past experiences indicate good effectiveness. 5.0	Relatively small impacted area and past experiences indicate good effectiveness. 5.0	Relatively small impacted area and past experiences indicate good effectiveness. 5.0
Ability to Control and Monitor Migration of Hazardous Substances (WAC 173-340-360(6)(a)(vii)) SCORE:	Long-term monitoring expected. Limited ability to mitigate a new release without a NoVOCs system in place. 4.0	Long-term monitoring expected. Ability to mitigate a new release is enhanced by the NoVOCs system. 5.0	Long-term monitoring expected. Ability to mitigate a new release is enhanced by the NoVOCs system. 5.0	Long-term monitoring expected. Ability to mitigate a new release is enhanced by the NoVOCs system. 5.0
Toxicity of Hazardous Substances Remaining at the Site (WAC 173-340-360(6)(a)(viii)) SCORE:	Substances toxic. 5.0	Substances toxic. 5.0	Substances toxic. 5.0	Substances toxic. 5.0
Documented Natural Processes which Reduce Concentrations of Hazardous Materials Occurring at the Site (WAC 173-340-360(6)(a)(ix)) SCORE:	Natural attenuation is documented by the presence of breakdown products and form of the area of impacted ground water. 5.0	Natural attenuation is documented by the presence of breakdown products and form of the area of impacted ground water. 5.0	Natural attenuation is documented by the presence of breakdown products and form of the area of impacted ground water. 5.0	Natural attenuation is documented by the presence of breakdown products and form of the area of impacted ground water. 5.0
TOTAL TIME FRAME SCORE:	**42.0**	**48.0**	**49.0**	**48.0**

Table 6-20
Cleanup Technologies
(WAC 173-340-360(4)(a))
Ground Water - Comparative Analysis of Remedial Alternatives

Remedial Alternative	*Alternative GW-1*	*Alternative GW-2*	*Alternative GW-3*	*Alternative GW-4*
Evaluation Criteria	▪ *Ground Water Monitoring* ▪ *Provide Alternate Receptor Water Supply*	▪ *NoVOCs Treatment of the Ground Water from Zone A* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A and the Municipal Solid Waste Landfill* ▪ *Alternative GW-1*	▪ *NoVOCs Treatment of the Ground Water from Zone A, the Municipal Solid Waste Landfill and the Off-Site Ground Water Plume* ▪ *Alternative GW-1*
Reuse or Recycling (WAC 173-340-360(4)(a)(i)) SCORE: 6	None --	None --	None --	None --
Destruction or Detoxification (WAC 173-340-360(4)(a)(ii)) SCORE: 5	Some COCs are destroyed through natural attenuation and the remainder is diluted to concentrations at or below Cleanup Levels. 0.85	Most of the COCs in ground water are destroyed before leaving the Pasco Sanitary Landfill property. The rest are destroyed or diluted to concentrations below Cleanup Levels through natural attenuation. 0.95	A small amount more of the COCs than in GW-2 are destroyed before leaving the Pasco Sanitary Landfill property. The rest are destroyed or diluted to concentrations below Cleanup Levels through natural attenuation. 0.95	A small amount more of the COCs than in GW-2 are destroyed throughout the impacted area. The rest are destroyed or diluted to concentrations below Cleanup Levels through natural attenuation. 0.95
Separation or Volume Reduction followed by Reuse, Recycling, Destruction or Detoxification of the Residuals (WAC 173-340-360(4)(a)(iii)) SCORE: 4	None --	None --	None --	None --
Immobilization of Hazardous Substances (WAC 173-340-360(4)(a)(iv)) SCORE: 3	None --	None --	None --	None --
On-Site or Off-Site disposal at an Engineered Facility (WAC 173-340-360(4)(a)(v)) SCORE: 2	None --	None --	None --	None --
Isolation or Containment with Attendant Engineering Controls (WAC 173-340-360(4)(a)(vi)) SCORE: 1	Remaining dilute COCs will be contained in the ground water plume. 0.15	Remaining dilute COCs will be contained in the ground water plume. 0.05	Remaining dilute COCs will be contained in the ground water plume. 0.05	Remaining dilute COCs will be contained in the ground water plume. 0.05
Institutional Controls and Monitoring (WAC 173-340-360(4)(a)(vii)) SCORE: 1/2	Controls for drinking ground water required throughout the impacted area. 0.15	Controls for drinking ground water required throughout the impacted area. 0.05	Controls for drinking ground water required throughout the impacted area. 0.05	Controls for drinking ground water required throughout the impacted area. 0.05
TOTAL TECHNOLOGIES SCORE:	**4.5**	**4.8**	**4.8**	**4.8**

Table 6-21
Total Score for Remedial Alternatives
Zones A-E and GW

	Alternative 1	*Alternative 2*	*Alternative 3*	*Alternative 4*	*Alternative 5*	*Alternative 6*
Zone A						
Total Score	75.7	79.5	78.9	**80.2**	70.8	
Percentage of Perfect Score*	75%	79%	78%	**79%**	70%	
Zone B						
Total Score	76.3	**80.5**	77.4	72.7	75.2	69.2
Percentage of Perfect Score*	76%	**80%**	77%	72%	74%	69%
Zones C and D						
Total Score	87.0	87.5	**88.3**	81.3	80.1	
Percentage of Perfect Score*	86%	87%	**87%**	80%	79%	
Zone E						
Total Score	73.5	**74.0**	70.9	67.0		
Percentage of Perfect Score*	73%	**73%**	70%	66%		
Groundwater						
Total Score	83.5	92.1	**93.3**	92.4		
Percentage of Perfect Score*	83%	91%	**92%**	91%		

*Perfect Score is 101

7 RECOMMENDED REMEDIAL ALTERNATIVE AND IMPLEMENTATION SCHEDULE

7.1 THE SITE-WIDE PREFERRED REMEDY

The site-wide preferred remedy is made up of the preferred remedial alternatives for each area of concern as indicated in Section 6. Taken together the site-wide preferred remedy is summarized in the following tasks:

- Removal and Destruction
  - The present soil vacuum extraction system will be maintained and expanded to further remove and destroy the contaminants of concern from Zone A and to minimize the restoration time frame for soils and groundwater at the site.
  - An active landfill gas extraction system will be installed at the Municipal Landfill to remove and destroy the contaminants of concern and to further minimize the restoration time frame for soils and groundwater at the site.
  - The present NoVOCs™ groundwater treatment system will be maintained and expanded to treat groundwater from Zone A to acceptable levels before it leaves the site.
- Containment and Isolation
  - All areas of concern will be capped with engineered isolation systems including impervious liners to minimize rainfall percolation through waste and direct contact with wastes. These caps will be inspected and maintained in perpetuity.
- Protection of Affected Households
  - The PLPs will continue providing alternate water supplies to those households whose wells have been adversely affected by the site.
- Continued Monitoring
  - The PLPs will continue groundwater and cap monitoring to confirm performance of all remedial alternatives.
- Access and Institutional Controls

- Appropriate access and institutional controls will be maintained at the site to prevent future exposure to wastes. This task is made easier due to the remote location of the site and use of the site as a municipal landfill.

These tasks taken together will cost over $19,700,000 and will effectively reduce risk from the Pasco Sanitary Landfill Site to human health and the environment. Remedial alternatives were chosen to have the most certainty in reducing risk. In particular, the alternatives do not include excavation of waste up or transporting wastes through the local community. Instead, the alternatives favor well-known and easily implementable techniques to minimize potential future exposures to wastes at the Pasco Sanitary Landfill Site.

7.2 COMPLIANCE WITH REMAINING MTCA REQUIREMENTS FOR SELECTION OF CLEANUP ACTIONS

Section 6 analyzed the remedial alternatives in accordance with WAC 173-340-360 (1) through (6). The remaining requirements to select a remedial action are set forth in WAC 173-340-360 (7) through (9).

7.2.1 GROUNDWATER RESTORATION

The preferred remedy complies with the groundwater restoration requirements as specified by WAC 173-340-360(7):

(b) When groundwater treatment to achieve the cleanup levels at or beyond the point of compliance within an existing groundwater plume is not practicable the following measures shall be taken:

Analysis of groundwater remediation alternatives concluded that it was not practicable to treat the entire groundwater plume.

(i) Treatment shall be used to reduce the levels to the maximum extent practicable;

The preferred remedy reduces the levels of groundwater contamination to the maximum extent practicable.

(ii) *Groundwater containment, including barriers or hydraulic control through groundwater pumping or both, shall be implemented to the maximum extent practicable to avoid lateral and vertical expansion of the groundwater volume affected by the hazardous substances;*

Groundwater containment was considered in this FS and was found to be impracticable due primarily to the prolific nature of the aquifer.

(iii) *Source control measures shall be implemented to prevent or minimize additional releases to the groundwater;*

Landfill gas extraction at the Municipal Landfill and soil gas extraction at Zone A will minimize releases to groundwater in the source areas. Engineered caps on all potential source areas will minimize future releases to groundwater.

(iv) *Adequate groundwater monitoring to demonstrate control and containment of the hazardous substances shall be conducted;*

The preferred remedy continues extensive groundwater monitoring throughout the area of groundwater contamination.

(v) *The potentially liable person shall provide an alternative water supply or treatment for persons with water supplies rendered unusable by the release; and*

The preferred remedy continues supplying alternate water supplies to impacted residential wells.

(vi) *The practicability of achieving groundwater cleanup levels by treating the groundwater affected by the releases shall be reevaluated during the periodic review under WAC 173-340-420.*

The implementation schedule of the preferred remedy discussed in section 7.3 allows for reevaluation of groundwater treatment after a five year period.

(c) *Appropriate restrictions on the use of groundwater shall be placed under WAC 173-340-440 until cleanup levels established under WAC 173-340-720 are achieved.*

Access and institutional controls will be implemented throughout the area of impacted groundwater as part of the preferred remedy.

(d) *The integrity and continued operation of any treatment or containment system shall be assured in accordance with WAC 173-340-440.*

Performance and confirmational monitoring of groundwater will be continue until groundwater cleanup levels are reached to ensure the integrity and continued operation of the cleanup and containment systems installed on-site.

