DOE/RL-2010-28
Revision 1

Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill

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

U.S. DEPARTMENT OF ENERGY

Richland Operations Office

P.O. Box 550
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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LE Bratton 12/2/2010
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Executive Summary

This groundwater monitoring plan has been prepared in accordance with the groundwater protection requirements pursuant to WAC 173-303-645, “Dangerous Waste Regulations,” “Releases from Regulated Units,” for both the Nonradioactive Dangerous Waste Landfill (NRDWL) and the Solid Waste Landfill (SWL). The NRDWL is a treatment, storage, and disposal unit regulated under RCW 70.105, “Public Health and Safety,” “Hazardous Waste Management.” RCW 70.105 is implemented through WAC 173-303. The SWL is a limited-purpose landfill regulated under RCW 70.95, “Public Health and Safety,” “Solid Waste Management – Reduction and Recycling.” RCW 70.95 is implemented through WAC 173-350-500, “Solid Waste Handling Standards,” “Ground Water Monitoring.”

The SWL closure and post-closure groundwater monitoring is subject to WAC 173-350-500; however, compliance with groundwater monitoring requirements for the SWL will be achieved through deferral under WAC 173-350-710(8) (“Permit Application and Issuance”) to equal or greater requirements within WAC 173-303-645. This plan has been written to meet WAC 173-350-500 requirements for the SWL and WAC 173-303-645 requirements for NRDWL under a combined monitoring program.

The combined monitoring program under this plan has been established to coordinate closure and post-closure of the NRDWL and the SWL. The new groundwater monitoring system established under this plan will be referred to as the NRDWL/SWL waste management area.

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Terms

ANOVA	analysis of variance
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CRDL	contract-required detection limit
DOE	U.S. Department of Energy
DUP	laboratory matrix duplicate
EB	equipment blank
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FTB	full trip blank
FXR	field transfer blank
FY	fiscal year
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
HEIS	Hanford Environmental Information System
IC	ion chromatography
ICP	inductively coupled plasma
ICP/MS	inductively coupled plasma/mass spectrometry
LCS	laboratory control sample
MB	method blank
MDA	minimum detectable activity
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
NA	not available
NAVD88	North American Vertical Datum of 1988
NRDWL	Nonradioactive Dangerous Waste Landfill

NTU	nephelometric turbidity units
OU	operable unit
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
QC	quality control
RCRA	*Resource Conservation and Recovery Act of 1976*
RPD	relative percent difference
RSD	relative standard deviation
SUR	surrogate
SVOC	semivolatile organic compound
SWL	Solid Waste Landfill
TCE	trichloroethene
TOC	total organic carbon
TOX	total organic halides
TSD	treatment, storage, and disposal
VOC	volatile organic compound
WMA	waste management area

1 Introduction

This groundwater monitoring plan has been prepared to support the closure and post-closure activities for the Nonradioactive Dangerous Waste Landfill (NRDWL) and the Solid Waste Landfill (SWL). This groundwater monitoring plan has been prepared in accordance with the groundwater protection requirements pursuant to WAC 173-303-645, “Dangerous Waste Regulations,” “Releases from Regulated Units,” for the NRDWL and WAC 173-350-500, “Solid Waste Handling Standards,” “Ground Water Monitoring,” for the SWL. The NRDWL is a treatment, storage, and disposal (TSD) unit regulated under RCW 70.105, “Public Health and Safety,” “Hazardous Waste Management.” RCW 70.105 is implemented through WAC 173-303. The SWL is a limited-purpose landfill regulated under RCW 70.95, “Public Health and Safety,” “Solid Waste Management – Reduction and Recycling.” RCW 70.95 is implemented through WAC 173-350-500 and WAC 173-304-490, “Minimum Functional Standards for Solid Waste Handling,” “Ground Water Monitoring Requirements.”

The existing SWL groundwater monitoring plan is based on WAC 173-304-490; however, for closure and post-closure activities, the SWL will continue to be a limited-purpose landfill, but the requirements have changed from those listed in WAC 173-304 to those of WAC 173-350. The requirements of WAC 173-350-500 will be met by deferral to the equivalent or superior requirements of WAC 173-303-645. This deferral request was granted under WAC 173-350-710(8), “Permit Application and Issuance,” by the Washington State Department of Ecology (Ecology) in 2010 and is fully detailed in the closure plan. This groundwater monitoring plan has been written to meet the requirements of WAC 173-303-645 for the NRDWL and SWL under one combined monitoring program.

The combined monitoring program under this plan has been established to coordinate closure and post-closure of the NRDWL and the SWL. The new groundwater monitoring system established under this plan will be referred to as the NRDWL/SWL waste management area (WMA).

This plan is anticipated to be approved in parallel with the closure plan for NRDWL and SWL. This plan will be implemented during the closure period and will remain effective in the post-closure period.

Chapter 2 of this groundwater monitoring plan discusses the facility, and Chapter 3 provides the groundwater hydrology and groundwater chemistry. Chapter 4 describes the groundwater monitoring program proposed for groundwater monitoring, Chapter 5 provides a brief summary of how a compliance monitoring program would be implemented (if required), and Chapter 6 is a placeholder for how a corrective action program would be established (if required) in the event that a compliance monitoring program is established.

1

2 Facility Background

This chapter provides an overview of the physical structures, operational history, and waste characteristics for the NRDWL and SWL prior to establishing the NRDWL/SWL WMA under this monitoring plan (Figure 2-1).

The NRDWL is located approximately 5.6 km (3.5 mi) southeast of the 200 East Area within the Hanford Site boundary. The landfill has an area of 4.0 ha (10 ac) and began operations in 1975. The NRDWL consists of 19 parallel trenches, each approximately 122 m (400 ft) long, 4.9 m (15 ft) wide at the base, and 4.6 m (15 ft) deep. The last receipt of dangerous waste was in May 1985, and the last receipt of asbestos waste occurred in May 1988.

The SWL is adjacent to the NRDWL on the south side. The SWL is approximately 907 m (2,980 ft) in length and 294 m (965 ft) in width. It is divided into five units, each consisting of a series of parallel trenches. The two oldest units of the SWL are identified as the Phase I area, covering approximately 11 ha (28 ac), and these units have been active since 1973. The Phase II area is divided into three units: north, middle, and south. Phase II was constructed in 1982 and covers approximately 15 ha (38 ac). In addition, several liquid waste disposal trenches were documented at SWL (as detailed in Section 2.2.2). The SWL received waste from 1973 through March 1996. Figure 2-2 shows the trench arrangements and dates of operation.

Figure 2-3 shows the locations of groundwater monitoring wells that have been used for monitoring the NRDWL and SWL.

2.1 Operational History

The SWL received principally solid waste including paper, construction debris, asbestos, and lunchroom waste. It also received sewage and bus garage washwater. Beginning in 1975 at the NRDWL, containerized chemical waste was disposed into six trenches, asbestos in nine trenches, non-hazardous solid waste in one trench, and three trenches were unused. At the end of each operating day, the waste containers were covered with soil.

2.2 Waste Characteristics

This section summarizes the general waste types, waste volumes, and dates of operation of the NRDWL and SWL. Additional details are available in the U.S. Department of Energy (DOE) closure/post-closure plan for the NRDWL and SWL (DOE/RL-90-17, *Nonradioactive Dangerous Waste Landfill/Solid Waste Landfill Closure/Postclosure Plan*).

2.2.1 Nonradioactive Dangerous Waste Landfill

The waste disposed at the NRDWL falls into the following categories (DOE/RL-90-17):

- Chemical waste with absorbents, including the following:
  - Small containers of laboratory chemicals
  - Bulk organic waste, solvent waste, paints, paint thinners, and waste oil
  - Empty containers
- Asbestos material
- Sanitary solid waste

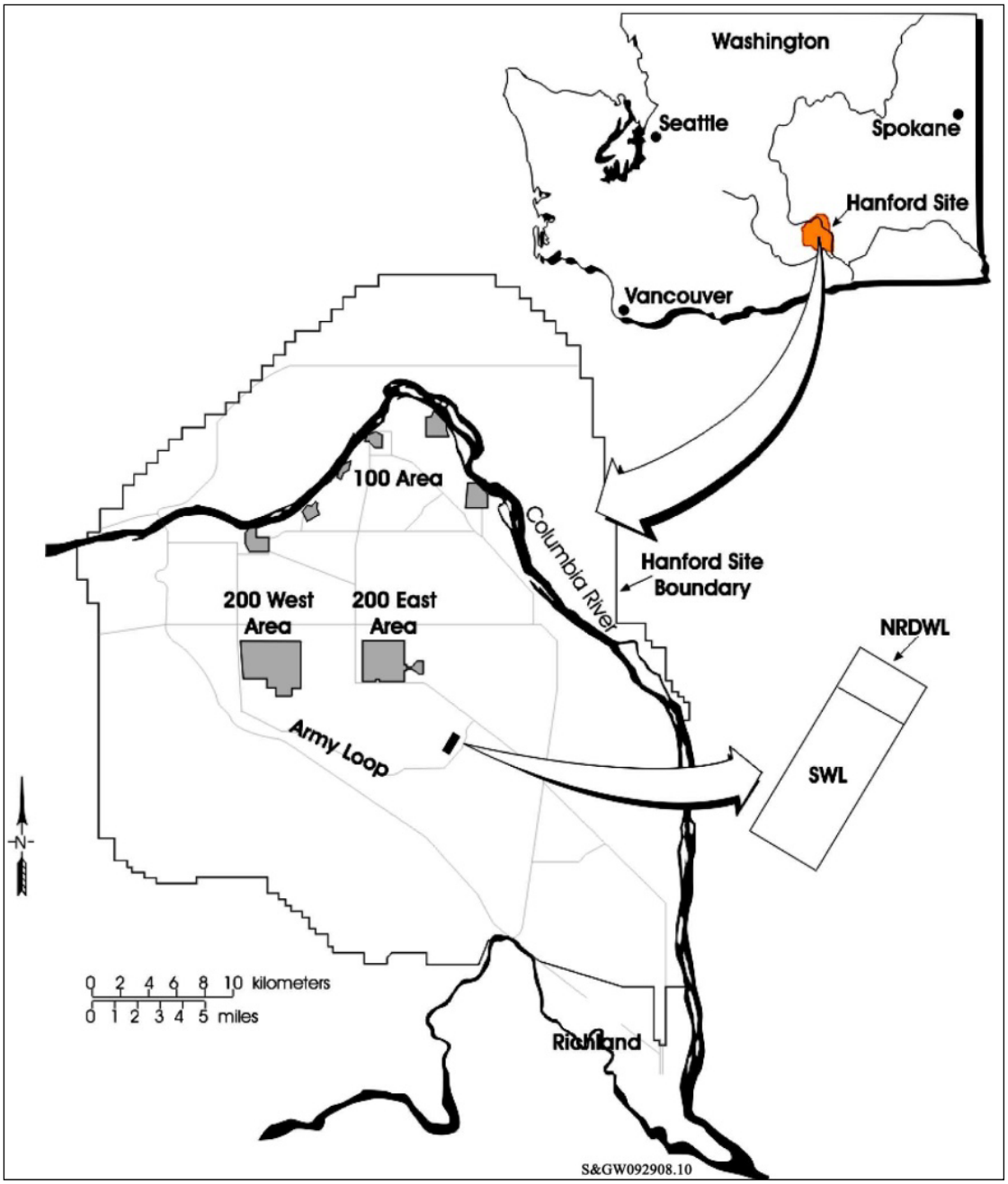

Figure 2-1. Regional Map with Locations of the Hanford Site, NRDWL, and SWL

Most of the chemical waste at the NRDWL was placed in metal drums prior to disposal. Containers of small-quantity laboratory chemicals were placed in laboratory packs and surrounded with sorbing material. Non-hazardous waste and asbestos waste were generally not placed into containers. In addition, some of the bulk organic wastes that were sorbed onto soil and other sorbents may not have been placed into containers. Additional details on the characteristics of waste disposed at the NRDWL are provided in DOE/RL-90-17.

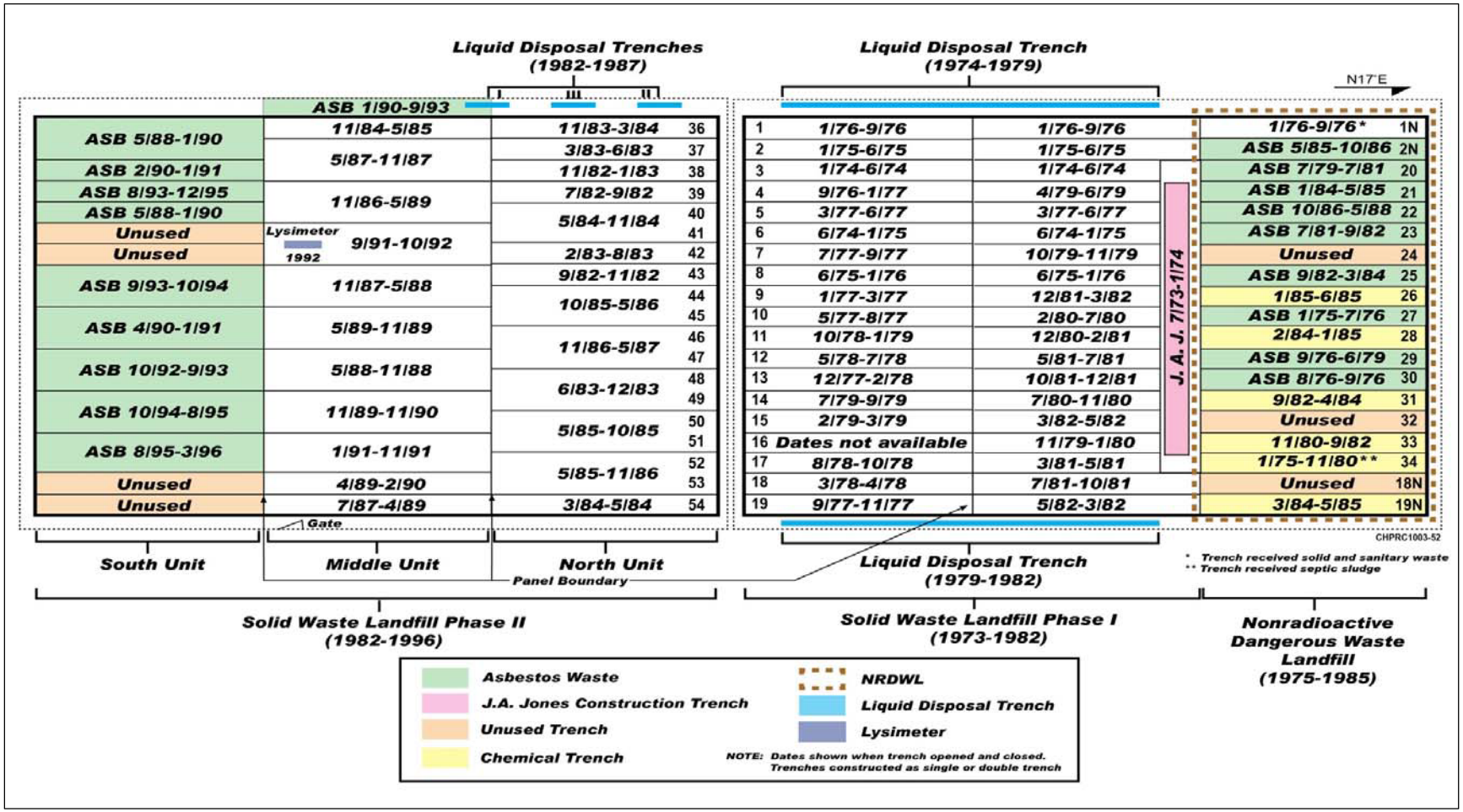

Figure 2-2. NRDWL and SWL Arrangement and Dates of Trench Operations

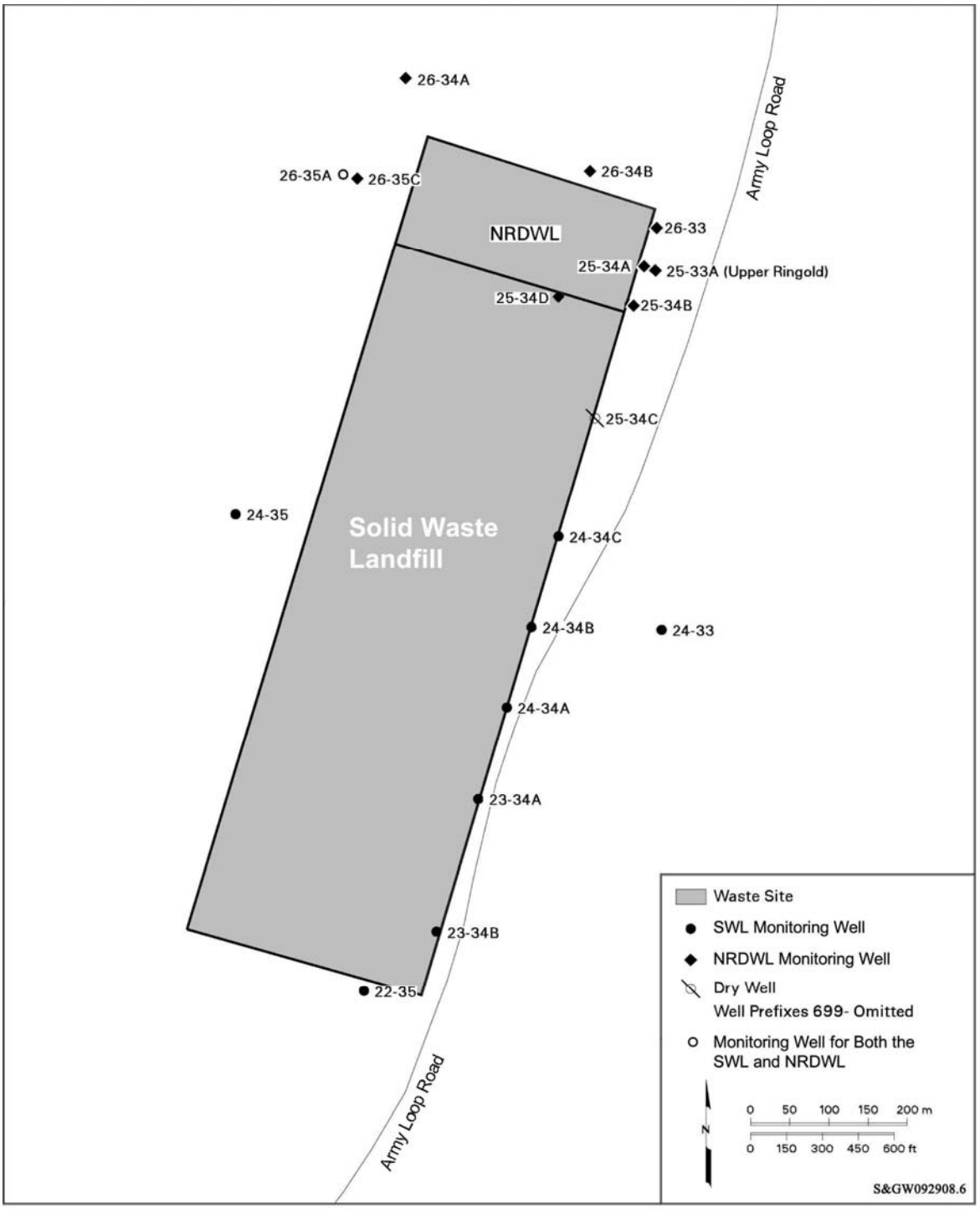

Figure 2-3. Current NRDWL and SWL Groundwater Monitoring Well Locations

2.2.2 Solid Waste Landfill

Both solid and liquid wastes were disposed at the SWL, including office waste, construction/demolition debris, asbestos material, bulky items, and miscellaneous waste (DOE/RL-2008-54, *Hanford Site Solid Waste Landfill Closure Plan*). Based on waste receipts, the SWL received approximately 400,266 m^3

(1,313,208 ft^3) of solid waste and 14,496 m^3 (47,559 ft^3) of asbestos waste from 1973 to 1995. An estimated 3,800,000 to 5,700,000 L (1,003,850 to 1,505,780 gal) of sewage were discharged to the liquid trenches from 1975 to April 1987.

From 1973 to 1987, liquids (including sewage and 1100 Area catch tank liquids) were discharged to the SWL in separate, shallow trenches dedicated for this purpose. The sewage originated from portable toilets and septic tanks. Non-dangerous catch tank liquid from the 1100 Area heavy equipment garage and bus shop was also disposed in these trenches from 1985 to 1987. The available chemical analysis of the 1100 Area non-dangerous catch liquid detected the following volatile organic compounds (VOCs):

- **Carbon tetrachloride:** Heavy equipment garage, 5.5 and 18 µg/L; bus shop, 31 and <60 µg/L.
- **1,1,1-trichloroethane:** Heavy equipment garage, 208 µg/L; bus shop, 87 µg/L.
- **Trichloroethene (TCE):** Heavy equipment garage, <10 µg/L; bus shop <40 µg/L.
- **Tetrachloroethene (PCE):** Heavy equipment garage, 26 µg/L; bus shop <60 µg/L.

For the 2 years that non-dangerous catch tank waste liquid was disposed at the SWL, the estimated total volume of catch tank waste liquid disposed was 380,000 L (100,385 gal) (DOE/RL-90-38, *Hanford Site Solid Waste Landfill Interim Closure Plan*, Rev. 1). The waste types and volumes are discussed in more detail in DOE/RL-90-38 and DOE/RL-2008-54.

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3 Hydrogeology and Groundwater – Chemistry

This chapter describes the geology, hydrogeology, and groundwater chemistry beneath the NRDWL/SWL WMA.

3.1 Physical Hydrogeology

The geologic units at the NRDWL/SWL WMA include the following, from top to bottom:

- Eolean deposits and recent fill
- Hanford formation
- Cold Creek unit(s)
- Ringold Formation

The Columbia River Basalt underlies the Ringold Formation. The hydrostratigraphic units, as described in *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 1993 Status Report* (PNL-8971), are roughly equivalent to the geologic units. The Hanford formation includes the entire vadose zone and the uppermost-saturated unit; pre-Hanford formation/post-Ringold Formation (Cold Creek) sediments underlie the Hanford formation. The upper portion of the Ringold Formation sediments locally includes a low-permeability unit, which apparently constitutes the local base of the unconfined aquifer beneath the NRDWL/SWL WMA. Figure 3-1 provides a generalized stratigraphic column for the NRDWL/SWL regional area; Figure 3-2 provides a cross-section along the downgradient side of the NRDWL/SWL WMA. Other cross-sections of the region are provided in the NRDWL/SWL closure/post-closure plan (DOE/RL-90-17). The low-permeability unit is a silty or clayey layer, approximately 60 m (197 ft) depth in the HSU5 hydrostratigraphic unit (undifferentiated Ringold). The HSU4 unit (the upper Ringold unit) is likely missing in the immediate vicinity of the NRDWL/SWL WMA, although it is present 4.5 km (2.8 mi) to the east and 3.5 km (2.2 mi) to the north. Wells installed at the SWL were not drilled deep enough to determine the presence of this low-permeability unit below the SWL.

The gravelly Ringold Unit E underlies the low-permeability unit of the upper Ringold. The Ringold lower mud unit is below Ringold Unit E throughout much of the Hanford Site, but the local presence of this unit cannot be verified because wells have not been installed to this depth beneath the NRDWL/SWL WMA. Aquifers in the Saddle Mountains Basalt and below are generally confined by the dense interiors of the basalt flows.

3.2 Groundwater Hydrology

Groundwater in the unconfined aquifer beneath the NRDWL/SWL WMA, as well as in the vadose zone, is discussed in this section. Aquifer characteristics are discussed first, followed by discussion of the vadose zone.

The water table beneath the NRDWL/SWL WMA is near the top of a silty sand unit in the lower portion of the Hanford formation or in the upper portion of the Cold Creek unit. The uppermost aquifer is unconfined and comprises the saturated Hanford sediments, the Cold Creek unit, and possibly the upper portion of Ringold Unit E. The saturated Hanford and Cold Creek unit sediments are gravelly sand to sandy gravel, approximately 18 m (59 ft) thick, and the upper Ringold underlying the Hanford sediments are slightly silty gravelly sand to sand, approximately 4 m (13 ft) thick. The average hydraulic conductivity of the uppermost unconfined aquifer is a composite of both of these units and is estimated at 520 to 1,500 m/day (1,706 to 4,921 ft/day) (WHC-EP-0021, *Interim Hydrogeologic Characterization*

Report and Groundwater Monitoring System for the Nonradioactive Dangerous Waste Landfill, Hanford Site, Washington).