7.2.2 CONTAINMENT ACTIONS

The preferred remedial alternatives rely on on-site containment of hazardous substances and all of the alternatives include the use of long-term institutional controls to minimize future exposure to hazardous materials in groundwater, in wastes or in soils at the site. The long-term effectiveness, adequacy and reliability of these institutional controls can be an issue. However, the subject site is a large municipal landfill located in a remote area. The site contains an operating sanitary landfill, a closed 40-acre municipal landfill, three burn trench landfills and a balefill. Current laws require that the site will have significant restrictions to future use. These restrictions are compatible with containment remedies in the Industrial Waste Area. Given the collective amount of waste on-site and the restrictions on future use already required by law, the reliability and long-term effectiveness of institutional controls at the Industrial Waste Area is increased.

The MTCA provides regulatory guidance for cleanup actions that rely on containment of hazardous substances (WAC 173-340-360(8)(a-c)). The guidance (italics), is presented below followed by a description of how the remedial alternatives comply:

(a) *A clean up action which relies primarily on on-site disposal, isolation, or containment of hazardous substances shall not be conducted if it is practicable to reuse, destroy, or detoxify those substances in a manner that remaining concentrations are below cleanup levels established under WAC 173-340-700 through 173-340-760.*

The technology screening presented in Section 4 and analysis presented in Section 6 shows that the preferred alternative is the practicable alternative that results in the most destruction of hazardous substances at the site. Other alternatives that result in more destruction of hazardous substances were considered and found to be impracticable.

(b) *Long-term monitoring (WAC 173-340-410) and institutional controls (WAC 173-340-440) shall be required if on-site disposal, isolation, or containment is the selected cleanup action for a site or a portion of a site. Such measures shall be required until residual hazardous substance concentrations no longer exceed site cleanup levels established under WAC 173-340-700 through 173-340-760.*

All cleanup alternatives include provisions for institutional controls. This includes restrictions on groundwater use for domestic purposes. In addition, long-term monitoring is included for as long as hazardous substances exceed cleanup standards.

(c) *If the proposed cleanup action involves on-site containment, the draft cleanup action plan shall specify the types, levels, and amounts of hazardous substances remaining on-site and the measures that will be utilized to prevent migration and contact with those substances.*

The types, levels, and amounts of hazardous substances remaining on-site are based on disposal records and are available for inclusion in the cleanup action plan. The preferred remedial alternative is the measure that will be utilized to prevent migration and contact with hazardous substances.

7.2.3 ECOLOGY EXPECTATIONS

The preferred alternatives meet the following Ecology expectations for cleanup actions as specified by WAC 173-340-360(9):

(a) *Ecology expects that treatment technologies will be used wherever practicable. Use of treatment technologies should be emphasized at sites containing liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile materials, and/or discrete areas of hazardous substances which lend themselves to treatment.*

Treatment technologies are part of the preferred alternative for Zone A, the Municipal Landfill and groundwater. The technologies remove, collect and destroy hazardous substances from the soil, wastes and groundwater. More aggressive treatment was found to be impracticable. Wastes at Zones B, CD and E do not appear to be mobile or to contain free liquids based on the lack of impact to groundwater. The types and quantities of wastes in these zones do not lend themselves to treatment and the location of the zones at a municipal landfill help to ensure that future land use will be compatible with the containment remedy.

(b) *To minimize the need for long-term management of contaminated materials, ecology expects that hazardous substances will be totally destroyed, detoxified, and/or removed to concentrations below cleanup levels throughout sites containing small volumes of hazardous substances.*

The six waste zones and municipal landfill addressed in this feasibility study each contain large volumes of hazardous substances and will require long-term management. However, as noted above, the site is a large municipal landfill in a remote area. Because it is a municipal landfill current laws will require long-term management of the site in any case. This fact helps to ensure that future land use will be compatible with the treatment remedy.

(c) *Ecology recognizes the need to use engineering controls, such as containment, for sites or portions of sites that contain large volumes of materials with relatively low levels of hazardous substances where treatment is impracticable.*

The areas addressed in this FS do not contain hazardous substances at relatively low levels. For this reason, the preferred remedy removes, collects and destroys the mobile contaminants. The remaining immobile contaminants are then contained with cap systems that are designed to isolate wastes and prevent future exposures.

(d) *Ecology expects institutional controls, such as water use restrictions and deed restrictions, will be used to supplement engineering controls in order to prevent or limit exposure to hazardous substances and protect the integrity of the cleanup action.*

Institutional controls, including restrictions on the use of contaminated water for domestic purposes and deed restrictions, are part of the preferred alternatives presented in this FS.

(e) *Ecology expects that cleanup actions will return useable groundwaters to their beneficial uses wherever practicable, within a reasonable time frame. When restoration of groundwater to beneficial uses is not practicable, ecology expects to require measures to minimize/prevent further migration, minimize ongoing releases, prevent exposure to contaminated water, and other appropriate measures (see WAC 173-340-360(7)).*

The preferred alternative for groundwater is designed to prevent further migration of contaminated water from the point of the release and to return groundwaters to their beneficial use in the shortest practicable time frame. The active landfill gas collection system at the municipal landfill and active SVE at Zone A will minimize ongoing releases from those areas. Capping all zones will minimize future releases. Alternate water supplies will prevent exposure to contaminated groundwater. Institutional controls will be used to prevent future use of contaminated groundwater for domestic purposes.

(f) *In order to minimize the potential for migration of hazardous substances, ecology expects that active measures will be taken to prevent precipitation and subsequent runoff from coming into contact with contaminated soils and waste materials. When such measures are impracticable, such as during active cleanup, ecology expects that site runoff will be contained and treated prior to release from the site.*

The engineered caps proposed in the preferred alternatives will prevent precipitation and runoff from contacting waste materials.

(g) *Ecology expects that when hazardous substances remain on-site at concentrations which exceed cleanup levels, those hazardous substances will be consolidated to the maximum extent practicable where needed to minimize the potential for direct contact and migration of hazardous substances.*

All of the areas containing hazardous substances are located on a municipal landfill site. Further consolidation of wastes was evaluated and found to offer more risks than benefits.

(h) *Ecology expects that, for facilities adjacent to a surface water body, active measures will be taken to prevent/minimize releases to surface water via surface runoff and groundwater discharges. Ecology expects that dilution will not be the sole method for demonstrating compliance with cleanup standards.*

The Pasco Landfill is not adjacent to a surface water body.

(i) *Ecology expects that cleanup actions conducted under this chapter will not result in a significantly greater overall threat to human health and the environment than other alternatives.*

Taken as a whole, the preferred remedy was chosen in this feasibility study because it reduces the current threat to human health and the environment at the site to the same or greater extent as other alternatives evaluated.

7.3 Implementation of a Performance Confirmation Period

To accurately estimate the restoration time frame and prove the protectiveness of the preferred remedy, the Pasco Sanitary Landfill PLP's are proposing a creative approach to implement the preferred remedy. Features of this approach are as follows:

- Fast Implementation

  The preferred remedy will be implemented as soon as possible, allowing for an appropriate public comment period.

- Continuous Monitoring

  During implementation and for five years after, active remediation systems and groundwater will be monitored on a quarterly basis.

- Performance Confirmation

  Continuous monitoring will confirm the performance of the preferred remedy. Performance confirmation will facilitate appropriate changes to the remedial system, if necessary, to optimize the performance of the remedy.

- Enhanced Public Involvement

  As described below, an enhanced public involvement process will be implemented that will provide the public with information on this new and creative approach as soon as possible.

At the end of the performance confirmation period the data will be used to estimate the restoration time frame and determine the effectiveness of the site-wide remedy. Once these data are evaluated, another public participation process will be implemented and a Final Cleanup Action Plan will be completed by Ecology.

7.4 Amendment to the Public Participation Plan

The work plan to complete this RI/FS contains a Public Participation Plan which describes the public participation process through acceptance of the Final FS. The addition of the performance confirmation period to the preferred remedy is a new and creative approach that implements the preferred remedy as soon as possible. Since public participation is a critical element in the site remediation process, the PLPs propose amending the Public Participation Plan to include an enhanced public involvement process that will provide the public with information on this new and creative approach.

The enhanced public involvement process will be conducted at the conclusion of the FS. The purpose of this enhanced public involvement process will be to give target audiences identified in Section 5 of the Public Participation Plan more comprehensive answers to questions they may have. At this time, we anticipate questions posed by the target audiences will include the following:

1. What is the nature and extent of the contamination at the site?
2. What have been the results of the interim actions at the site?
3. What is the preferred remedy for cleanup at the site?
4. What will happen next at the site?

During this process the following messages will be communicated to the public:

1. The environmental study of the Pasco Sanitary Landfill is now at the stage where remedies can be evaluated.
2. The actions taken by Ecology and the PLPs have succeeded in characterizing the nature and extent of the waste and have identified an effective treatment to cleanup contamination.
3. The Feasibility Study is now available for public comment. It contains information about how possible remedies may work to prepare a final cleanup action plan for the site.
4. The PLPs are proposing to expand and continue the interim remedial measures (IRMs) that have worked so well in limiting contamination from moving off the site. The continuation of the IRMs for another five years will give the state, the PLPs and the community more data to evaluate how best to implement the final cleanup action plan, while preventing further off-site migration of groundwater contamination.
5. The PLPs also suggest early implementation of a cleanup strategy to cap the landfill and other waste disposal zones now, rather than wait several years while the cleanup

action plan is developed. This will result in the reduction of potential impacts to the groundwater from precipitation.

6. There is a benefit to the community in avoiding removal of the waste from the site. The risks to public health, on-site workers and the environment are substantial if the waste is attempted to be removed and transported to another disposal location.
7. This strategy will benefit the community by continuing the successful removal of contamination from groundwater leaving the site and providing more technical data on which to base a final cleanup recommendation. It will also avoid a costly and risky waste removal solution.

The following activities will be performed as part of the enhanced public involvement process.

INDIVIDUAL BRIEFINGS

AUDIENCE	RESPONSIBILITY	COLLATERAL MATERIALS*
• Benton-Franklin Health District • Franklin County Commissioners • Pasco City Council • State Legislators • Lewis Street Residents • Hispanic Organizations	PLPs with Ecology	Letters of invitation, background packet (narrative and charts/graphs), fact sheet
• NW Food Processors Association • Local Groundwater Management Area Committee • Pasco Chamber of Commerce • Service Clubs (e.g. Rotary) • Other Business Groups	PLPs Representatives	Letters of invitation, background packet (narrative and charts/graphs), fact sheet

PUBLIC MEETING

Media Site Mailing List General Public	Ecology/PLPs	Fact Sheet, news release, display ad

* All collateral materials will be produced in English and Spanish – interpreters available for public meeting and/or briefings as required.

7.5 IMPLEMENTATION SCHEDULE

The implementation schedule for the preferred remedy is given on Table 7-1.

7.6 SEPA ENVIRONMENTAL CHECKLIST

The State Environmental Policy Act (SEPA) Rules require the lead agency to consider an Environmental Checklist in making the threshold determination required under SEPA. (WAC 197-11-315.) The purpose of the threshold determination is described in Section 3.1.3 of this Feasibility Study. The Environmental Checklist must substantially conform to the form set out in WAC 197-11-960.

This section contains the Environmental Checklist prepared for the Site-Wide Preferred Remedy. The Environmental Checklist shows that the Site-Wide Preferred Remedy will not have probable adverse environmental impacts and, in fact, will have probable positive environmental impacts because of the reduction of hazardous substances in the soil and groundwater. In addition, the Site-Wide Preferred Remedy avoids the potential adverse environmental impacts associated with implementation of the alternative remedies involving excavation and removal of hazardous substances and transportation of such wastes on public highways.

SEPA ENVIRONMENTAL CHECKLIST

WAC 197-11-960

A. BACKGROUND

1. Name of proposed project, if applicable:

   Remedial Measures, Pasco Landfill

2. Proponent/Applicant Name and Phone Number:

   Philip Environmental Services Corporation (425) 227-0311

   Proponent/Applicant Address:

   PO Box 3552, Seattle WA 98055

3. Contact Person Name and Phone Number:

   Don Robbins (425) 227-6160

   Contact Person Address:

   P.O. Box 3552 , Seattle, WA 98124 (mailing)

   955 Powell Avenue SW, Renton, WA 98055 (physical)

4. Date checklist prepared:

   November 25, 1998

5. Agency requesting checklist:

   Washington State Department of Ecology

6. Proposed timing or schedule (including phasing, if applicable):

   Pending approval of the Feasibility Study, Remedial Work Plan and Final Remedial Design by the Department of Ecology's Toxic Cleanup Program, the Remedial Measures will be implemented. The measures will be evaluated over a five year performance confirmation period. After this period the Department of Ecology will issue the Cleanup Action Plan that will define the final remedial measures for the site.

7. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain:

   No

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal:

   Pasco Landfill Phase I Remedial Investigation Report

   Pasco Landfill Risk Assessment/Cleanup Level Report

   Pasco Sanitary Landfill Closure Plan

   Pasco Landfill Phase II Remedial Investigation

   Pasco Landfill Feasibility Study Report

   Pasco Landfill Remedial Work Plan (future)

   Pasco Landfill Remedial Design (future)

9. Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain:

   No

10. List any government approvals or permits that will be needed for your proposal, if known:

    Washington State Department of Ecology approval of the Feasibility Study, Work Plan and Design.

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page:

Zone A –

Construct an Impervious Cap to minimize rainfall percolation and direct contact with wastes

Expand the existing Soil Vacuum Extraction System to destroy contaminants and minimize the restoration time frame

Implement Access and Institutional Controls to prevent future exposures to wastes at the Site

Zone B –

Construct an Impervious Cap to minimize rainfall percolation and direct contact with wastes

Install Access and Institutional Controls to prevent future exposures to wastes at the Site

Zone C & D –

Construct an Impervious Cap to minimize rainfall percolation and direct contact with wastes

Install Access and Institutional Controls to prevent future exposures to wastes at the Site

Zone E –

Construct an Impervious Cap to minimize rainfall percolation and direct contact with wastes

Install Access and Institutional Controls to prevent future exposures to wastes at the Site

Municipal Landfill –

Implement the Pasco Sanitary Landfill Closure Plan which includes the Accepted (Presumptive) Remedy for Correcting Municipal Landfills

Ground Water –

Continue and expand the successful NoVOCs™ Recirculating Well Groundwater Treatment System proximal to Zone A to remove and destroy contaminants in groundwater

Monitor groundwater for at least a five-year period

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any. If a proposal would occur over a range of area, provide the range or boundaries of the site(s)

Pasco Landfill, 1901 Dietrich Road, Pasco, WA 99301

Township: 9N Section: 30E

(See Figures 1-1 through 1-3)

B. ENVIRONMENTAL ELEMENTS

1. Earth

a. General description of the site (circle one):

Rolling hills

b. What is the steepest slope on the site (approximate percent slope)?

approximately 5%

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any prime farmland.

silty sand

d. Are there surface indications or history of unstable soils in the immediate vicinity?

None

e. Describe the purpose, type and approximate quantities of filling or grading proposed. Indicate source of fill.

Filling and grading will be conducted as necessary to prepare areas for capping and to bury piping associated with the active remediation systems. All fill will come from on-site sources.

f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe.

Erosion is not expected to occur due to the limited trenching/ clearing needed for the project. In addition, the filling and grading to prepare areas for capping are designed to decrease the present level of erosion at the site

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

1.5 %

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:

Caps are designed to minimize erosion.

2. Air

a. What types of emissions to the air would result from the proposal (i.e., dust, automobile, odors, industrial wood smoke) during construction and when the project is completed? If any, generally describe and give approximate quantities, if known.

During construction, dust may become airborne as a result of the movement of equipment and vehicles. Standard dust control measures will be taken during earth moving operations. However, after cap construction dust and vapor emissions from the site will decrease to below present levels. Municipal Landfill emissions will be further minimized after construction by flaring vapors from the active landfill gas collection system.

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

No

c. Proposed measures to reduce or control emissions or other impacts to air, if any.

Gas-phase activated carbon with be used on NoVOCs and Soil Vapor extraction systems to remove 99% of potential emissions. Flares will be used to destroy vapor emissions from the Municipal Landfill. Caps will be maintained with indigenous plants to minimize wind blown dust. These measures will reduce impacts from the site to the air to below present levels.

3. Water

a. Surface

1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.

No

2) Will the project require any work in or adjacent to (within 200 feet) of the described waters? If yes, please describe and attach available plans.

No

3) Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.

None

4) Will the proposal require surface water withdrawals or diversions? Give general description, purpose, and approximate quantities, if known.

No

5) Does the proposal lie within a 100-year flood plain? If so, note location on the site plan.

No

6) Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.

No

b. Ground:

1) Will the ground water be withdrawn, or will water be discharged to ground water? Give general description, purpose, and approximate quantities, if known.

No, the NoVOCs™ system treats contaminated groundwater in situ.

2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any. For example: domestic sewage, industrial, containing the following chemicals;. . . agricultural; etc. Describe the general size of the system, the number of such systems, the number of houses to be served, if applicable, or the number of animals or humans the system(s) are expected to serve.

None. The Remedial Measures will result in a decrease in the amount, toxicity, and mobility of wastes already in the ground and groundwater at the site.

c. Water Runoff (including storm water):

1) Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

All surface water runoff will be contained on-site. Runoff controls will be engineered to avoid any adverse impact.

2) Could waste materials enter ground or surface waters?

Remedial Measures are designed to reduce the amount of wastes which are presently entering ground water. No measurable impacts to surface water occur or will occur from the site.

d. Proposed measures to reduce or control surface, ground, and runoff water impacts, if any.

The Remedial Measures are designed with the purpose of reducing all impacts from wastes presently on the site. Runoff from capped waste cells will be contained on site.

4. Plants

a. Check or circle types of vegetation found on the site.

Sagebrush, tumbleweed

b. What kind and amount of vegetation will be removed or altered?

Sagebrush and tumbleweed will be removed from approximately 1.5 acres and areas will be replanted with indigenous plants to maintain caps.

c. List threatened or endangered species known to be on or near the site.

None known

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:

Caps will be replanted with indigenous plants and maintained in perpetuity so that the environment will be enhanced compared to present conditions.

5. Animals

a. Underline any birds and animals which have been observed on or near the site or are known to be on or near the site:

Birds: magpies, hawks, seagulls

Mammals: rabbit, coyotes, rats

b. List any threatened or endangered species known to be on or near the site.

None known

c. Is the site part of a migration route? If so, explain.

No

d. Proposed measures to preserve or enhance wildlife, if any.

Disturbed areas will be replanted with indigenous plant species to avoid loss of habitat.

6. Energy and Natural Resources

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs:

Electricity will be required to power extraction blowers.

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

No

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any.

None

7. Environmental Health

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur as a result of this proposal? If so, describe.

The purpose of the Remedial Measures is to minimize and ultimately eliminate the ongoing release of hazardous substances from the site. For this reason the result of implementing this proposal will be to enhance environmental health by substantially reducing existing risks to both human health and the environment. However, during well installation and trenching activities, skin and eye contact and inhalation of organic vapors are potential chemical hazards to site contractors. Landfill gases, predominately methane, could also pose a potential hazard to site workers during drilling activities.

1) Describe special emergency services that might be required.

The nearest hospital has been identified and location maps are available in each on site Philip Environmental vehicle.

2) Proposed measures to reduce or control environmental health hazards, if any:

As indicated above, the Remedial Measures are specifically designed to reduce and control long term environmental health hazards from the Pasco Landfill Site. In addition, all Philip employees and subcontractors working on the Pasco Landfill site are required to have completed the hazardous waste operations training requirements according to OSHA 29 CFR 1910.120 and WAC 296-62. All Philip field participants, subcontractors and observers must read, sign, and adhere to the Pasco Landfill Phase II RI/FS Health and Safety Plan.

b. Noise

1) What types of noise exist in the area which may affect your project, (for example: traffic, equipment, operation, other)?

None

2) What types of levels would be created by or associated with the project on a short-term or long-term basis (i.e., traffic, construction, operation, other)? Indicate what hours noise would come from the site.

Noise coming from the system regenerative blowers, 24 hours a day.

3) Proposed measures to reduce or control noise impacts, if any.

None needed because site is not in close proximity to residential areas.

8. Land and Shoreline Use

a. What is the current use of the site and adjacent properties?

Currently, the site contains a solid waste disposal facility operated under a Benton-Franklin District Health Department (BFDHD) permit. Adjacent land is utilized for agricultural production.

b. Has the site been used for agriculture? If so, describe.

Yes, irrigated crop circles.

c. Describe any structures on the site.