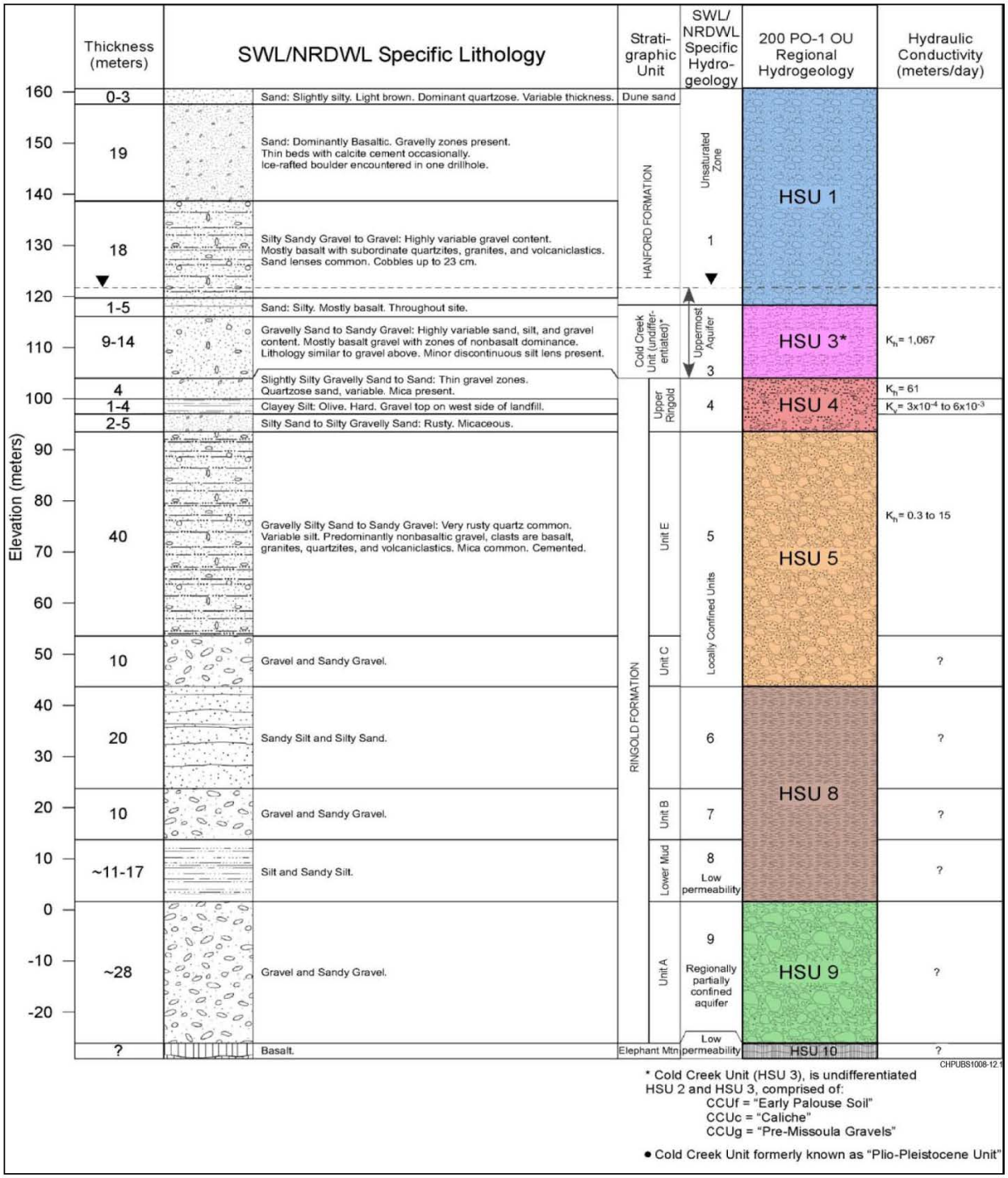


Figure 3-1. Regional Stratigraphy in the Vicinity of the NRDWL/SWL

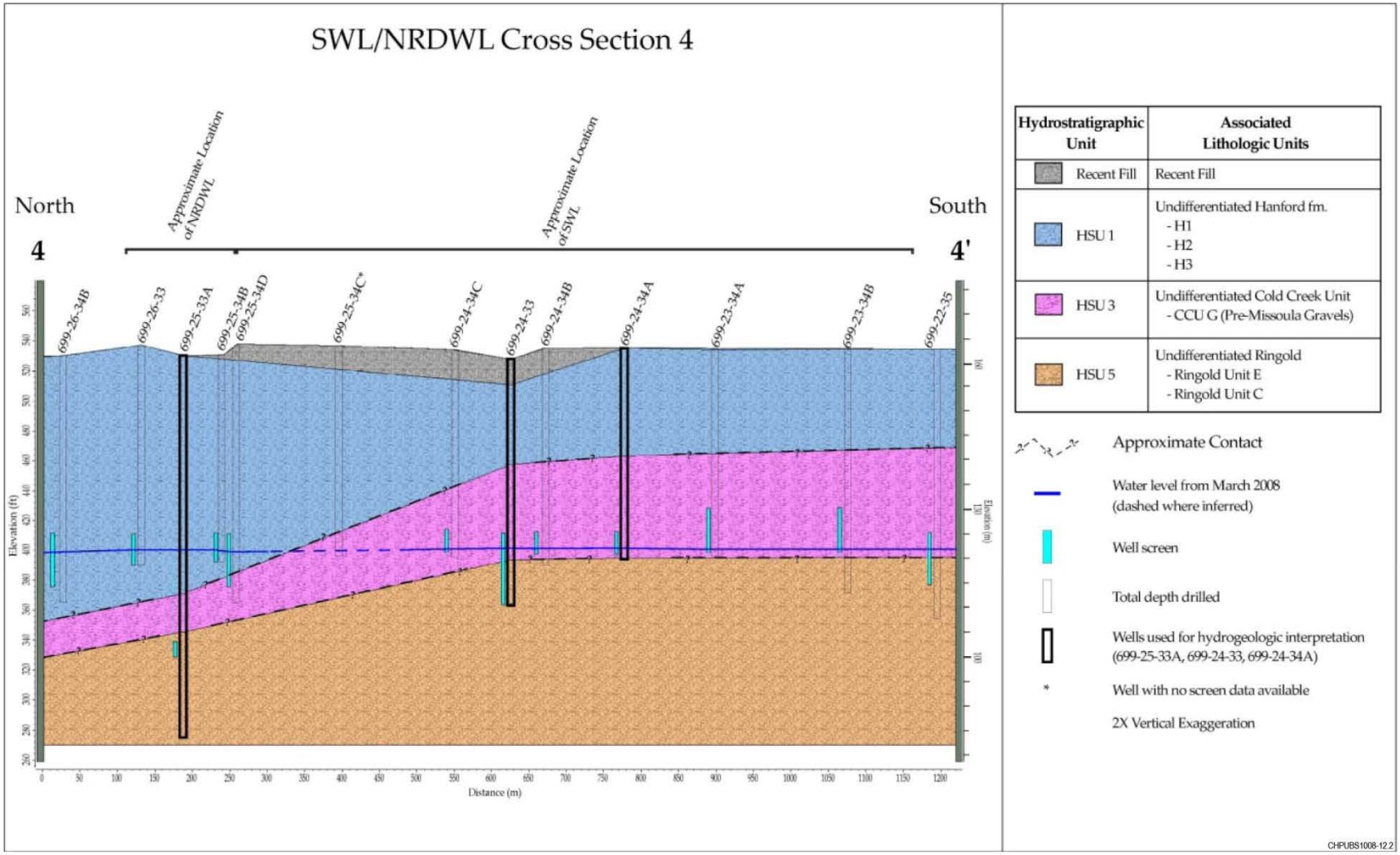


Figure 3-2. Cross-Section Along the Downgradient Side of the NRDWL/SWL WMA

A low-permeability unit in Ringold Unit E is believed to locally form the base of the uppermost aquifer because its hydraulic conductivity is orders of magnitude lower than the overlying sediments. It consists of hard, clayey silt, which is approximately 1 m (3 ft) thick on the east side of the NRDWL and approximately 4 m (13 ft) thick on the west side of the NRDWL. The vertical hydraulic conductivity is estimated to range from 0.0001 to 0.02 m/day (3 to 7 ft/day) (WHC-EP-0021) based on laboratory analysis. The low-permeability unit is believed to be continuous across the NRDWL/SWL WMA because it is continuous across the NRDWL and is approximately 3 m (10 ft) thick in well 699-23-33 (located 640 m [2,100 ft] south of well 699-25-33A). However, this unit is not present at well 699-28-40 (located 1.8 km [1.12 mi] west of the NRDWL/SWL WMA).

Silty sand to sandy gravel of the Ringold Unit E underlies the low-permeability unit, has a hydraulic conductivity of approximately 0.3 to 15 m/day (1 to 49 ft/day), and acts as a locally confined aquifer. The Ringold lower mud unit is below the Ringold Unit E throughout much of the Hanford Site, but the local presence of this unit cannot be verified because wells have not been installed to this depth beneath the NRDWL.

The Columbia River Basalt group underlies the Ringold Formation. Aquifers in the basalt and below are generally confined by the dense interiors of the basalt flows.

The water table directly beneath the NRDWL/SWL WMA is fairly flat, between 121.8 and 122.0 m (399.6 and 400.3 ft) in elevation. The gradient is estimated at 0.00002 (DOE/RL-2008-66, *Hanford Site Groundwater Monitoring for Fiscal Year 2008*, Table B-1), and groundwater flows toward the east and southeast (Figure 3-3). Although the gradient is too low to measure with a high degree of certainty, historical water table maps from 1944, 1989, and 1995 (DOE/RL-96-61, *Hanford Site Background: Part 3, Groundwater Background*) and groundwater contaminant plumes from the 200 East Area corroborate groundwater flow toward the east and southeast (DOE/RL-2008-66). In addition, groundwater is inferred to flow southeast within the region between the 200 East Area and the NRDWL/SWL WMA because the average water-level elevation at the landfill (121.88 m [400 ft] North American Vertical Datum of 1988 [NAVD88] for March 2008) is 0.14 m (0.46 ft) less than the average elevation in the 200 East Area (122.02 m NAVD88 for March 2008) over a distance of approximately 8 km (5 mi). This yields a regional hydraulic gradient of 1.8×10^{-5} (DOE/RL-2008-66).

The groundwater flow rate beneath the NRDWL/SWL WMA is calculated to range from 0.03 to 0.27 m/day (0.10 to 0.89 ft) based on a hydraulic conductivity range of 500 to 1,500 m/day (1,640 to 4,921 ft/day), an effective porosity range of 0.1 to 0.3, and using the standard Darcy equation (DOE/RL-2008-66, Table B-1).

Two wells at the NRDWL (699-25-35C and 699-25-33A) sample the bottom of the uppermost aquifer, just above the low-permeability unit. Heads in these wells are virtually the same as in adjacent wells completed at the top of the aquifer, indicating no significant vertical gradient (PNNL-12086, *Hanford Site Groundwater Monitoring for Fiscal Year 1998*, Section 3.7).

The vadose zone is approximately 40 m (131 ft) thick, including sand, silty sandy gravel, and gravel. Because of the relatively thick vadose zone and low moisture content of the vadose zone sediments, travel time for unsaturated flow through the vadose may be longer than the time since the landfills were put into service.

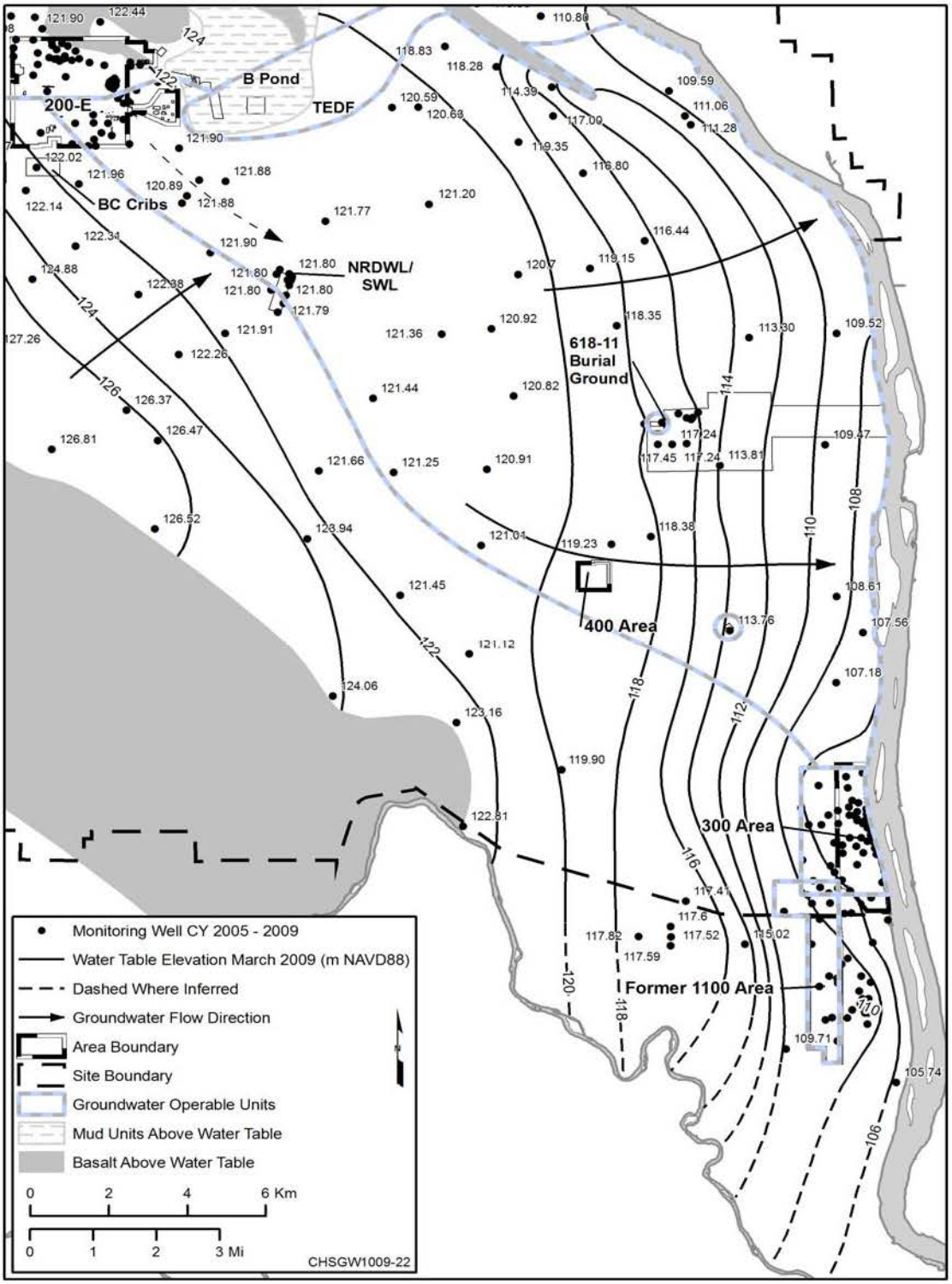


Figure 3-3. Water Table Map of the 200-PO-1 Groundwater OU, Including the NRDWL/SWL WMA, March 2009

3.3 Current Well Completions and Conditions

Basic well information is summarized in Table 3-1 for the NRDWL/SWL WMA. The existing groundwater monitoring system at NRDWL includes nine wells (three upgradient and six downgradient) (Figure 2-3). All nine wells meet Washington State standards for resource protections wells in accordance with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells" (construction details of the wells are provided in PNNL-12227, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*). The six downgradient wells are arranged around the east and southeast sides of the landfill in order to detect groundwater constituents moving in the southeastward groundwater flow direction, typical of the uppermost unconfined aquifer in this area. Conversely, the three upgradient wells are located on the western and northwestern sides to sample upgradient (background) groundwater. Two of the nine wells at NRDWL are screened just above the low-permeability unit in the upper portion of the Ringold Formation. These wells (699-26-35C is upgradient, and 699-25-33A is downgradient) were completed in this lower unit in order to sample groundwater at the local base of the unconfined aquifer to assess whether constituents derived from the NRDWL are transported to the lower portions of the aquifer. The remaining seven wells are screened at the top of the uppermost aquifer.

Figure 2-3 shows the wells at the SWL, and Table 3-1 provides additional information for these wells. The existing well system includes nine wells, two of which are upgradient; one of these wells (699-25-35A) is shared with the current NRDWL well system. Downgradient well 699-24-33 is the only well not constructed in accordance with WAC 173-160; this is an older well constructed prior to promulgation of the WAC 173-160 well construction requirements. The wells proposed for the groundwater monitoring system under this plan are discussed in Chapter 4.

Table 3-1. Information for Current NRDWL and SWL Monitoring Wells

Well Name	Depth to Water (ft bgs)	Water-Level Date	Water Table Elevation – MSL NAVD88 (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Measured Water Column (ft) (Date Measured)
NRDWL Monitoring Wells						
699-25-33A	130	7/20/2009	400	191	201	10[c]
699-25-34A	132	7/20/2009	400	118	138	2.6 (3/2010)
699-25-34B	131	8/21/2009	400	118	138	7.6 (2006)
699-25-34D	138	8/21/2009	400	127	162	24[c]
699-26-33	137	8/21/2009	400	124	144	7.2 (4/2010)
699-26-34A	130	8/21/2009	400	117	137	7.3 (2002)
699-26-34B	130	8/21/2009	400	118	154	24[c]
699-26-35C	134	8/21/2009	400	193	203	10[c]
699-26-35A[d]	134	7/20/2009	400	120	140	9 (2/2006)

Table 3-1. Information for Current NRDWL and SWL Monitoring Wells

Well Name	Depth to Water (ft bgs)	Water-Level Date	Water Table Elevation – MSL NAVD88 (ft)	Screen Top (ft bgs)	Screen Bottom (ft bgs)	Measured Water Column (ft) (Date Measured)
SWL Monitoring Wells						
699-22-35	~134	7/20/2009	400	122	157	23[c]
699-23-34A	134	7/20/2009	400	121	136	2.4 (6/2008)
699-23-34B	~134	7/20/2009	400	105	136	2[c]
699-24-33[b]	126	7/20/2009	400	116[a]	164[a]	38[c]
699-24-34A	135	7/20/2009	400	123	137	2.1 (5/2007)
699-24-34B	135	7/20/2009	400	122	137	2.3 (8/2008)
699-24-34C	134	7/20/2009	400	121	136	3.2 (12/2003)
699-24-35	140	7/20/2009	400	128	143	2.9 (5/2008)

a. No screen; perforated casing. Depth to top and bottom of casing perforations.

b. Not compliant with WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

c. Calculated from well construction records and water table levels.