The Pasco Landfill has buildings located on-site including: maintenance shop, scalehouse, and a pumphouse.

d. Will any structures be demolished? If so, what?

No

e. What is the current zoning classification of the site?

Agricultural

f. What is the current comprehensive plan designation of the site?

Agricultural

g. If applicable, what is the current shoreline master program designation of the site?

N/A

h. Has any part of the site been classified as an "environmentally sensitive" area? If so, specify.

No

i. Approximately how many people would reside or work in the completed project?

None

k. Proposed measures to avoid or reduce displacement impacts, if any.

None

l. Proposed measures to ensure the proposal is compatible with existing and projected land use and plans, if any.

The proposal is consistent with existing zoning and comprehensive plan designation because the existing solid waste disposal facility is a permitted special use. Applicant is unaware of any pending or projected plans to change land use plans.

9. Housing

a. Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.

None

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.

None

c. Proposed measures to reduce or control housing impacts, if any.

None

10. Aesthetics

a. What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?

Fifteen feet.

b. What views in the immediate vicinity would be altered or obstructed?

None

c. Proposed measures to reduce or control aesthetic impacts, if any.

None

11. Light and Glare

a. What type of light or glare will the proposal produce? What time of day would it mainly occur?

None

b. Could light or glare from the finished project be a safety hazard or interfere with views?

No

c. What existing off-site sources of light or glare may affect your proposal?

None

d. Proposed measures to reduce or control light and glare impacts, if any.

None

12. Recreation

a. What designation and informal recreational opportunities are in the immediate vicinity?

None

b. Would the proposed project displace any existing recreational uses? If so, describe.

No

c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any.

None

13. Historic and Cultural Preservation

a. Are there any places or objects listed on, or proposed for, national, state, or local preservation registers known to be on or next to the site?

None

b. Generally describe any landmarks or evidence of historic, archaeological, scientific , or cultural importance known to be on or next to the site.

None

c. Proposed measures to reduce or control impacts, if any.

None

14. Transportation

a. Identify public streets and highways serving the site, and describe proposed access to the existing street system. Show on site plans, if any.

See site map (Figure 1-2). Proposal will be accessed by existing street system.

b. Is site currently served by public transit? If not, what is the approximate distance to the nearest transit stop?

Unknown

c. How many parking spaces would the completed project have? How many would the project eliminate?

None created/None eliminated.

d. Will the proposal require any new roads or streets, or improvements to existing roads or streets, not including driveways? If so, generally describe (indicate whether public or private).

No

e. Will the project use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

No

f. How many vehicular trips per day would be generated by the completed project? If known, indicate when peak volumes would occur.

Two trips a month.

g. Proposed measures to reduce or control transportation impacts, if any.

N/A

15. Public Services

a. Would the project result in an increased need for public services (i.e., fire protection, police protection, health care, schools, other)? If so, generally describe.

No

b. Proposed measures to reduce or control direct impacts on public services, if any.

None. The Remedial Measures enhance public services by continuing to provide public water to certain residences.

16. Utilities

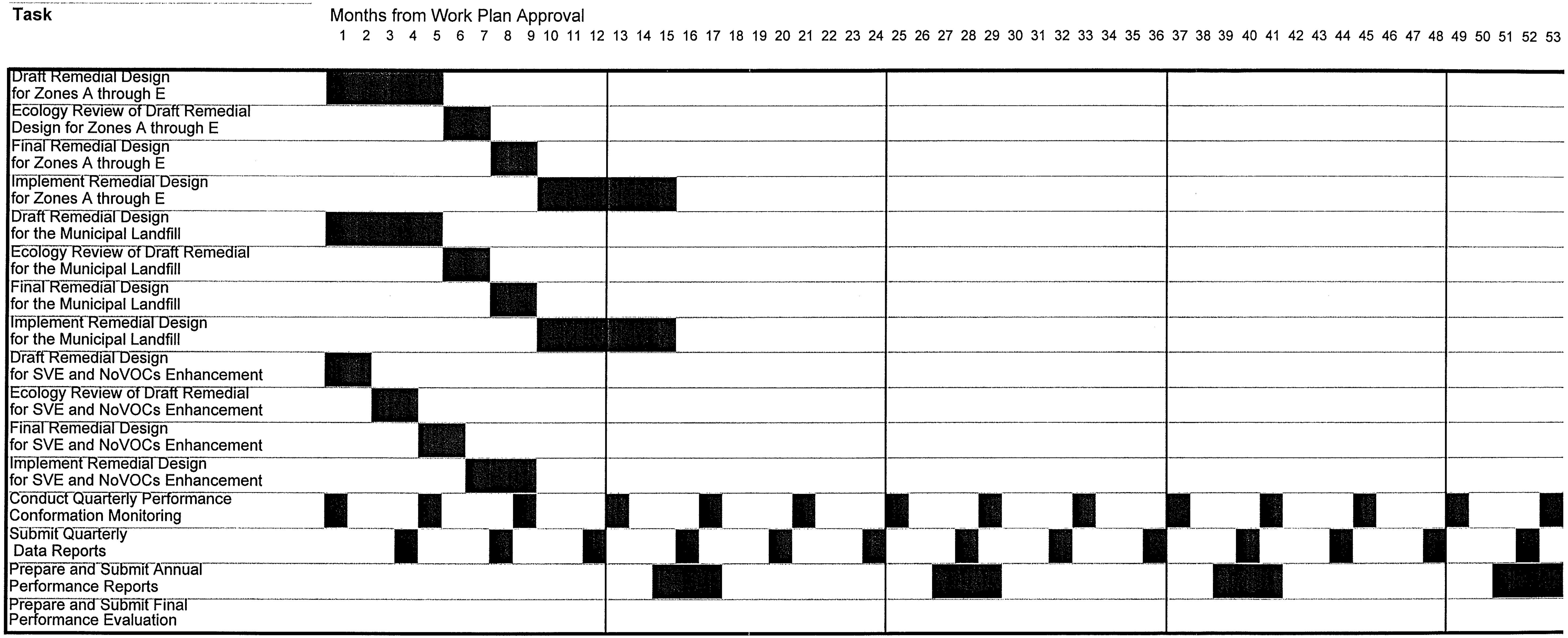
Underline utilities currently available at the site:

electricity, water, telephone, septic system.

b. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

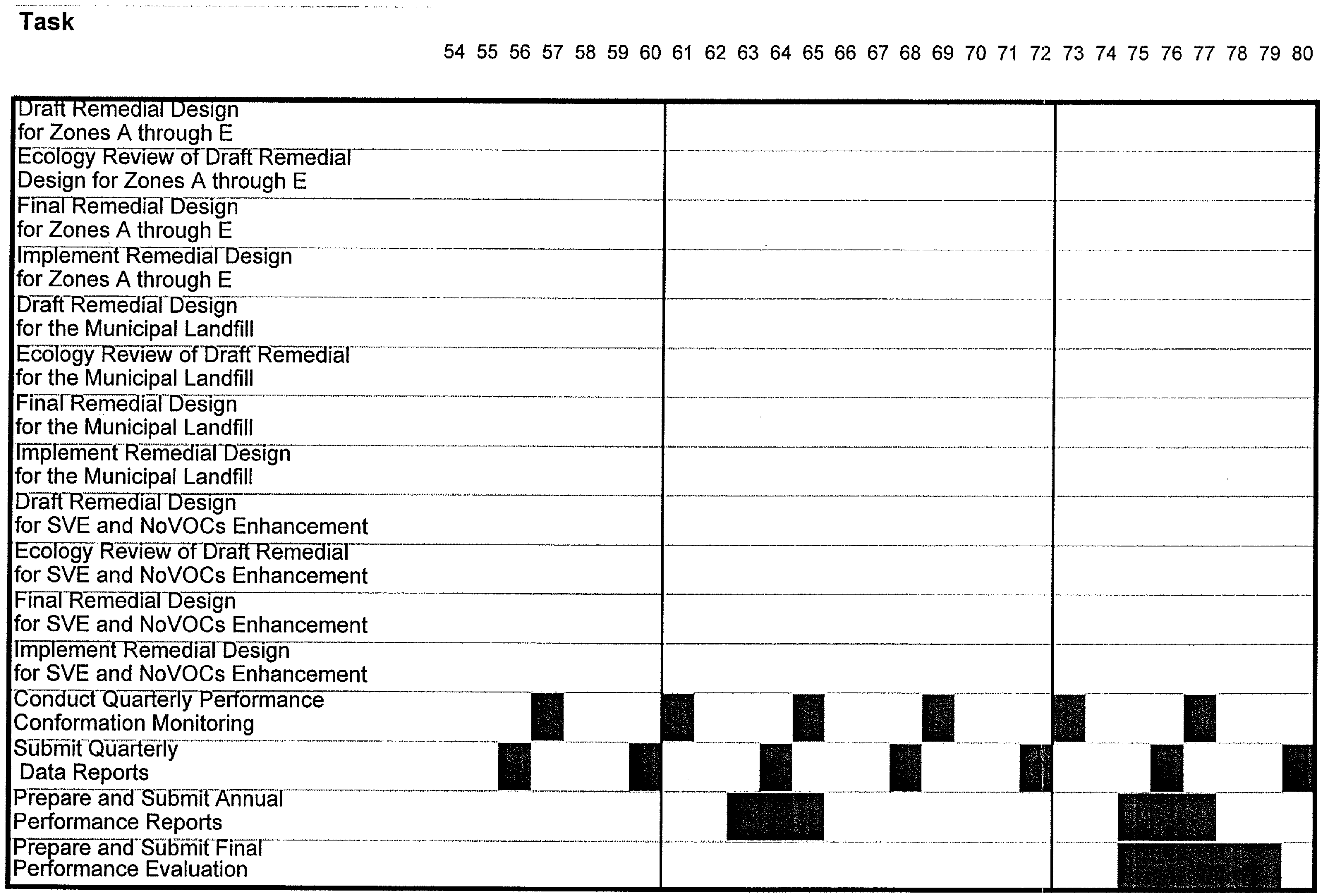
Electricity, Franklin County P.U.D.

Figure 7-1
Proposed Implementation Schedule



*Prior to signing the Agreed Order the enhanced public participation plan will be performed according to the schedule provided in Section 7.2.
The Draft Remedial Workplan describing the tasks to be performed to implement the preferred remedy will be submitted to Ecology on or before February 1, 1999.

Figure 7-1
Proposed Implementation Schedule **(continued)**



*Prior to signing the Agreed Order the
The Draft Remedial Workplan describi

Appendix A
HELP Model Output

HELP Model - Cap

The Hydrologic Evaluation of Landfill Performance (HELP) model was executed to verify that the preliminary design of the landfill caps provided sufficient protection from infiltration. This model was developed by the U.S. Army Corps of Engineers for the EPA to evaluate water balance analysis of landfills, landfill caps, and disposal containment cells. HELP Version 3.07 was used in the estimation of percolation/leakage through the the waste. The reader may refer to a discussion of this model and assumptions used related to the input parameters in the "Pasco Sanitary Landfill Closure Plan," prepared by Woodward-Clyde (Seattle, WA) for Philip Environmental Services Corporation (Renton, WA) dated October 3, 1995.

The following additional assumptions were applied to the input parameters of the model:

- The model was executed over 40 years (the life of the landfill cap) using synthetically-generated evapotranspiration, precipitation, and temperature data from Yakima, WA (Woodward-Clyde, 1995).
- The area of each landfill was assumed to be the design area of each landfill cap calculated previously.
- The landfill area was modeled with an average slope of 2% and a maximum slope length of half of the longest dimension of each zone. The SCS curve number was computed from these values and assuming a poor stand of grass.
- The flexible membrane layers were assumed to contain a pinhole density of 1 hole/acre (conservative), installation defect density of 4 holes/acre (fair/good), and "good" (average) placement quality.
- The native top-soil was assumed to be type SM (silty sand) with a saturated hydraulic conductivity of 5.2×10^{-4} cm/sec.
- The lateral drainage layer was assumed to be soil type SW (well-graded sand) with a saturated hydraulic conductivity of 5.8×10^{-3} cm/sec.
- For Zones A and B, the layer of waste was assumed to have the characteristics of municipal waste with channeling.
- For Zones C/D and E, the layer of waste was assumed to have the characteristics of municipal waste without channeling.

Using these assumptions, modeling results for all the zones indicate that the majority (86.5%) of the average total annual precipitation is converted by evapotranspiration. The modeling results for the landfill cap design for all the zones indicate that the average percolation/leakage through the waste over a 40-year period is less than 1×10^{-4} inches per month.

HELP Model – On-Site Lined Cell

The Hydrologic Evaluation of Landfill Performance (HELP) model was executed to verify that the preliminary design of the on-site lined cells provided sufficient protection from infiltration. This model was developed by the U.S. Army Corps of Engineers for the EPA to evaluate water balance analysis of landfills, landfill caps, and disposal containment cells. Version 3.07 was used in the estimation of percolation/leakage through the bottom barrier soil layer of the cells. The reader may refer to a discussion of this model and assumptions used related to the input parameters in the "Pasco Sanitary Landfill Closure Plan," prepared by Woodward-Clyde (Seattle, WA) for Philip Environmental Services Corporation (Renton, WA) dated October 3, 1995.

The following additional assumptions were applied to the input parameters of the model:

- The model was executed over 40 years (the life of the landfill cap) using synthetically-generated evapotranspiration, precipitation, and temperature data from Yakima, WA (Woodward-Clyde, 1995).
- The area of each landfill was assumed to be the design area of each landfill cap calculated previously.
- The landfill area was modeled with an average slope of 2% and a maximum slope length of half of the longest dimension of each zone. The SCS curve number was computed from these values and assuming a poor stand of grass.
- The flexible membrane layers were assumed to contain a pinhole density of 1 hole/acre (conservative), installation defect density of 4 holes/acre (fair/good), and "good" (average) placement quality.
- The native top-soil was assumed to be type SM (silty sand) with a saturated hydraulic conductivity of 5.2×10^{-4} cm/sec.
- The lateral drainage layer in the cap was assumed to be soil type SW (well-graded sand) with a saturated hydraulic conductivity of 5.8×10^{-3} cm/sec.
- The lateral drainage layers in the primary and secondary leachate collection systems in the on-site lined cell were assumed to be soil type SP with a saturated hydraulic conductivity of 1.0×10^{-2} cm/sec.
- The barrier soil layers were assumed to be high density soils with a saturated hydraulic conductivity of 1.0×10^{-7} cm/sec.
- The filter media layer was assumed to be gravel with a saturated hydraulic conductivity of 0.3 cm/sec.
- For Zones A and B, the layer of waste was assumed to have the characteristics of municipal waste with channeling.
- For Zones C/D and E, the layer of waste was assumed to have the characteristics of municipal waste without channeling.

Using these assumptions, modeling results for all the zones indicate that the majority (86.5%) of the average total annual precipitation is converted by evapotranspiration. The modeling results for the on-site lined cell design for all the zones indicate that the average percolation/leakage through the bottom barrier soil layer over a 40-year period is less than 1×10^{-4} inches per month.

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******************************************************************************
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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ALLZONES.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\Allzones.OUT


TIME: 11:43     DATE:  3/ 8/1999


******************************************************************************

     TITLE:  On-Site Lined Cell for all Zones

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =      24.00   INCHES
           POROSITY                   =       0.4730 VOL/VOL
           FIELD CAPACITY             =       0.2220 VOL/VOL
           WILTING POINT              =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0620 VOL/VOL
WILTING POINT	=	0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0625 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	130.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	72.00 INCHES
POROSITY	=	0.1680 VOL/VOL
FIELD CAPACITY	=	0.0730 VOL/VOL
WILTING POINT	=	0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4170	VOL/VOL
FIELD CAPACITY	=	0.0450	VOL/VOL
WILTING POINT	=	0.0180	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 350. FEET.

SCS RUNOFF CURVE NUMBER	=	82.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	9.200	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	38.990	INCHES
TOTAL INITIAL WATER	=	38.990	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
YAKIMA WASHINGTON

STATION LATITUDE	=	46.34 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60
START OF GROWING SEASON (JULIAN DATE)	=	108
END OF GROWING SEASON (JULIAN DATE)	=	292
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61

RUNOFF

TOTALS	0.201	0.371	0.043	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.102	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112

EVAPOTRANSPIRATION

TOTALS	0.431	0.274	1.411	1.191	0.616	0.918
	0.342	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.287	0.445
	0.366	0.286	0.347	0.206	0.151	0.101

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0078	0.0071	0.0632	0.1150	0.0932	0.0607
	0.0420	0.0276	0.0177	0.0121	0.0078	0.0058
STD. DEVIATIONS	0.0196	0.0176	0.1101	0.1328	0.0985	0.0633
	0.0436	0.0287	0.0184	0.0126	0.0081	0.0070

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0498	0.0502	0.4033	0.7580	0.5947	0.4000
	0.2678	0.1761	0.1166	0.0773	0.0512	0.0373
STD. DEVIATIONS	0.1252	0.1245	0.7024	0.8756	0.6283	0.4174
	0.2783	0.1831	0.1212	0.0803	0.0531	0.0448

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0002	0.0002
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	266032.6	100.00
RUNOFF	0.648 (0.5221)	21655.96	8.140
EVAPOTRANSPIRATION	6.889 (1.0587)	230054.30	86.476
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.46004 (0.51051)	15363.589	5.77508
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00026 (0.00028)	8.823	0.00332
AVERAGE HEAD ON TOP OF LAYER 3	0.249 (0.276)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00003 (0.00004)	0.995	0.00037
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00023 (0.00024)	7.828	0.00294

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00023 (	0.00023)	7.744	0.00291
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.089	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.031 (	0.9521)	-1050.15	-0.395

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	32060.158
RUNOFF	1.495	49934.6250
DRAINAGE COLLECTED FROM LAYER 2	0.01722	575.05127
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000009	0.28801
AVERAGE HEAD ON TOP OF LAYER 3	3.405	
MAXIMUM HEAD ON TOP OF LAYER 3	5.123	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	32.2 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.04396
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000007	0.23234
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.003	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00000	0.16126
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00033
AVERAGE HEAD ON TOP OF LAYER 10	0.001	
MAXIMUM HEAD ON TOP OF LAYER 10	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.02	100853.0940

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7441	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	5.2560	0.0730
6	0.3840	0.0320
7	0.5400	0.0450
8	0.0000	0.0000
9	0.5400	0.0450
10	0.0000	0.0000
11	15.3720	0.4270
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07   (1 NOVEMBER 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONACAP.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONACAP.OUT


TIME:  10:50      DATE:   2/10/1999


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     TITLE:  ZONE A LANDFILL CAP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
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                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   7
           THICKNESS                     =      24.00    INCHES
           POROSITY                      =       0.4730 VOL/VOL
           FIELD CAPACITY                =       0.2220 VOL/VOL
           WILTING POINT                 =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT    =       0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0625	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	130.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	144.00	INCHES
POROSITY	=	0.1680	VOL/VOL
FIELD CAPACITY	=	0.0730	VOL/VOL
WILTING POINT	=	0.0190	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0726	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	83.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.890	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.359	INCHES
TOTAL INITIAL WATER	=	27.359	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM YAKIMA WASHINGTON

STATION LATITUDE	=	46.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60	
START OF GROWING SEASON (JULIAN DATE)	=	108	
END OF GROWING SEASON (JULIAN DATE)	=	292	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61
RUNOFF						
TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.102	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112
EVAPOTRANSPIRATION						
TOTALS	0.431	0.274	1.411	1.191	0.616	0.918
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.287	0.445
	0.366	0.285	0.347	0.206	0.151	0.101
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0078	0.0071	0.0632	0.1148	0.0931	0.0606
	0.0419	0.0275	0.0176	0.0121	0.0077	0.0058
STD. DEVIATIONS	0.0196	0.0176	0.1101	0.1327	0.0986	0.0634
	0.0437	0.0288	0.0184	0.0126	0.0081	0.0070
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0498	0.0502	0.4032	0.7570	0.5937	0.3993
	0.2670	0.1756	0.1163	0.0770	0.0510	0.0372
STD. DEVIATIONS	0.1252	0.1245	0.7024	0.8746	0.6287	0.4178
	0.2788	0.1834	0.1214	0.0804	0.0532	0.0448