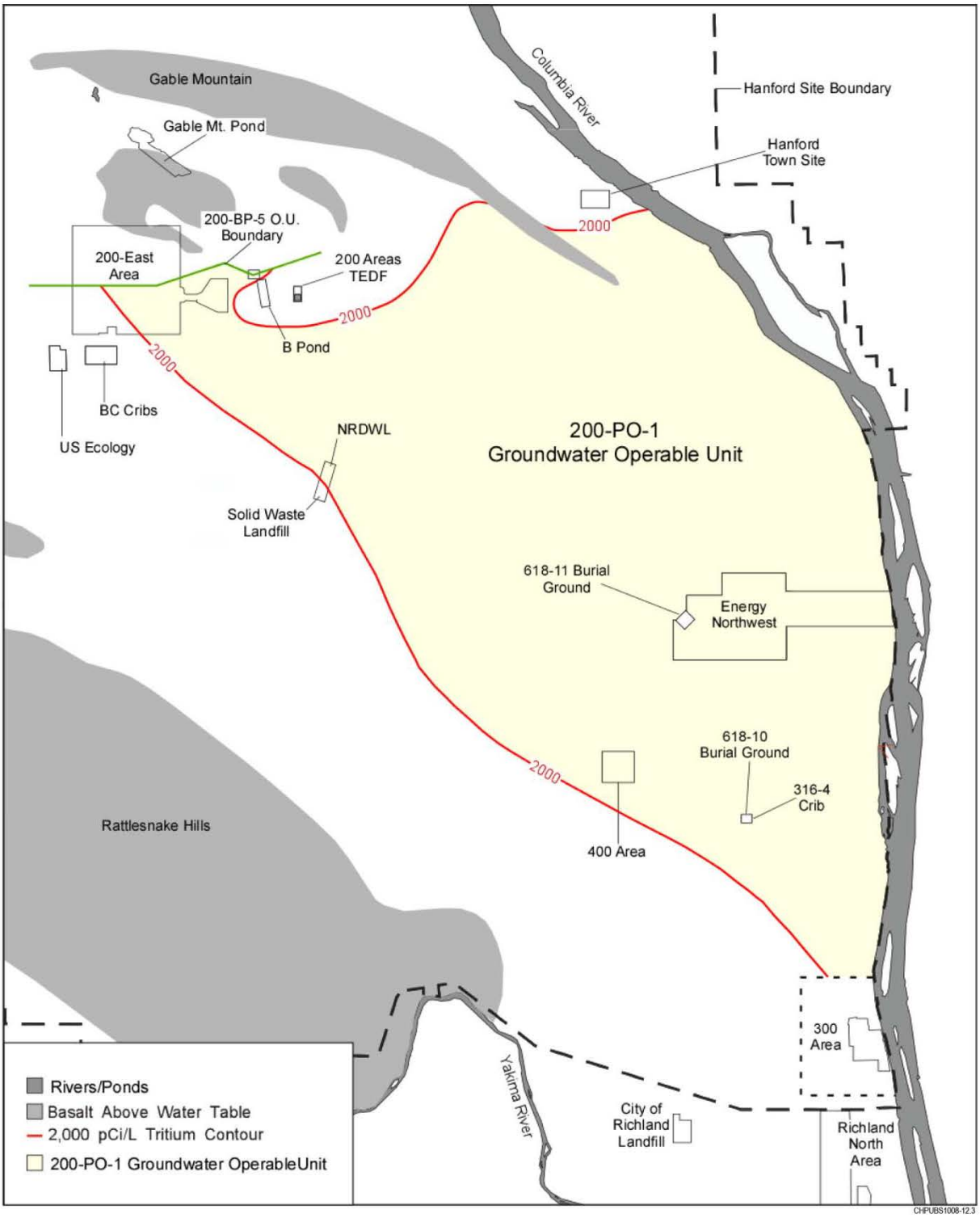
d. Well is shared by NRDWL and SWL in current monitoring plans.

3.4 Groundwater Chemistry

Groundwater monitoring results from the 200-PO-1 Groundwater Operable Unit (OU) and the current NRDWL and SWL monitoring programs are discussed in the following subsections.

3.4.1 Background Conditions

Regional groundwater contaminant sources are identified through the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation activities at the 200-PO-1 Groundwater OU. The 200-PO-1 OU comprises the groundwater beneath a large area in the southeastern portion of the Hanford Site (Figure 3-4). Monitoring results for the 200-PO-1 OU have shown that groundwater upgradient of the NRDWL/SWL WMA has been contaminated from sources in the 200 East Area. The principal contaminant plume from the 200 East Area is a nitrate plume. As this nitrate plume reaches the NRDWL/SWL area, the plume's concentration is approximately 20 mg/L (DOE/RL-2008-66). The drinking water standard (DWS) for nitrate is 45 mg/L (or 10 mg/L nitrogen in nitrate). Other potential groundwater contaminants from the 200 East Area are either not detected beneath the NRDWL/SWL WMA or are similar to background concentrations.



Source: DOE/RL-2008-01, *Hanford Site Groundwater Monitoring Report for FY 2007*.

Figure 3-4. 200-PO-1 Groundwater OU Boundary

3.4.2 NRDWL and SWL Groundwater Monitoring Results

Groundwater monitoring of the NRDWL previously focused on interim status monitoring requirements of the *Resource Conservation and Recovery Act of 1976* (RCRA). The NRDWL facility and closure plan will be incorporated into final status under the Hanford Site RCRA Permit (WA7890008967). Under interim status, the indicator parameters include pH, specific conductance, total organic carbon (TOC), and total organic halides (TOX) (PNNL-12227). Statistical comparisons are made between upgradient and downgradient concentrations. Critical means are calculated from upgradient wells. When downgradient concentrations exceed a critical mean, sampling and analyses are repeated for verification purposes. If verified, monitoring would advance to a groundwater quality assessment program.

The VOCs are monitored because they are contaminants of concern associated with the NRDWL. Nitrate is present in groundwater and has a source in the 200 East Area. The groundwater quality parameters (chloride, iron, manganese, phenols, sodium, and sulfate) are required analytes under the interim status groundwater monitoring program of WAC 173-303-400(3) ("Interim Status Facility Standards") but are either not detected (i.e., phenols) or are detected in concentrations below their respective DWSs (DOE/RL-2008-66).

Two of the four indicator parameters (specific conductance and TOC) have exceeded their critical means in NRDWL downgradient wells in the past, but none currently exceed a critical mean. Specific conductance increased in NRDWL wells and, in fiscal year (FY) 2001, surpassed the previously established critical mean (600.7 µS/cm in FY 2001) at wells 699-25-34A and 699-25-34B. An evaluation of the results indicated that the exceedance was caused by increases in the concentrations of non-dangerous constituents potentially from the adjacent SWL, where these constituents were higher than at the NRDWL. The exceedance of the critical mean for specific conductance did not indicate that the NRDWL had contaminated groundwater with dangerous constituents. The DOE submitted "Results of Assessment at the Non-Radioactive Dangerous Waste Landfill (NRDWL)" (0101-GWVZ-025), which served as both the assessment plan and the assessment report. Indicator evaluation monitoring status resumed in FY 2001. From 2002 to 2009, there were no significant exceedances of the three other indicator parameters.

The critical mean value for TOC was exceeded in samples collected in August 2008 from downgradient wells 699-25-34A and 699-25-34B, and the *Groundwater Quality Assessment Plan for the Non-Radioactive Dangerous Waste Landfill* (SGW-40274) was then prepared and implemented. The results, which are reported in *Groundwater Quality Assessment Report for the Nonradioactive Dangerous Waste Landfill* (SGW-41904), did not indicate dangerous constituents in groundwater associated with the elevated TOC. Indicator evaluation monitoring resumed in FY 2009 and continues to the present.

During FY 2009, specific conductance remained elevated at both the NRDWL and SWL, still due to elevated levels of calcium and magnesium. Concentration trends of specific conductance, calcium, and magnesium (Figures 3-5 through and 3-7) in well 699-24-34C at the SWL and wells 699-25-34A and 699-25-34D at the NRDWL are similar, but concentrations remain higher at the SWL than at the NRDWL.

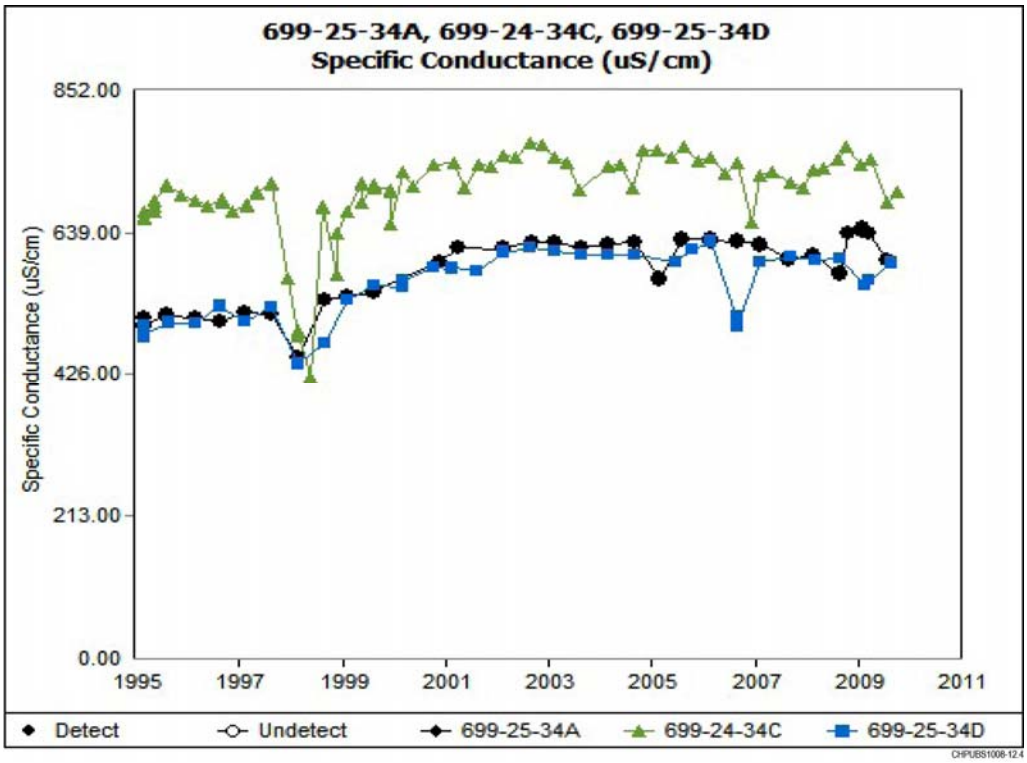


Figure 3-5. Specific Conductance Trends in Wells 699-25-34A, 699-24-34C, and 699-25-34D

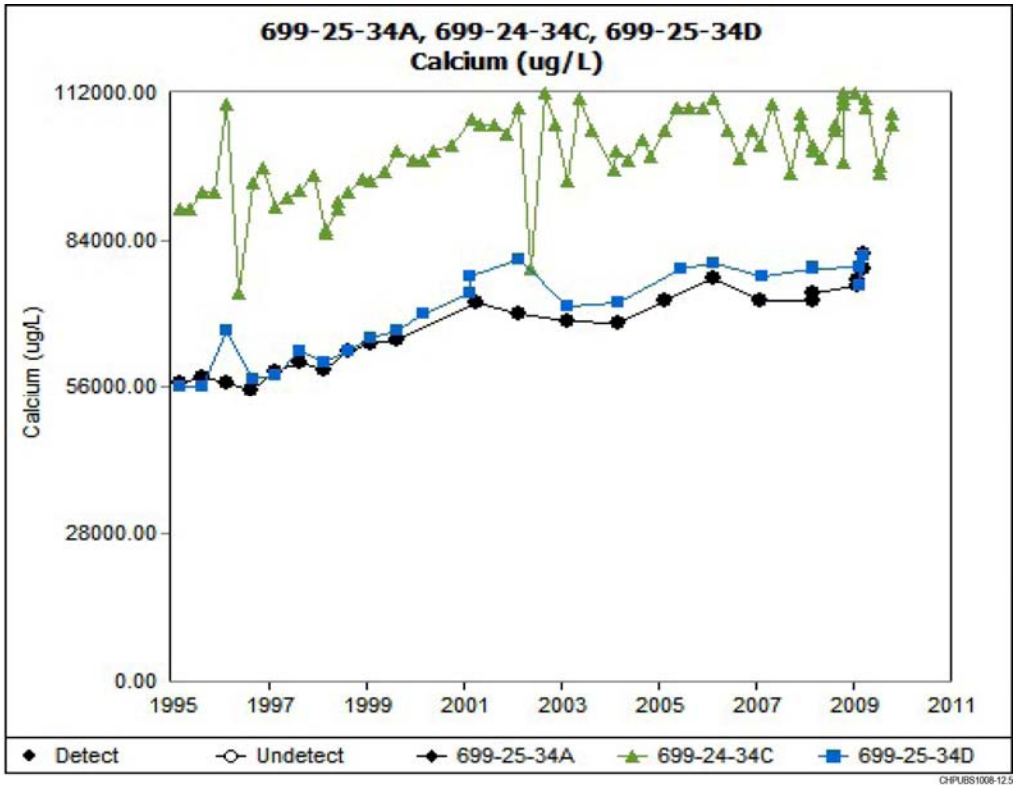


Figure 3-6. Calcium Trends in Wells 699-25-34A, 699-24-34C, and 699-25-34D

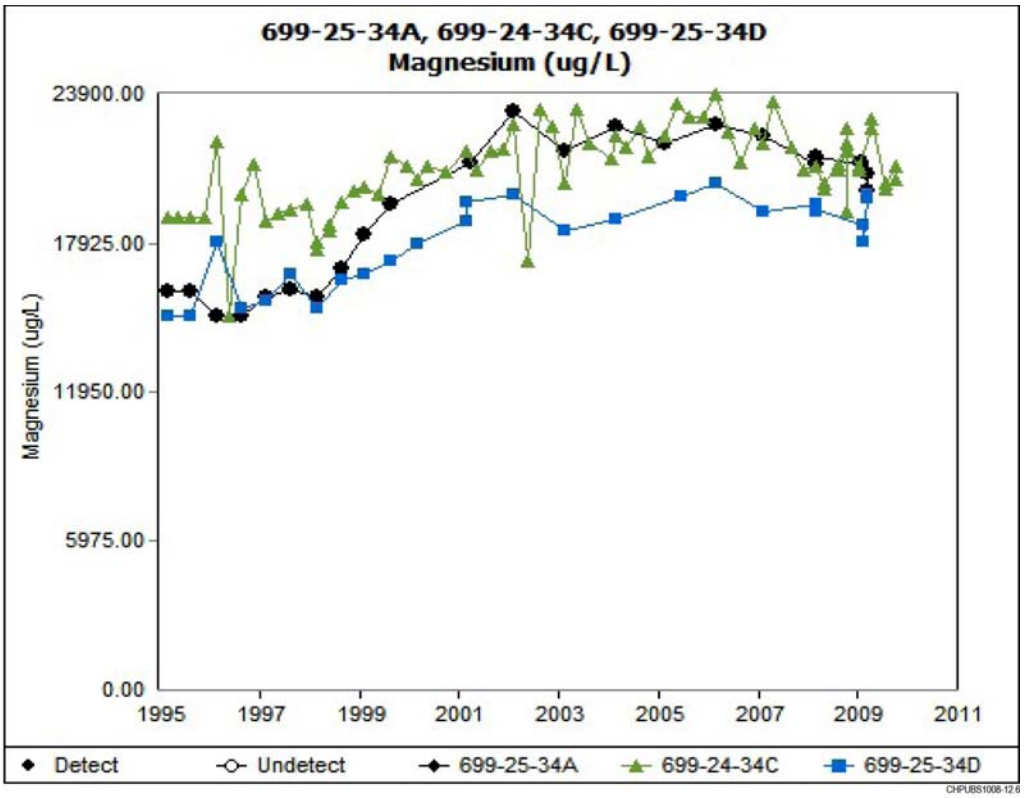


Figure 3-7. Magnesium Trends in Wells 699-25-34A, 699-24-34C, and 699-25-34D

Beginning in 1987, various VOCs were detected in NRDWL and SWL wells (Figures 3-8 through 3-16). Concentrations were already elevated at the time the wells were installed, and concentrations have steadily decreased over time. Six chlorinated hydrocarbons were detected in groundwater during FY 2007 in wells 699-24-33, 699-24-34A, 699-24-34B, 699-24-34C, 699-24-35, 699-25-34A, 699-25-34B, 699-25-34A, 699-26-33, 699-26-34A, 699-26-34B, and 699-26-35A. The detected chlorinated hydrocarbons included PCE, TCE, 1,1,1-trichloroethane, 1,1-dichloroethane, carbon tetrachloride, and chloroform. Most of these results were qualified as estimated values, and none were detected at concentrations above their respective federal DWSs, although concentrations of PCE, carbon tetrachloride, 1,1-dichloroethane, and TCE have exceeded the respective Washington State water quality standards for groundwater (WAC 173-200-040, "Water Quality Standards for Ground Waters of the State of Washington," "Criteria"), as noted in Figure 3-8 and Figures 3-11 through 3-16. Several detections of these same chlorinated hydrocarbons were also reported in FY 2008 and FY 2009 at levels near their respective laboratory method detection limits (MDLs).

Figure 3-8 illustrates that PCE has been below 3 µg/L for a long period, as shown in three selected wells (699-25-34B, 699-25-34D, and 699-26-33), but a short-duration increase was observed in late 2008 and early 2009 (Figure 3-8), which subsequently decreased in late 2009. The TCE in these wells has been stable and below 1 µg/L since 1993 (Figure 3-9). A long-term declining trend is also observed for 1,1,1-trichloroethane, and concentrations have been below 1 µg/L since 2003 (Figure 3-10). Carbon tetrachloride (DWS of 5 µg/L; water quality standard of 0.3 µg/L) in these wells has been below 1 µg/L since FY 1994 (Figure 3-11), with the exception of a reported value of 2 µg/L in early 2009. Subsequently, carbon tetrachloride concentrations returned to non-detect levels. The current MDL for these constituents is 1 µg/L.

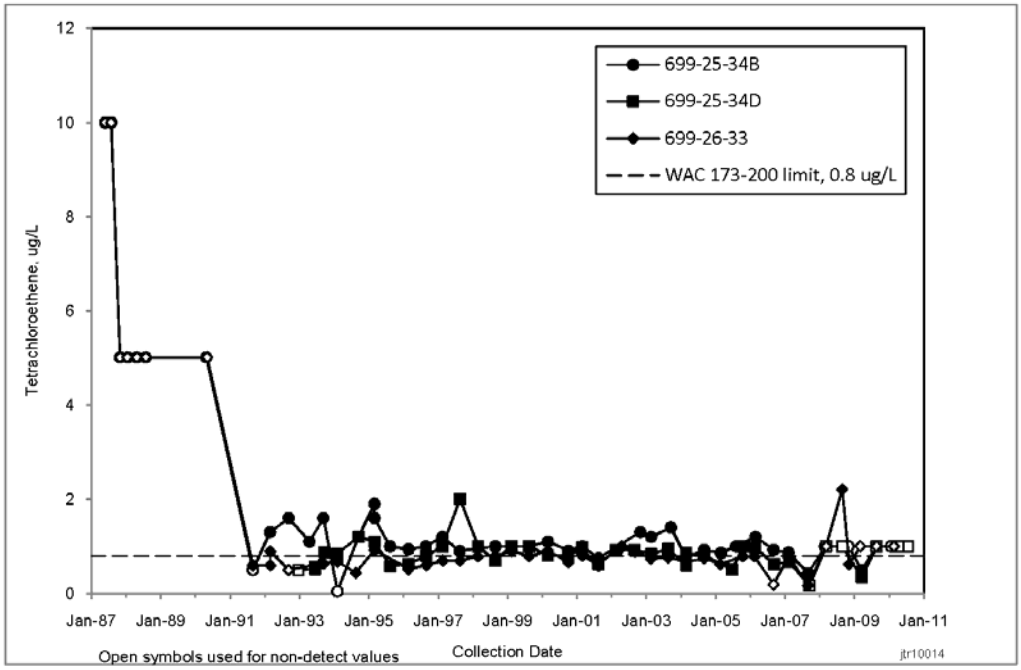


Figure 3-8. PCE Concentrations in Wells 699-25-34B, 699-25-34D, and 699-26-33

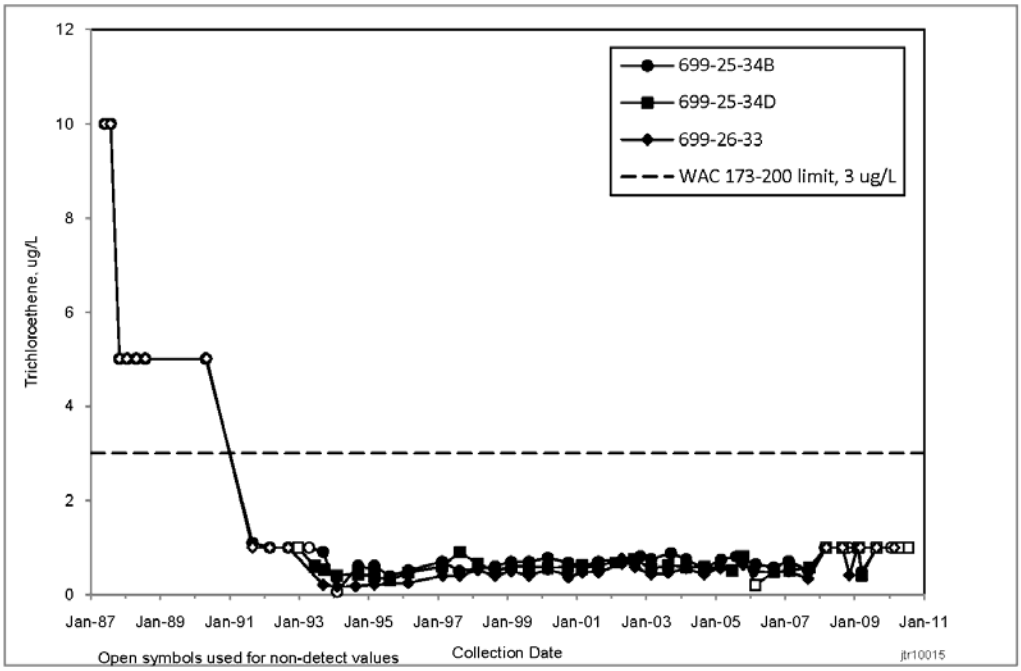


Figure 3-9. TCE Concentrations in Wells 699-25-34B, 699-25-34D, and 699-26-33

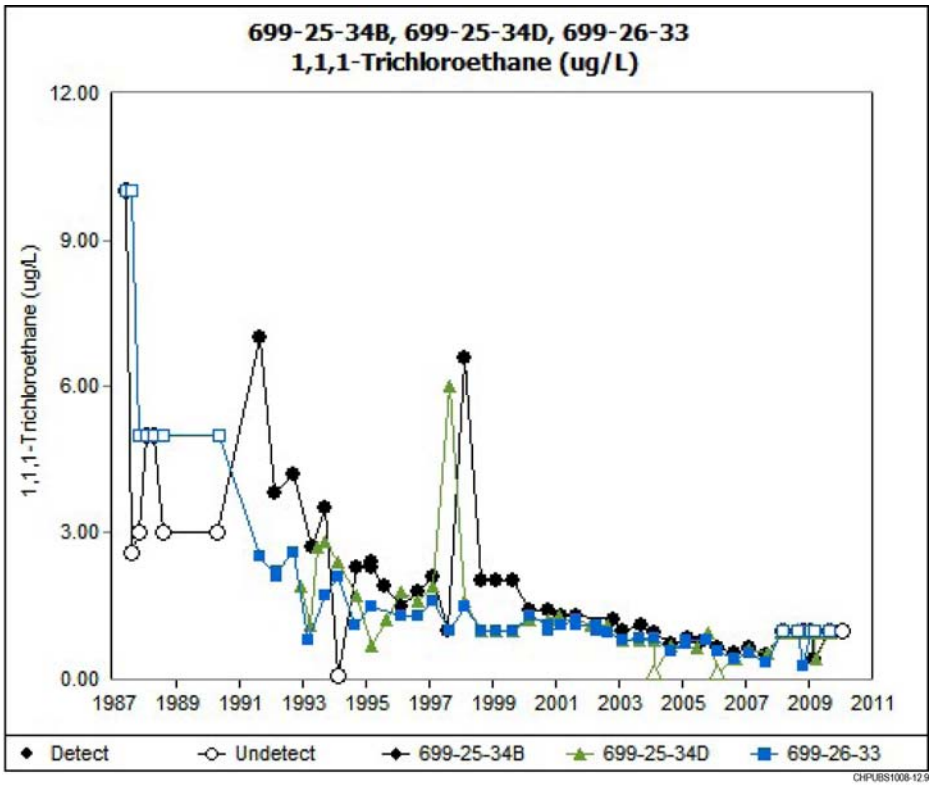


Figure 3-10. 1,1,1-Trichloroethane Concentrations in Wells 699-25-34B, 699-25-34D, and 699-26-33

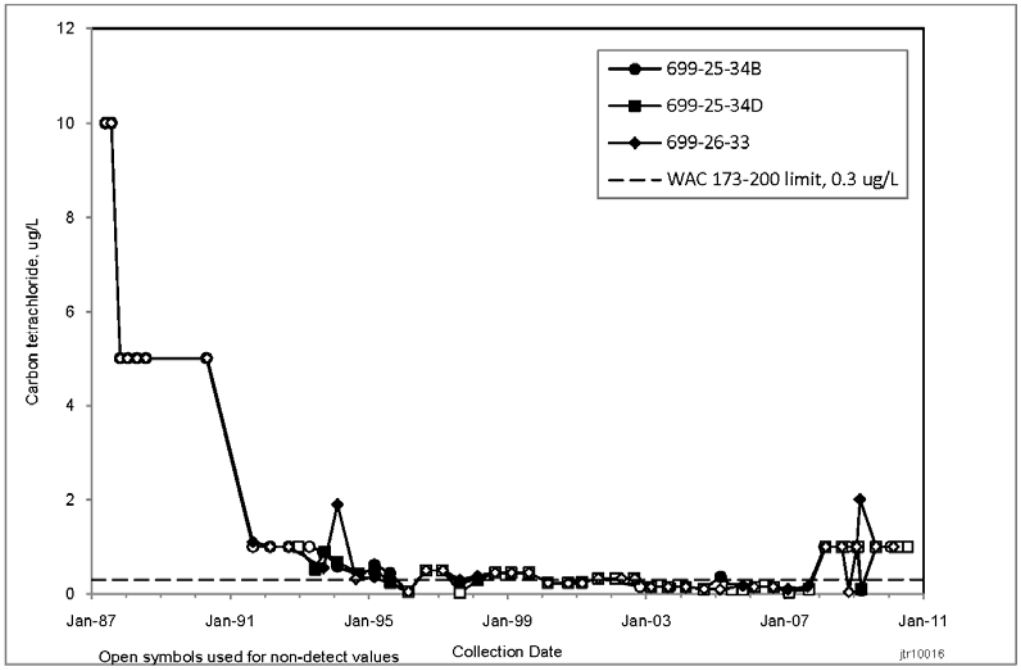


Figure 3-11. Carbon Tetrachloride Concentrations in Wells 699-25-34B, 699-25-34D, and 699-26-33

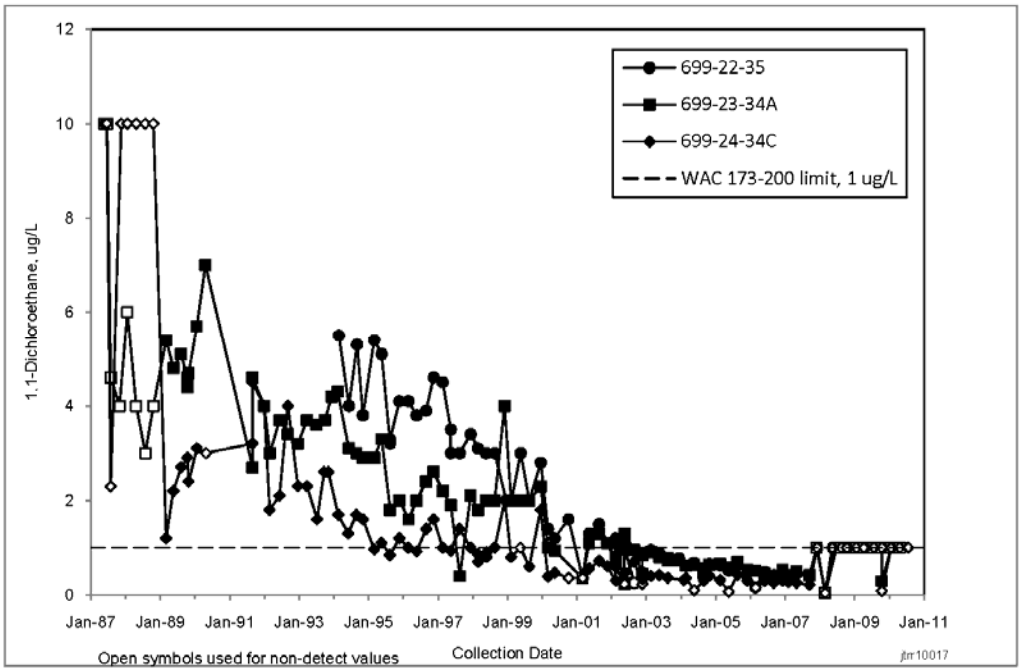


Figure 3-12. 1,1-Dichloroethane Trends in Wells 699-22-35, 699-23-34A, and 699-24-34C at the SWL