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	54652.3	100.00
RUNOFF	0.649 (0.5222)	4450.74	8.144
EVAPOTRANSPIRATION	6.889 (1.0591)	47264.55	86.482
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45928 (0.51074)	3150.982	5.76550
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00026 (0.00028)	1.809	0.00331
AVERAGE HEAD ON TOP OF LAYER 3	0.248 (0.276)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-0.031 (0.9519)	-213.93	-0.391

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	6586.272
RUNOFF	1.495	10258.3086
DRAINAGE COLLECTED FROM LAYER 2	0.01722	118.13553
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000009	0.05917
AVERAGE HEAD ON TOP OF LAYER 3	3.405	
MAXIMUM HEAD ON TOP OF LAYER 3	5.123	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	32.2 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00000
SNOW WATER	3.02	20718.7324
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7441	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	10.4717	0.0727
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONBCAP.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONBCAP.OUT


TIME:  11:18     DATE:   2/10/1999


******************************************************************************

     TITLE:  ZONE B LANDFILL CAP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =     24.00   INCHES
           POROSITY                   =      0.4730 VOL/VOL
           FIELD CAPACITY             =      0.2220 VOL/VOL
           WILTING POINT              =      0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                 LAYER  2
                                 --------
```

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

```
THICKNESS                  =      12.00    INCHES
POROSITY                   =       0.4370 VOL/VOL
FIELD CAPACITY             =       0.0620 VOL/VOL
WILTING POINT              =       0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.579999993000E-02 CM/SEC
SLOPE                      =       2.00    PERCENT
DRAINAGE LENGTH            =      55.0     FEET
```

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

```
THICKNESS                  =       0.04    INCHES
POROSITY                   =       0.0000 VOL/VOL
FIELD CAPACITY             =       0.0000 VOL/VOL
WILTING POINT              =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY        =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS   =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD
```

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

```
THICKNESS                  =      24.00    INCHES
POROSITY                   =       0.4270 VOL/VOL
FIELD CAPACITY             =       0.4180 VOL/VOL
WILTING POINT              =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000001000E-06 CM/SEC
```

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

```
THICKNESS                  =     144.00    INCHES
POROSITY                   =       0.1680 VOL/VOL
FIELD CAPACITY             =       0.0730 VOL/VOL
WILTING POINT              =       0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0726 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 55. FEET.

SCS RUNOFF CURVE NUMBER	=	84.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.260	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	27.353	INCHES
TOTAL INITIAL WATER	=	27.353	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM YAKIMA WASHINGTON

STATION LATITUDE	=	46.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60	
START OF GROWING SEASON (JULIAN DATE)	=	108	
END OF GROWING SEASON (JULIAN DATE)	=	292	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61
RUNOFF						
TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.103	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112
EVAPOTRANSPIRATION						
TOTALS	0.431	0.274	1.411	1.191	0.617	0.918
	0.342	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.286	0.444
	0.366	0.286	0.347	0.206	0.151	0.101
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0078	0.0074	0.1171	0.1757	0.0919	0.0351
	0.0143	0.0053	0.0019	0.0008	0.0003	0.0013
STD. DEVIATIONS	0.0352	0.0249	0.2062	0.1968	0.0950	0.0354
	0.0147	0.0054	0.0020	0.0008	0.0003	0.0073
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0211	0.0222	0.3160	0.4901	0.2481	0.0978
	0.0386	0.0143	0.0054	0.0020	0.0008	0.0034
STD. DEVIATIONS	0.0950	0.0744	0.5565	0.5490	0.2564	0.0987
	0.0397	0.0147	0.0055	0.0021	0.0008	0.0197

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES		CU. FEET	PERCENT
PRECIPITATION	7.97	(1.381)	7518.3	100.00
RUNOFF	0.649	(0.5223)	612.51	8.147
EVAPOTRANSPIRATION	6.889	(1.0578)	6502.11	86.484
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45892	(0.52129)	433.133	5.76104
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00011	(0.00012)	0.108	0.00144
AVERAGE HEAD ON TOP OF LAYER 3	0.105	(0.119)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000	(0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-0.031	(0.9525)	-29.44	-0.392

***

PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	906.048
RUNOFF	1.495	1411.1936
DRAINAGE COLLECTED FROM LAYER 2	0.03252	30.69049
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000007	0.00662
AVERAGE HEAD ON TOP OF LAYER 3	2.720	
MAXIMUM HEAD ON TOP OF LAYER 3	3.652	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	18.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00000
SNOW WATER	3.02	2850.1960

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	10.4656	0.0727
SNOW WATER	0.000	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:    C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:      C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:  C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:    C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:  C:\PROGRA~1\HELP3\ZONCDCAP.D10
OUTPUT DATA FILE:           C:\PROGRA~1\HELP3\ZONCDCAP.OUT