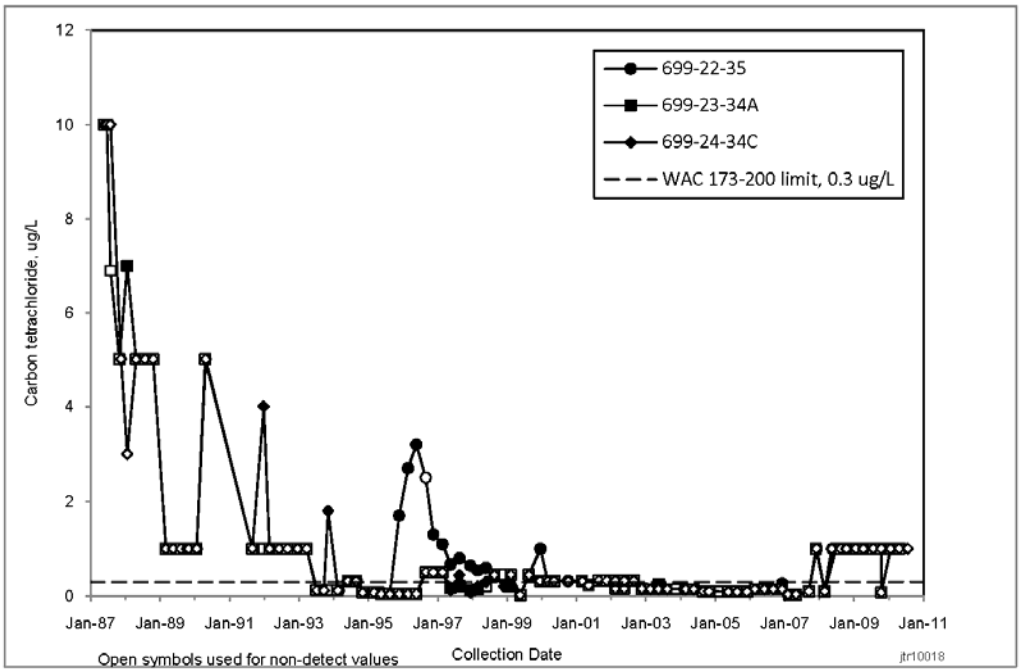


Figure 3-13. Carbon Tetrachloride Trends in Wells 699-22-35, 699-23-34A, and 699-24-34C at the SWL

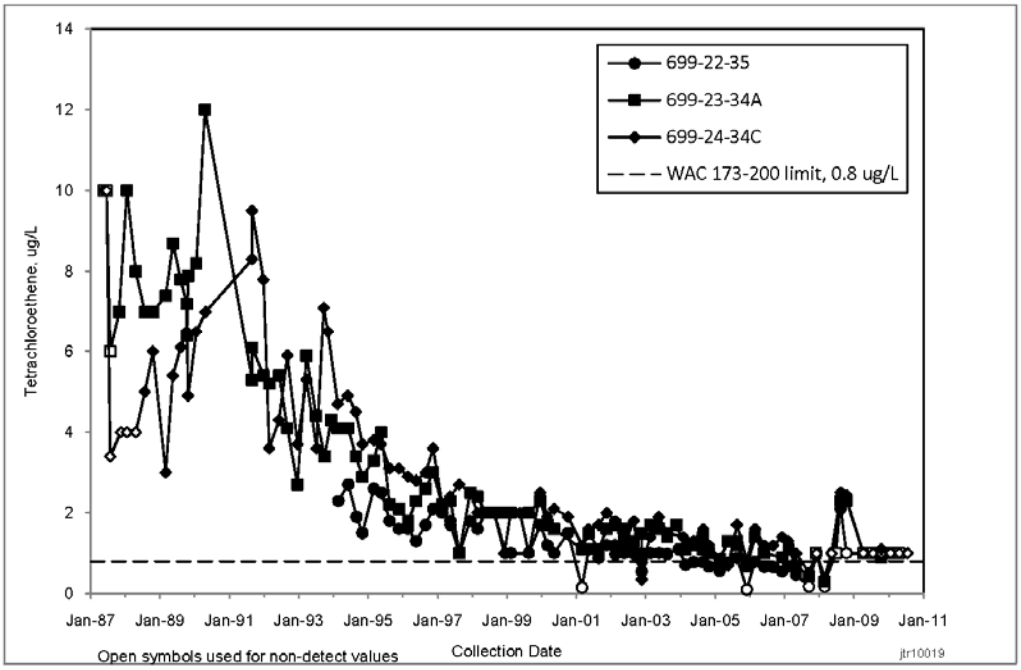


Figure 3-14. PCE Trends in Wells 699-22-35, 699-23-34A, and 699-24-34C at the SWL

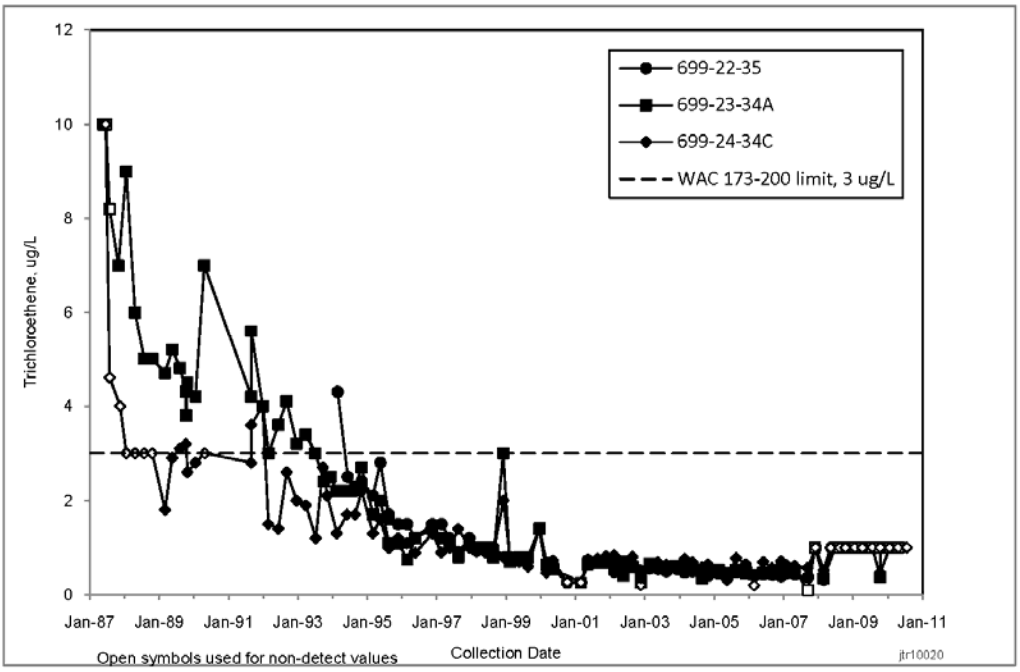


Figure 3-15. TCE Trend in Wells 699-22-35, 699-23-34A, and 699-24-34C at the SWL

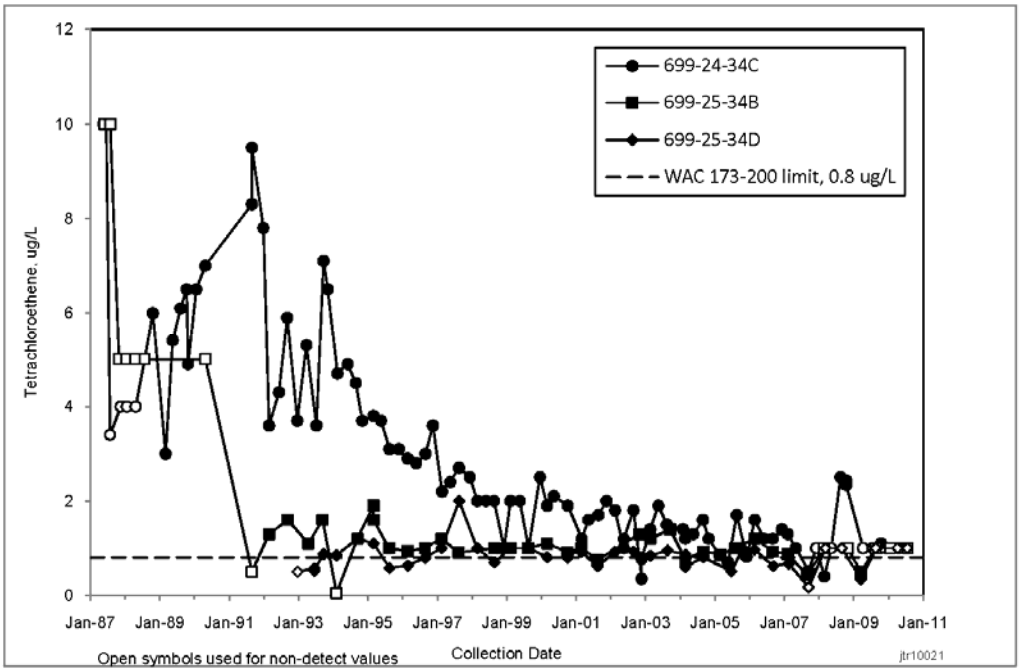


Figure 3-16. PCE Trends in SWL Well 699-24-34C and NRDWL Wells 699-25-34B and 699-25-34D

Two leading possibilities are postulated as the source and transport mechanisms of the chlorinated hydrocarbon contamination in groundwater beneath the NRDWL/SWL WMA. The source is most likely the trenches within the SWL that were known to have received chlorinated hydrocarbon wastes. The contaminants may have had a liquid source from the SWL trenches, traveling through the vadose zone laterally and vertically until reaching the groundwater. Secondly, these contaminants exist in the vadose zone as vapors and possibly traveled laterally through the vadose zone and then vertically to groundwater. Significant movement of the contamination in the aquifer to the upgradient wells cannot occur under groundwater advection alone, so lateral spreading in the vadose zone by vapor migration is a likely predominant transport mechanism.

Groundwater contaminant levels support the assertion that the SWL is a likely source of contamination beneath the NRDWL/SWL WMA. Trend plots for 1,1-dichloroethane, carbon tetrachloride, PCE, and TCE for SWL wells 699-22-35, 699-23-34A, and 699-24-34C are provided in Figures 3-12 through 3-15 to demonstrate the previously elevated levels and the declining trends of these contaminants in SWL wells. The PCE concentrations for SWL well 699-24-34C and NRDWL wells 699-25-34B and 699-25-34D (Figure 3-16) demonstrate the relationship between the contamination in downgradient SWL and NRDWL wells. The PCE levels in SWL wells have historically been higher than levels in NRDWL wells; this is also demonstrated by PCE distributions in groundwater for August 1991, February 1994, and February 2007, as shown in Figures 3-17 through 3-19. These figures also further illustrate the declining trends in PCE concentrations.

The increase in PCE in late 2008 and early 2009 to levels as high as 4.5 µg/L cannot be explained; however, the results were flagged with a “J” qualifier, which indicates results greater than the laboratory MDL but less than the contract-required detection limit. In addition, the increase occurred in 12 wells nearly simultaneously; results were reported between 3.3 and 4.5 µg/L for samples collected between January 19 and February 10, 2009. The results for samples collected after March 2010 have returned to <1 µg/L or non-detect. Furthermore, results from six wells in the 200 West Area between December 2008

and January 2009 indicated similar increases, with subsequent results returning to non-detects. The elevated results have been flagged as suspect in the database.

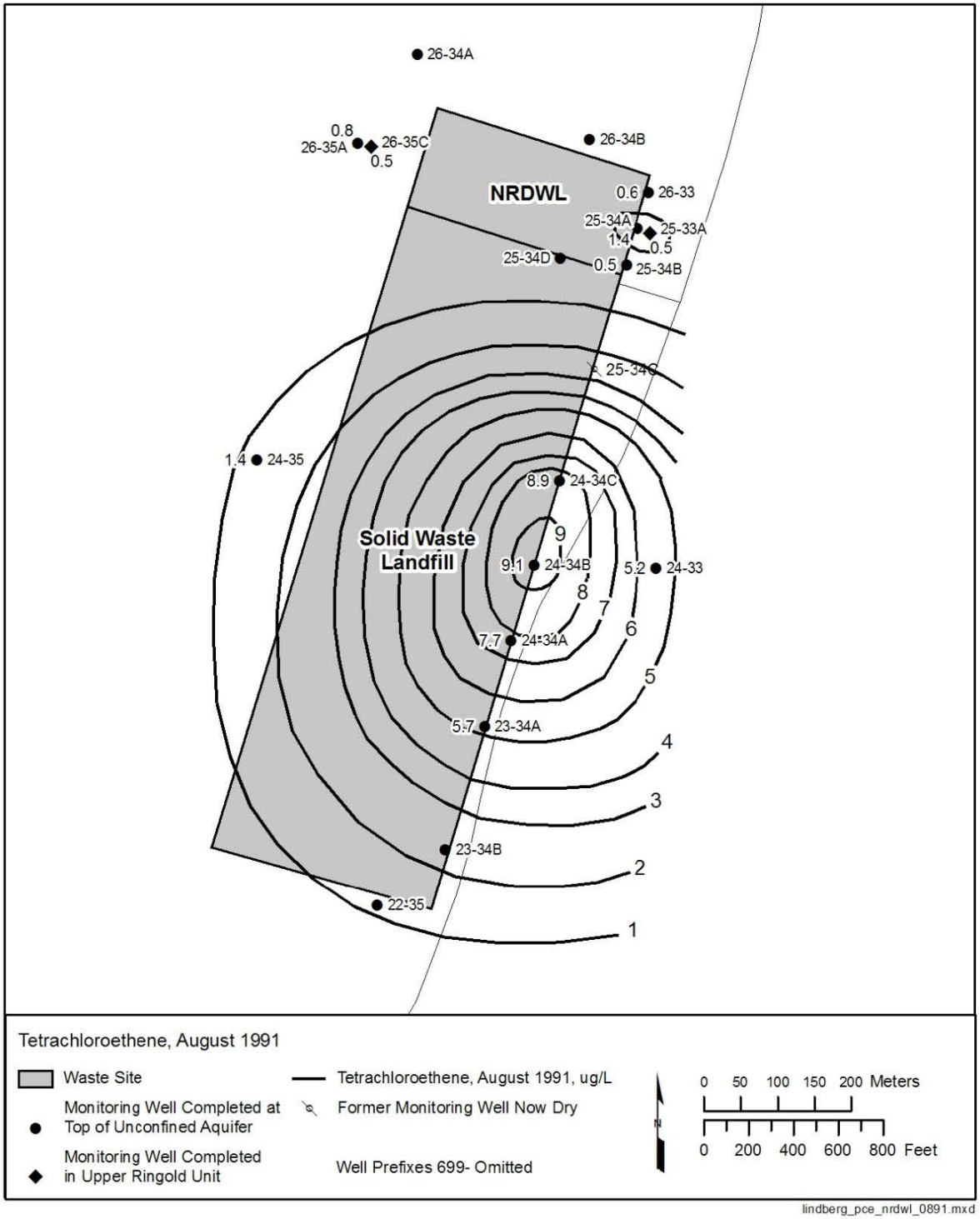


Figure 3-17. PCE Plume at the NRDWL and SWL, August 1991

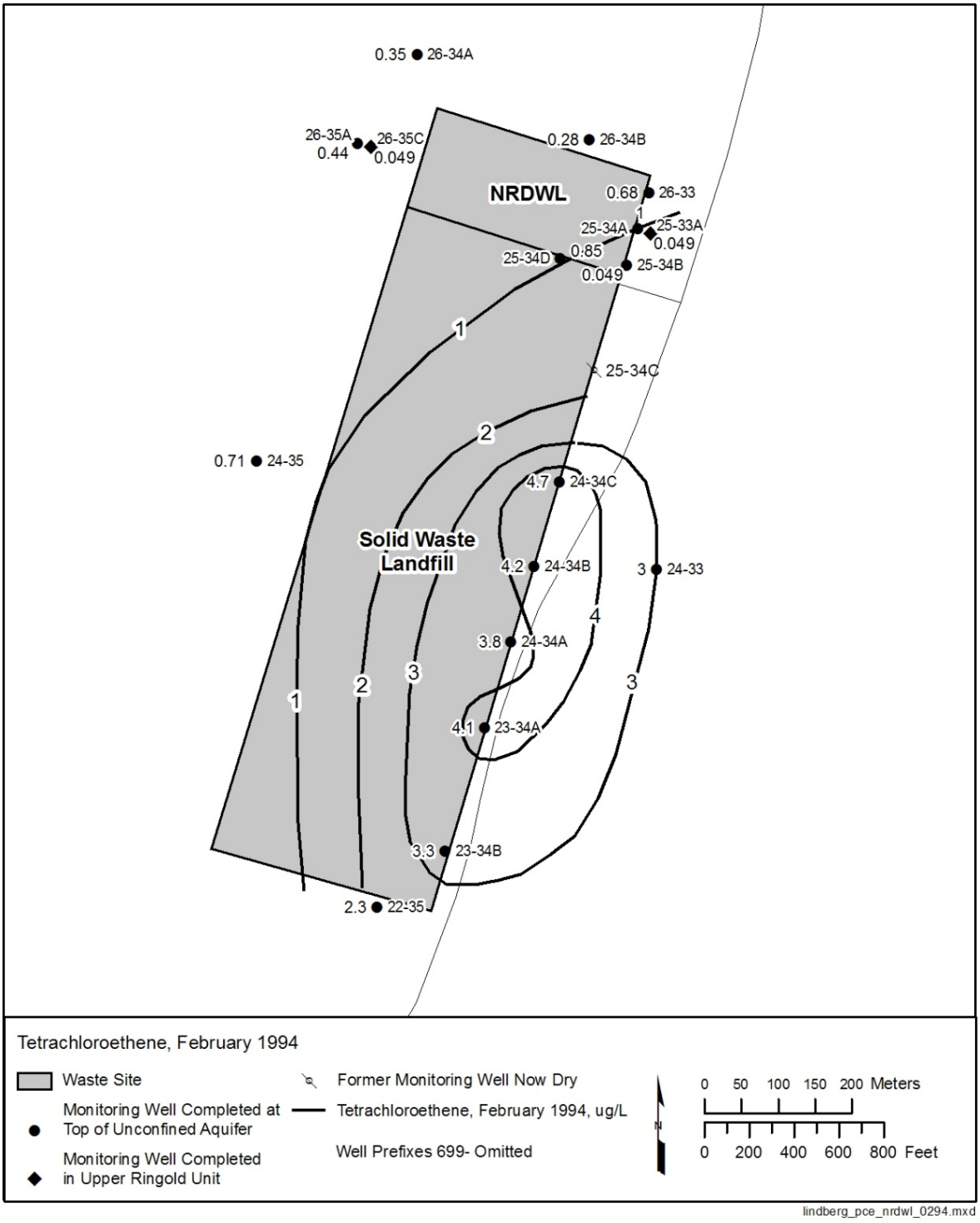


Figure 3-18. PCE Plume at the NRDWL and SWL, February 1994

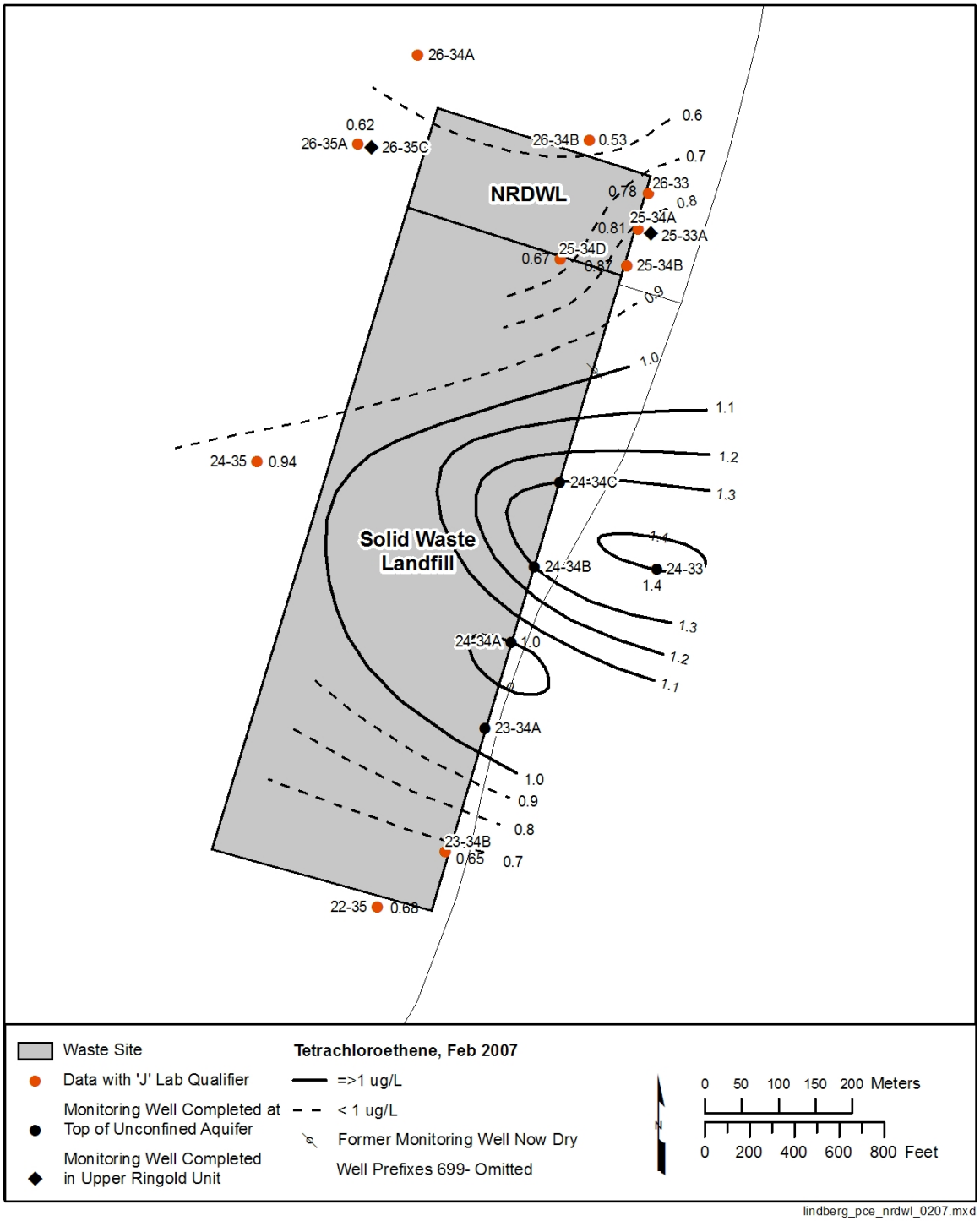


Figure 3-19. PCE Plume at the NRDWL and SWL, February 2007

3.4.3 Barium and Nickel at the NRDWL and SWL

Since 1986, the SWL was monitored as a solid waste managed unit under WAC 173-304, not as a TSD unit under WAC 173-303. According to the approved groundwater monitoring plan, specific parameters were evaluated and reported, which did not include barium and nickel. However, for qualitative

characterization in support of development of the revised groundwater monitoring plan for final closure and post-closure activities, detections of all available analytical constituents at the SWL were compared to Appendix 5 of Ecology Publication 97-407, *Chemical Test Methods for Designating Dangerous Waste: WAC 173-303-090 and -100*. As a result of the analysis, two constituents on that list, barium and nickel, were measured at concentrations elevated relative to upgradient measurements at a limited number of wells at the SWL, and they were not found at elevated levels at the NRDWL. The following subsections provide a more detailed discussion of these findings.

3.4.3.1 Barium

Figure 3-20 shows barium concentrations measured near the SWL. The maximum concentration limit for barium is 1,000 µg/L (WAC 173-303-645, Table 1). Barium concentrations are highest at well 699-22-35, near the southern border of the SWL, but concentrations well below the maximum contaminant level. Barium levels decrease northward but are consistently higher than concentrations near upgradient well 699-24-35. Well 699-32-43 is a far-field well (>2,000 m [6,562 ft]) upgradient and shows low levels of barium, indicating that barium may not be originating from upgradient sources in the 200 East Area.

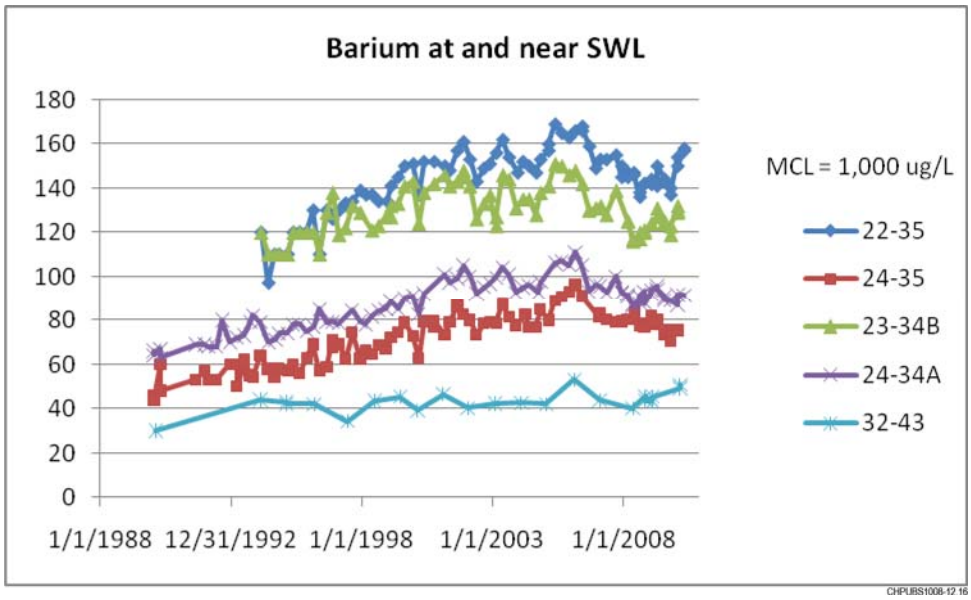


Figure 3-20. Barium Concentrations near the SWL

Figure 3-21 shows the elevated barium concentrations from 2008 to present at downgradient well 699-22-35 relative to upgradient well 699-24-35. The information in this section provides qualitative information that barium concentrations are elevated relative to other wells, including upgradient wells. Statistical analysis performed in accordance with this plan will provide a quantitative analysis whether barium concentrations in some downgradient wells are statistically significant relative to barium concentrations in upgradient wells.

3.4.3.2 Nickel

Figure 3-22 shows nickel concentrations for wells 699-24-34A and 699-24-35 measured from 2005 to April 2010. Nickel appears to be consistently higher in downgradient well 699-24-34A than in upgradient well 699-24-35.

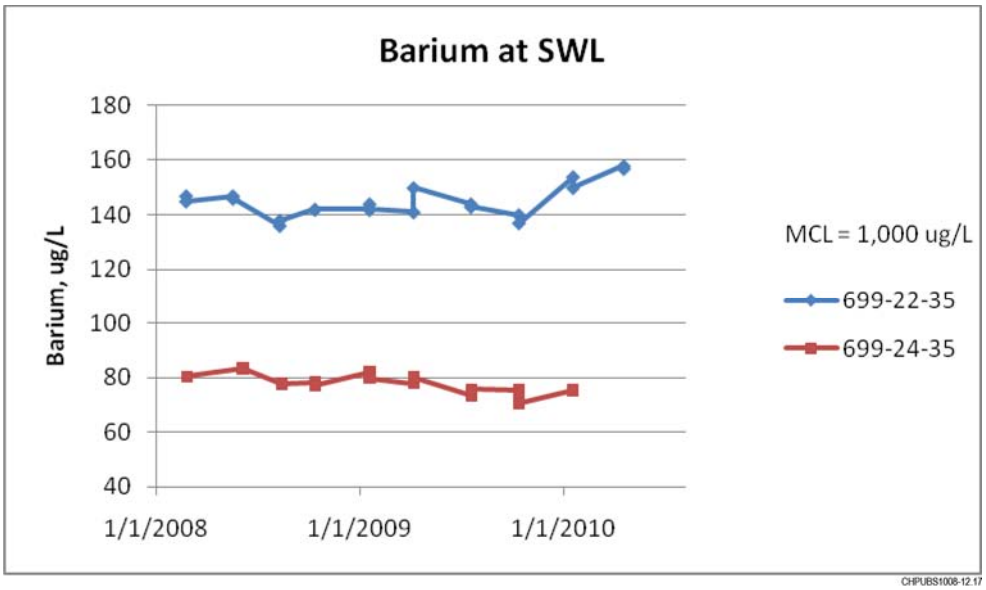


Figure 3-21. Barium at Well 699-22-35 Versus Well 699-24-35 Since 2008

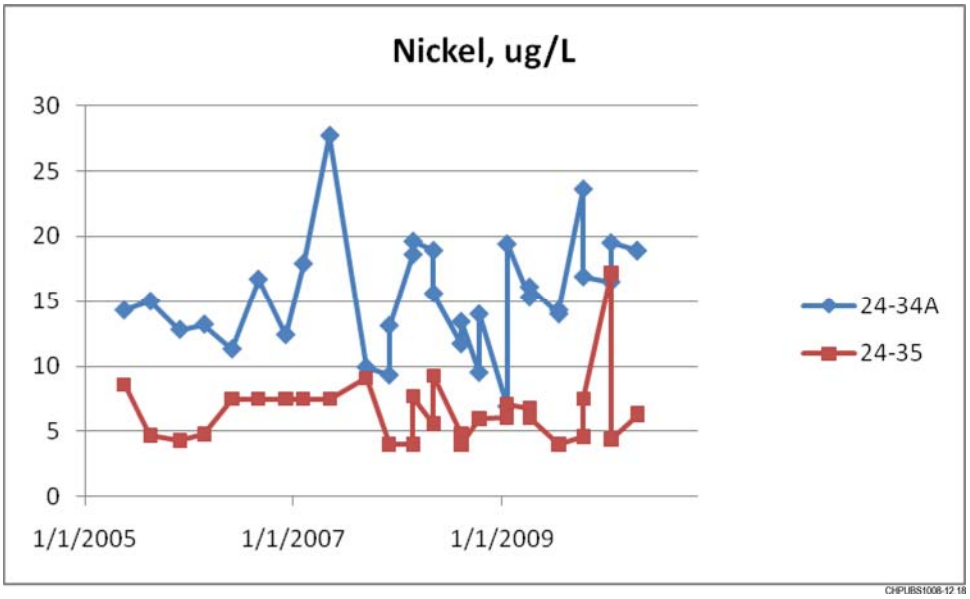


Figure 3-22. Concentration Differences for Nickel in Wells 699-24-34A and 699-24-35

Figure 3-23 shows nickel concentrations for additional wells 699-24-34B and 699-22-35 over the same period. Well 699-22-35 exhibited high concentrations of barium but not high nickel concentrations. Nickel measurements in these wells exhibited significant variability; however, well 699-24-34A appears to have consistently higher nickel measurements than the other SWL wells.