TIME:  11:34     DATE:   2/10/1999


******************************************************************************

     TITLE:  ZONE C/D LANDFILL CAP

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                           MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =     24.00    INCHES
           POROSITY                   =      0.4730 VOL/VOL
           FIELD CAPACITY             =      0.2220 VOL/VOL
           WILTING POINT              =      0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
                                   --------
```

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0620 VOL/VOL
WILTING POINT	=	0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0622 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	110.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	108.00 INCHES
POROSITY	=	0.6710 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2918 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 110. FEET.

SCS RUNOFF CURVE NUMBER	=	83.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.710	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	48.407	INCHES
TOTAL INITIAL WATER	=	48.407	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM YAKIMA WASHINGTON

STATION LATITUDE	=	46.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60	
START OF GROWING SEASON (JULIAN DATE)	=	108	
END OF GROWING SEASON (JULIAN DATE)	=	292	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61
RUNOFF						
TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.102	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112
EVAPOTRANSPIRATION						
TOTALS	0.431	0.274	1.411	1.191	0.616	0.917
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.286	0.444
	0.365	0.285	0.347	0.206	0.151	0.101
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0069	0.0066	0.0713	0.1270	0.0970	0.0588
	0.0379	0.0231	0.0137	0.0087	0.0052	0.0039
STD. DEVIATIONS	0.0220	0.0192	0.1258	0.1463	0.1020	0.0608
	0.0389	0.0237	0.0141	0.0089	0.0053	0.0057
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0373	0.0396	0.3850	0.7086	0.5237	0.3282
	0.2048	0.1248	0.0766	0.0471	0.0289	0.0212
STD. DEVIATIONS	0.1189	0.1148	0.6791	0.8162	0.5507	0.3390
	0.2100	0.1279	0.0786	0.0483	0.0296	0.0306

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	20530.8	100.00
RUNOFF	0.649 (0.5222)	1672.07	8.144
EVAPOTRANSPIRATION	6.888 (1.0581)	17752.39	86.467
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.46040 (0.51517)	1186.595	5.77959
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00022 (0.00024)	0.580	0.00282
AVERAGE HEAD ON TOP OF LAYER 3	0.210 (0.235)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-0.031 (0.9533)	-80.29	-0.391

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	2474.208
RUNOFF	1.495	3853.6504
DRAINAGE COLLECTED FROM LAYER 2	0.01944	50.10712
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000008	0.02131
AVERAGE HEAD ON TOP OF LAYER 3	3.253	
MAXIMUM HEAD ON TOP OF LAYER 3	4.799	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	28.8 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00000
SNOW WATER	3.02	7783.2275

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	31.5212	0.2919
SNOW WATER	0.000	

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONECAP.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONECAP.OUT


TIME:  12: 1     DATE:   2/10/1999


******************************************************************************

     TITLE:  ZONE E LANDFILL CAP

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   7
           THICKNESS                 =      24.00   INCHES
           POROSITY                  =       0.4730 VOL/VOL
           FIELD CAPACITY            =       0.2220 VOL/VOL
           WILTING POINT             =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0620 VOL/VOL
WILTING POINT	=	0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0622 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	105.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	120.00 INCHES
POROSITY	=	0.6710 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2918 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 105. FEET.

SCS RUNOFF CURVE NUMBER	=	83.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.920	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	51.910	INCHES
TOTAL INITIAL WATER	=	51.910	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM YAKIMA WASHINGTON

STATION LATITUDE	=	46.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60	
START OF GROWING SEASON (JULIAN DATE)	=	108	
END OF GROWING SEASON (JULIAN DATE)	=	292	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61
RUNOFF						
TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.103	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112
EVAPOTRANSPIRATION						
TOTALS	0.431	0.274	1.411	1.191	0.616	0.918
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.287	0.444
	0.366	0.285	0.347	0.206	0.151	0.101
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.0067	0.0066	0.0738	0.1305	0.0977	0.0579
	0.0365	0.0217	0.0126	0.0078	0.0045	0.0035
STD. DEVIATIONS	0.0227	0.0196	0.1304	0.1502	0.1027	0.0598
	0.0375	0.0223	0.0130	0.0080	0.0047	0.0055
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0347	0.0374	0.3802	0.6946	0.5034	0.3083
	0.1878	0.1118	0.0671	0.0403	0.0242	0.0179
STD. DEVIATIONS	0.1169	0.1118	0.6721	0.7998	0.5293	0.3186
	0.1932	0.1150	0.0690	0.0414	0.0248	0.0282

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	26603.3	100.00
RUNOFF	0.649 (0.5222)	2166.72	8.145
EVAPOTRANSPIRATION	6.889 (1.0583)	23005.25	86.475
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45973 (0.51660)	1535.309	5.77113
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00021 (0.00023)	0.717	0.00269
AVERAGE HEAD ON TOP OF LAYER 3	0.201 (0.225)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.000	0.00000
CHANGE IN WATER STORAGE	-0.031 (0.9532)	-104.03	-0.391

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	3206.016
RUNOFF	1.495	4993.4624
DRAINAGE COLLECTED FROM LAYER 2	0.02010	67.12279
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000008	0.02728
AVERAGE HEAD ON TOP OF LAYER 3	3.210	
MAXIMUM HEAD ON TOP OF LAYER 3	4.709	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	28.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00000
SNOW WATER	3.02	10085.3086

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6477	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	35.0248	0.2919
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONACELL.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONACELL.OUT


TIME:  11: 8     DATE:   2/10/1999


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     TITLE:  ZONE A ON-SITE LINED CELL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =      24.00   INCHES
           POROSITY                   =       0.4730 VOL/VOL
           FIELD CAPACITY             =       0.2220 VOL/VOL
           WILTING POINT              =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =   0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0620 VOL/VOL
WILTING POINT	=	0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0625 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	130.0 FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 19

THICKNESS	=	144.00 INCHES
POROSITY	=	0.1680 VOL/VOL
FIELD CAPACITY	=	0.0730 VOL/VOL
WILTING POINT	=	0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	130.0 FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	130.0 FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 130. FEET.

SCS RUNOFF CURVE NUMBER	=	83.70	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.890	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	44.246	INCHES
TOTAL INITIAL WATER	=	44.246	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
YAKIMA WASHINGTON

STATION LATITUDE	=	46.34 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60
START OF GROWING SEASON (JULIAN DATE)	=	108
END OF GROWING SEASON (JULIAN DATE)	=	292
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61

RUNOFF

TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.102	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112

EVAPOTRANSPIRATION

TOTALS	0.431	0.274	1.411	1.191	0.616	0.918
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.287	0.445
	0.366	0.285	0.347	0.206	0.151	0.101

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0078	0.0071	0.0632	0.1148	0.0931	0.0606
	0.0419	0.0275	0.0176	0.0121	0.0077	0.0058
STD. DEVIATIONS	0.0196	0.0176	0.1101	0.1327	0.0986	0.0634
	0.0437	0.0288	0.0184	0.0126	0.0081	0.0070

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0498	0.0502	0.4032	0.7570	0.5937	0.3993
	0.2670	0.1756	0.1163	0.0770	0.0510	0.0372
STD. DEVIATIONS	0.1252	0.1245	0.7024	0.8746	0.6287	0.4178
	0.2788	0.1834	0.1214	0.0804	0.0532	0.0448

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0002	0.0002
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	54652.3	100.00
RUNOFF	0.649 (0.5222)	4450.74	8.144
EVAPOTRANSPIRATION	6.889 (1.0591)	47264.55	86.482
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45928 (0.51074)	3150.982	5.76550
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00026 (0.00028)	1.809	0.00331
AVERAGE HEAD ON TOP OF LAYER 3	0.248 (0.276)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00003 (0.00004)	0.204	0.00037
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00023 (0.00024)	1.605	0.00294

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00023 (	0.00023)	1.588	0.00291
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.018	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.031 (	0.9521)	-215.74	-0.395

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	6586.272
RUNOFF	1.495	10258.3086
DRAINAGE COLLECTED FROM LAYER 2	0.01722	118.13553
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000009	0.05917
AVERAGE HEAD ON TOP OF LAYER 3	3.405	
MAXIMUM HEAD ON TOP OF LAYER 3	5.123	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	32.2 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00903
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000007	0.04773
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.003	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00000	0.03313
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00007
AVERAGE HEAD ON TOP OF LAYER 10	0.001	
MAXIMUM HEAD ON TOP OF LAYER 10	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.02	20718.7324

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7441	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	10.5120	0.0730
6	0.3840	0.0320
7	0.5400	0.0450
8	0.0000	0.0000
9	0.5400	0.0450
10	0.0000	0.0000
11	15.3720	0.4270
SNOW WATER	0.000	

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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**            HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONBCELL.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONBCELL.OUT


TIME:  11:28     DATE:   2/10/1999


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     TITLE:  ZONE B ON-SITE LINED CELL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =      24.00    INCHES
           POROSITY                   =       0.4730 VOL/VOL
           FIELD CAPACITY             =       0.2220 VOL/VOL
           WILTING POINT              =       0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
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             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   2
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4370 VOL/VOL
FIELD CAPACITY               =       0.0620 VOL/VOL
WILTING POINT                =       0.0240 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0620 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.579999993000E-02 CM/SEC
SLOPE                        =       2.00    PERCENT
DRAINAGE LENGTH              =      55.0     FEET


                         LAYER  3
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.04    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                         LAYER  4
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER  16
THICKNESS                    =      24.00    INCHES
POROSITY                     =       0.4270 VOL/VOL
FIELD CAPACITY               =       0.4180 VOL/VOL
WILTING POINT                =       0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000E-06 CM/SEC


                         LAYER  5
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER  19
THICKNESS                    =     144.00    INCHES
POROSITY                     =       0.1680 VOL/VOL
FIELD CAPACITY               =       0.0730 VOL/VOL
WILTING POINT                =       0.0190 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0730 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                         LAYER  6
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TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	55.0 FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 9

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 1

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0450 VOL/VOL
WILTING POINT	=	0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999978000E-02 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	55.0 FEET

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 55. FEET.

SCS RUNOFF CURVE NUMBER	=	84.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.260	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	44.240	INCHES
TOTAL INITIAL WATER	=	44.240	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
YAKIMA WASHINGTON

STATION LATITUDE	=	46.34 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60
START OF GROWING SEASON (JULIAN DATE)	=	108
END OF GROWING SEASON (JULIAN DATE)	=	292
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61

RUNOFF

TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.103	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112

EVAPOTRANSPIRATION

TOTALS	0.431	0.274	1.411	1.191	0.617	0.918
	0.342	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.286	0.444
	0.366	0.286	0.347	0.206	0.151	0.101

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0078	0.0074	0.1171	0.1757	0.0919	0.0351
	0.0143	0.0053	0.0019	0.0008	0.0003	0.0013
STD. DEVIATIONS	0.0352	0.0249	0.2062	0.1968	0.0950	0.0354
	0.0147	0.0054	0.0020	0.0008	0.0003	0.0073

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0211	0.0222	0.3160	0.4901	0.2481	0.0978
	0.0386	0.0143	0.0054	0.0020	0.0008	0.0034
STD. DEVIATIONS	0.0950	0.0744	0.5565	0.5490	0.2564	0.0987
	0.0397	0.0147	0.0055	0.0021	0.0008	0.0197

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	7518.3	100.00
RUNOFF	0.649 (0.5223)	612.51	8.147
EVAPOTRANSPIRATION	6.889 (1.0578)	6502.11	86.484
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45892 (0.52129)	433.133	5.76104
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00011 (0.00012)	0.108	0.00144
AVERAGE HEAD ON TOP OF LAYER 3	0.105 (0.119)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00002 (0.00003)	0.023	0.00030
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00009 (0.00009)	0.085	0.00114

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00009 (	0.00009)	0.083	0.00110
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.002	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.031 (	0.9525)	-29.55	-0.393

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	906.048
RUNOFF	1.495	1411.1936
DRAINAGE COLLECTED FROM LAYER 2	0.03252	30.69049
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000007	0.00662
AVERAGE HEAD ON TOP OF LAYER 3	2.720	
MAXIMUM HEAD ON TOP OF LAYER 3	3.652	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	18.1 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00176
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000005	0.00446
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00000	0.00353
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.000	
MAXIMUM HEAD ON TOP OF LAYER 10	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.02	2850.1960
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040	

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	10.5120	0.0730
6	0.3840	0.0320
7	0.5400	0.0450
8	0.0000	0.0000
9	0.5400	0.0450
10	0.0000	0.0000
11	15.3720	0.4270
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)               **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONCDCEL.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONCDCEL.OUT


TIME:  11:56     DATE:   2/10/1999


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     TITLE:  ZONE C/D ON-SITE LINED CELL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                   LAYER  1
                                   --------

                        TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =       24.00   INCHES
           POROSITY                   =        0.4730 VOL/VOL
           FIELD CAPACITY             =        0.2220 VOL/VOL
           WILTING POINT              =        0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =        0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =   0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                   LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0622	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	110.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	108.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                   =      12.00    INCHES
POROSITY                    =       0.3970 VOL/VOL
FIELD CAPACITY              =       0.0320 VOL/VOL
WILTING POINT               =       0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC


                     LAYER  7
                     --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      12.00    INCHES
POROSITY                    =       0.4170 VOL/VOL
FIELD CAPACITY              =       0.0450 VOL/VOL
WILTING POINT               =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =       2.00    PERCENT
DRAINAGE LENGTH             =     110.0     FEET


                     LAYER  8
                     --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                   =       0.06    INCHES
POROSITY                    =       0.0000 VOL/VOL
FIELD CAPACITY              =       0.0000 VOL/VOL
WILTING POINT               =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY         =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS    =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                     LAYER  9
                     --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                   =      12.00    INCHES
POROSITY                    =       0.4170 VOL/VOL
FIELD CAPACITY              =       0.0450 VOL/VOL
WILTING POINT               =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT  =       0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
SLOPE                       =       2.00    PERCENT
DRAINAGE LENGTH             =     110.0     FEET
```

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 110. FEET.

SCS RUNOFF CURVE NUMBER	=	83.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.710	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	65.267	INCHES
TOTAL INITIAL WATER	=	65.267	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
YAKIMA WASHINGTON

STATION LATITUDE	=	46.34 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60
START OF GROWING SEASON (JULIAN DATE)	=	108
END OF GROWING SEASON (JULIAN DATE)	=	292
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61

RUNOFF

TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.102	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112

EVAPOTRANSPIRATION

TOTALS	0.431	0.274	1.411	1.191	0.616	0.917
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.286	0.444
	0.365	0.285	0.347	0.206	0.151	0.101

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0069	0.0066	0.0713	0.1270	0.0970	0.0588
	0.0379	0.0231	0.0137	0.0087	0.0052	0.0039
STD. DEVIATIONS	0.0220	0.0192	0.1258	0.1463	0.1020	0.0608
	0.0389	0.0237	0.0141	0.0089	0.0053	0.0057

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0373	0.0396	0.3850	0.7086	0.5237	0.3282
	0.2048	0.1248	0.0766	0.0471	0.0289	0.0212
STD. DEVIATIONS	0.1189	0.1148	0.6791	0.8162	0.5507	0.3390
	0.2100	0.1279	0.0786	0.0483	0.0296	0.0306

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	20530.8	100.00
RUNOFF	0.649 (0.5222)	1672.07	8.144
EVAPOTRANSPIRATION	6.888 (1.0581)	17752.39	86.467
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.46040 (0.51517)	1186.595	5.77959
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00022 (0.00024)	0.580	0.00282
AVERAGE HEAD ON TOP OF LAYER 3	0.210 (0.235)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00003 (0.00003)	0.074	0.00036
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00020 (0.00020)	0.505	0.00246

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00019 (	0.00020)	0.499	0.00243
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.007	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.031 (	0.9535)	-80.87	-0.394

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	2474.208
RUNOFF	1.495	3853.6504
DRAINAGE COLLECTED FROM LAYER 2	0.01944	50.10712
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000008	0.02131
AVERAGE HEAD ON TOP OF LAYER 3	3.253	
MAXIMUM HEAD ON TOP OF LAYER 3	4.799	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	28.8 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00368
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000007	0.01679
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00000	0.01194
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 10	0.000	
MAXIMUM HEAD ON TOP OF LAYER 10	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.02	7783.2275

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6476	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	31.5360	0.2920
6	0.3840	0.0320
7	0.5400	0.0450
8	0.0000	0.0000
9	0.5400	0.0450
10	0.0000	0.0000
11	15.3720	0.4270
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP3\ZONECELL.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP3\ZONECELL.OUT


TIME:  12: 9     DATE:   2/10/1999


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     TITLE:  ZONE E ON-SITE LINED CELL

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   7
           THICKNESS                  =     24.00   INCHES
           POROSITY                   =      0.4730 VOL/VOL
           FIELD CAPACITY             =      0.2220 VOL/VOL
           WILTING POINT              =      0.1040 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2458 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.520000001000E-03 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.49
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                  LAYER  2
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TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 2

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0622	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.579999993000E-02	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	105.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	120.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

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          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  21
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.3970 VOL/VOL
FIELD CAPACITY               =       0.0320 VOL/VOL
WILTING POINT                =       0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.300000012000     CM/SEC


                      LAYER  7
                      --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC
SLOPE                        =       2.00    PERCENT
DRAINAGE LENGTH              =     105.0     FEET


                      LAYER  8
                      --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  35
THICKNESS                    =       0.06    INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY          =       1.00    HOLES/ACRE
FML INSTALLATION DEFECTS     =       4.00    HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                      LAYER  9
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            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   1
THICKNESS                    =      12.00    INCHES
POROSITY                     =       0.4170 VOL/VOL
FIELD CAPACITY               =       0.0450 VOL/VOL
WILTING POINT                =       0.0180 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0450 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999978000E-02 CM/SEC
SLOPE                        =       2.00    PERCENT
DRAINAGE LENGTH              =     105.0     FEET
```

LAYER 10

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	1.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 11

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	36.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 7 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 2.% AND A SLOPE LENGTH OF 105. FEET.

SCS RUNOFF CURVE NUMBER	=	83.90	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	0.920	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.568	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.514	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.872	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	68.770	INCHES
TOTAL INITIAL WATER	=	68.770	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
YAKIMA WASHINGTON

STATION LATITUDE	=	46.34 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.60
START OF GROWING SEASON (JULIAN DATE)	=	108
END OF GROWING SEASON (JULIAN DATE)	=	292
EVAPORATIVE ZONE DEPTH	=	18.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.44	0.74	0.65	0.50	0.48	0.60
0.14	0.36	0.33	0.47	0.97	1.30

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.20	36.10	41.90	49.20	57.30	64.50
70.40	68.60	60.90	49.90	38.20	31.50

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR YAKIMA WASHINGTON
AND STATION LATITUDE = 46.34 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 40

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.45	0.57	0.67	0.54	0.46	0.70
	0.16	0.39	0.43	0.44	0.92	1.23
STD. DEVIATIONS	0.57	0.35	0.48	0.36	0.33	0.39
	0.21	0.35	0.44	0.27	0.54	0.61

RUNOFF

TOTALS	0.201	0.371	0.044	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.033
STD. DEVIATIONS	0.264	0.478	0.103	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.112

EVAPOTRANSPIRATION

TOTALS	0.431	0.274	1.411	1.191	0.616	0.918
	0.343	0.345	0.292	0.268	0.364	0.437
STD. DEVIATIONS	0.140	0.206	0.421	0.498	0.287	0.444
	0.366	0.285	0.347	0.206	0.151	0.101

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	0.0067	0.0066	0.0738	0.1305	0.0977	0.0579
	0.0365	0.0217	0.0126	0.0078	0.0045	0.0035
STD. DEVIATIONS	0.0227	0.0196	0.1304	0.1502	0.1027	0.0598
	0.0375	0.0223	0.0130	0.0080	0.0047	0.0055

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 9

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 11

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0347	0.0374	0.3802	0.6946	0.5034	0.3083
	0.1878	0.1118	0.0671	0.0403	0.0242	0.0179
STD. DEVIATIONS	0.1169	0.1118	0.6721	0.7998	0.5293	0.3186
	0.1932	0.1150	0.0690	0.0414	0.0248	0.0282

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 10

AVERAGES	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	7.97 (1.381)	26603.3	100.00
RUNOFF	0.649 (0.5222)	2166.72	8.145
EVAPOTRANSPIRATION	6.889 (1.0583)	23005.25	86.475
LATERAL DRAINAGE COLLECTED FROM LAYER 2	0.45973 (0.51660)	1535.309	5.77113
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00021 (0.00023)	0.717	0.00269
AVERAGE HEAD ON TOP OF LAYER 3	0.201 (0.225)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00003 (0.00003)	0.095	0.00036
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00019 (0.00019)	0.622	0.00234

AVERAGE HEAD ON TOP OF LAYER 8	0.000 (	0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.00018 (	0.00019)	0.613	0.00230
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (	0.00000)	0.009	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000 (	0.000)		
CHANGE IN WATER STORAGE	-0.031 (	0.9534)	-104.75	-0.394

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 40

	(INCHES)	(CU. FT.)
PRECIPITATION	0.96	3206.016
RUNOFF	1.495	4993.4624
DRAINAGE COLLECTED FROM LAYER 2	0.02010	67.12279
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000008	0.02728
AVERAGE HEAD ON TOP OF LAYER 3	3.210	
MAXIMUM HEAD ON TOP OF LAYER 3	4.709	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	28.0 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00487
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000006	0.02136
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 9	0.00000	0.01530
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 10	0.000	
MAXIMUM HEAD ON TOP OF LAYER 10	0.001	
LOCATION OF MAXIMUM HEAD IN LAYER 9 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	3.02	10085.3086

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3311
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1040

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 40

LAYER	(INCHES)	(VOL/VOL)
1	4.6477	0.1937
2	0.7440	0.0620
3	0.0000	0.0000
4	10.2480	0.4270
5	35.0400	0.2920
6	0.3840	0.0320
7	0.5400	0.0450
8	0.0000	0.0000
9	0.5400	0.0450
10	0.0000	0.0000
11	15.3720	0.4270
SNOW WATER	0.000	

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Appendix B
Groundwater Mass Treated Calculations

MEMORANDUM

DATE: March 30, 1999

TO: Guy Gregory, WA Department of Ecology
Don Robbins, Philip Services Corporation

FROM: John Brasino
Environmental Partners, Inc.

RE: Ground Water Treatment Alternatives: Mass Treated
EPI Project No. 12602.0

As we have discussed, the conceptual model of contaminant fate and transport is an important part of choosing the preferred remedy. As with our Zone A discussion, to help us get started on a conceptual model that we can all agree on, I am providing the following "straw dog".

The two files with this memo present our best effort to answer two important questions concerning ground water restoration at the Pasco Sanitary Landfill Site.

1. What is the relative mass of COCs that will be treated in each alternative.
2. What is the relative mass of COCs destroyed versus diluted during natural attenuation.

To determine the answers to these questions the following parameters were calculated;

1. A - The mass flux rate of COCs down gradient of Zone A (note this is also down gradient of the Sanitary Landfill). This is the mass flux treated in Alternative GW-2.
2. B - The mass flux rate down gradient of the Sanitary Landfill, excluding A. This is the incremental additional mass flux treated in Alternative GW-3.
3. C - The total mass of COCs present outside Pasco Sanitary Landfill property. This is the incremental additional mass treated in Alternative GW-4.

To compare the mass treated in each alternative, it was necessary to estimate the duration of the mass flux A and B. These times were estimated at 20 and 10 years respectively. The results are as follows:

GW-1 No treatment
GW-2 11480 lbs of COCs treated
GW-3 11889 lbs of COCs treated
GW-4 12435 lbs of COCs treated

The answer to the second question was calculated by assuming that C, the total mass of COCs present outside Pasco Sanitary Landfill property is no longer being destroyed in the natural attenuation process but is instead subject only to dilution. To calculate the mass of COCs that originally left the site that ultimately has degraded to C, we assumed that A and B occurred for 6 years prior to the operation of the IRMs. The mass flux over this period then represents the total off-site mass and subtracting C from this mass is the amount of COCs that have been destroyed. The results are as follows:

C – Mass of COCs Remaining	546 lbs
Original Mass of COCs	3689 lbs
Amount of COCs Destroyed	3143 lbs
Percent of COCs Destroyed	Approximately 85%

I hope this helps. Feel free to call with questions.

62.36	lb/cubic foot of water
0.3	Porosity
1E-09	ppb

Mass of COCs from 6 Years of Flow Past Zone A

Flow ft/day	Length ft	Depth ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Total Number of Pounds	Percent of total
15	600	10	934	1.57259448	6	3444	81.3%

Mass of COCs from 6 Years of Flow Past the Sanitary Landfill

Flow ft/day	Length ft	Depth ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Total Number of Pounds	Percent of total
15	1100	10	36.3	0.112051566	6	245	5.8%

Mass of COCs Presently Off-Site

Treatment Period years	Length ft	Depth ft	Width ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Total Number of Pounds	Percent of total	Number of Pounds Destroyed	Total Flux in 6 Years
1.5	9750	10	1800	73.9	0.997119742	1.5	546	14.8%	3143	3689

62.36	lb/cubic foot of water
0.3	Porosity
1E-09	ppb

Pounds of COCs Treated in GW-2

Flow ft/day	Length ft	Depth ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Total Number of Pounds Treated	Percent of total
15	600	10	934	1.57259448	20	11480	92.3%

Incremental Increase in Pounds of COCs Treated in GW-3

Flow ft/day	Length ft	Depth ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Incremental Number of Pounds Treated	Percent of total	Total Number of Pounds Treated
15	1100	10	36.3	0.112051566	10	409	3.3%	11889

Incremental Increase in Pounds of COCs Treated in GW-4

Treatment Period years	Length ft	Depth ft	Width ft	Average Concentration Total COCs ppb	COCs Treated lbs/day	Years of Treatment	Incremental Number of Pounds Treated	Percent of total	Total Number of Pounds Treated
1.5	9750	10	1800	73.9	0.997119742	1.5	546	4.4%	12435