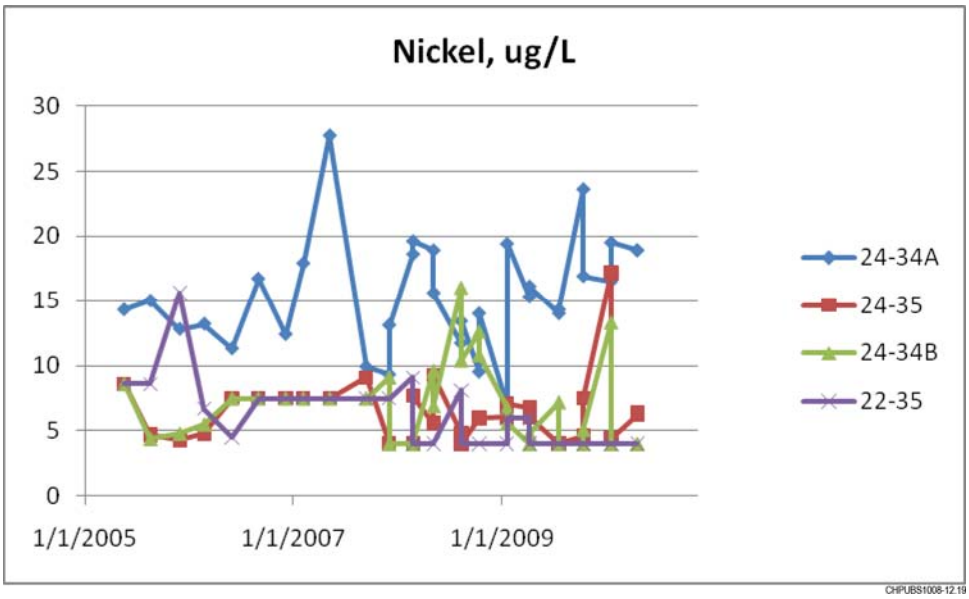


Figure 3-23. Nickel in Several Wells near the SWL

The results discussed above cannot be used to determine whether the WMA has impacted groundwater quality because the results are only qualitative comparisons using concentration trend plots. To make decisions regarding whether downgradient wells have higher concentrations than upgradient wells, the use of one or more statistical treatments is required in accordance with WAC 173-303-645. Future sampling, analysis, and evaluation under this plan, and in accordance with the requirements of WAC 173-303-645, will allow for such a determination.

3.4.4 Vadose Zone Chemistry

The vadose zone beneath the NRDWL/SWL site was impacted by sewage and 1100 Area catch tank liquid that were discharged to the liquid waste trenches at the SWL, as well as potentially small quantities of liquid waste in drums or laboratory packs with surrounding absorbing material. The total quantity of liquid waste discharged to the liquid waste trenches was 4.18 to 6.08 million L (4,180 to 6,080 m^3, or 1.1 to 1.6 million gal) over a 12-year period from 1975 to 1987 (see Section 2.2.2). The volume of the pore space beneath the trenches (to the water table) is approximately 26,380 m^3 (6,968,859 gal), assuming 25 percent pore space in the vadose zone sediment (2,638 m^2 [28,395 ft^2] for the area of the liquid waste trenches and 40 m [131 ft] to the water table). Thus, the volume of waste is approximately 6,000 m^3 (1,585,032 gal), and the available pore space is approximately 26,000 m^3 (6,868,473 gal). With the total volume of wastewater less than one-fourth of the available pore volume beneath the liquid waste trenches, it is unlikely that liquid waste discharges migrated to the water table as saturated flow.

The impact to the groundwater from the waste disposed within the NRDWL/SWL facility is likely limited to that which can be transported by soil vapor, such as pH and anion/cation changes due to carbon dioxide increases from the sewage, and VOCs from soil vapor discharged from the 1100 Area catch tank liquid. It is also helpful to explain the radial pattern to the PCE plume maps shown in Figures 3-17, 3-18, and 3-19 and the impact to upgradient wells that would (under normal advection in the aquifer) remain unaffected by PCE transport in liquid form. The remainder of this section provides a discussion of the results from soil vapor surveys (Section 3.4.4.1) and the leachate collection system (Section 3.4.4.2).

3.4.4.1 Soil Vapor Survey

The first soil vapor survey was conducted at the SWL from June 1988 through February 1989 to determine the areal extent of chlorinated hydrocarbons (PNL-7147, *Final Report: Soil Gas Survey at the Solid Waste Landfill*). The survey found detectable concentrations of 1,1,1-trichloroethane, TCE, PCE, 1,1-dichloroethane, carbon tetrachloride, carbon dioxide, and methane. Concentrations of 1,1,1-trichloroethane, PCE, and TCE were detected as far as 130 m (427 ft) west and 115 m (426 ft) east of the SWL trenches. This further supports the hypothesis provided earlier regarding lateral transport of contaminants by vapor migration. This lateral transport of VOC vapors also likely affects underlying groundwater. Low levels of these same VOCs were discovered in groundwater samples, including samples from upgradient wells. However, the vadose zone soil vapor survey results show that the areas of relatively high soil vapor concentrations generally do not necessarily coincide with locations of the known liquid disposal trenches.

In situ soil vapor samples were collected during the drilling of groundwater monitoring well 699-22-35 and 699-23-34B at the southeast corner of the SWL in FY 1993 and FY 1994 (PNNL-11709, *Borehole Completion Data Package for Solid Waste Landfill Facility Wells 699-22-35 and 699-23-34B*). Samples were collected approximately every 6 m (20 ft) at each borehole. The only target analyte detected in the borehole samples was carbon tetrachloride. Each of the 11 borehole samples contained detectable quantities of carbon tetrachloride in concentrations, ranging from 0.1 to 1.4 parts per million by volume.

Sixteen soil vapor probes were permanently installed at eight locations around the perimeter of the SWL (Figure 3-24) in September 1993 to monitor concentrations of landfill gases (methane, carbon dioxide, and oxygen) in accordance with WAC 173-304; they were also sampled and analyzed using field-screening methods for chlorinated hydrocarbons. Regular monitoring has continued from 1996 to present. The only VOC analyte noted in the 1996 sampling was 1,1,1-trichloroethane, which quickly decreased from a high of 2.44 µg/L in November 1996 to non-detectable starting in January 1999. The VOCs were no longer detected after 2006. These results are summarized in DOE/RL-2008-54.

3.4.4.2 Leachate Collection System

In 1992, a basin lysimeter was installed beneath the southern end of double Trench 41 and 42 (Figure 2-2), which was closed in October 1992. The lysimeter has a collection area of 88 m^2 (289 ft^2). A discharge pipe drains the leachate from the lysimeter basin to a sump where leachate generated by water infiltrating through the overlying waste trench is collected. The leachate quality and quantity are analyzed to evaluate the impact that leachate may potentially have on groundwater quality. The leachate lysimeter monitoring system is discussed further in DOE/RL-2008-54.

Leachate samples were initially analyzed for parameters specified in the SWL permit application (DOE/RL-90-38, *Hanford Site Solid Waste Landfill Permit Application*, Rev. 0). A sampling and analysis plan for leachate was developed that is consistent with the provisions of the SWL interim closure plan and the permit application (DOE/RL-90-38, Rev. 1). Several organic contaminants, including 1,4-dioxane, were detected in the early rounds of sampling in 1996 and 1997; however, levels have since dropped for most organic contaminants. Results from 2006 and 2007 indicated the continued presence of low levels of 1,4-dichlorobenzene. Total dissolved solids, arsenic, iron, manganese, and nickel exceeded their respective primary or secondary DWSs at least once in the 2006 and 2007 leachate samples (DOE/RL-2008-54). This leachate is collected just below the waste, approximately 35 m (115 ft) above the groundwater. The leachate results are useful for selecting indicator parameters for detection monitoring.

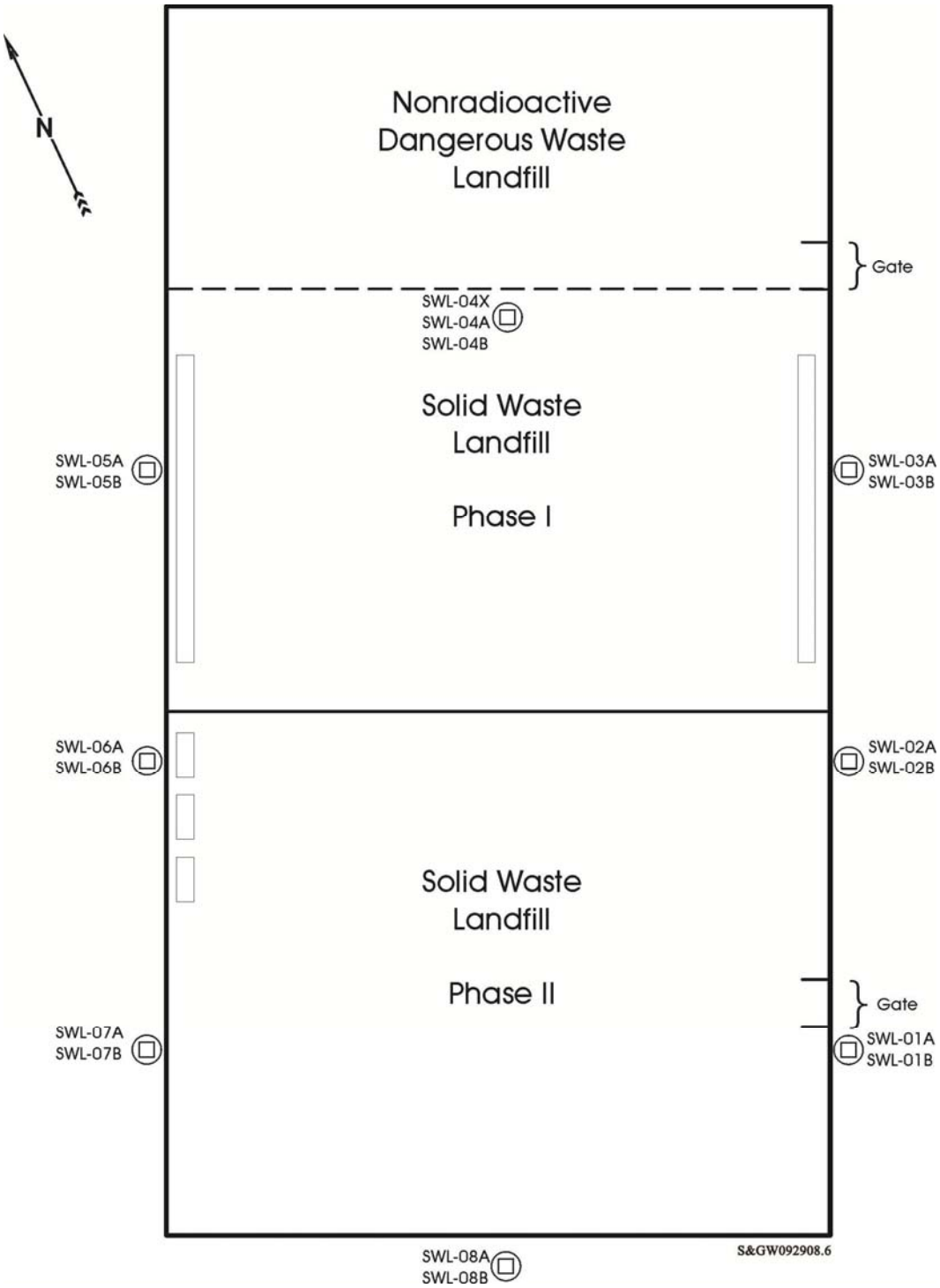


Figure 3-24. Location of Soil Vapor Monitoring Stations at the SWL

4 Groundwater Monitoring Program

Figure 4-1 shows the groundwater monitoring wells to be monitored at the NRDWL/SWL WMA under this monitoring plan. This well system is capable of yielding groundwater samples from the uppermost aquifer that provide the following:

- Represent the quality of background water that has not been affected by leakage from the NRDWL/SWL WMA
- Represent the quality of groundwater passing the point of compliance
- Allow for the detection of contamination when constituents have migrated from the NRDWL/SWL WMA to the uppermost aquifer

This groundwater monitoring program is designed to determine whether statistically significant evidence exists of contamination in the uppermost aquifer attributable to the NRDWL/SWL WMA and to provide the process and schedule for actions, notification, and permit modification, if necessary. The detection monitoring system provides a new groundwater monitoring system that includes upgradient wells, compliance wells, a far-field well, and deep wells. The wells are discussed in Section 4.3.

The leachate collection and soil vapor monitoring systems have been useful in the past to provide information about the presence of liquid waste beneath the trenches and contaminants as soil vapor in the vadose zone at the SWL. These systems also provide an indication of moisture infiltration from the surface. Because these systems provide information to complement the groundwater monitoring well system, the systems will continue to be operational during the closure and post-closure periods.

4.1 Groundwater Monitoring Well System

Groundwater monitoring will be conducted under a detection monitoring program in accordance with WAC 173-303-645(9). Although the dangerous constituents barium and nickel appear to be elevated relative to upgradient wells, those results were not obtained in accordance with a monitoring system implemented under requirements of WAC 173-303-645. The monitoring well system will include the following changes to the existing well system:

- A new well along the point of compliance to replace dry well 699-25-34C (new compliance well; Figure 4-1).
- Two new upgradient wells (proposed upgradient wells 1 and 2; Figure 4-1) will be installed at distances far enough upgradient (approximately 500 m [1,640 ft]) to minimize the effects of VOCs from soil vapor in the vadose zone. Sections 3.2 and 3.4.4 discuss the presence of VOCs in upgradient wells by soil vapor transport in the vadose zone from the NRDWL/SWL WMA.
- Up to four additional far-field downgradient well(s) (proposed downgradient wells 1 through 4; Figure 4-1) beyond the line of compliance at the request of Ecology. The purpose for these wells is to determine if dangerous waste constituents released earlier from the facility may be present downgradient of the current well monitoring system.

The new groundwater monitoring wells will be installed in a phased, or stepped, approach. The first phase will include installation of the well in 2011 at the point of compliance where existing well 699-25-34C went dry in 2003, followed by the two new upgradient wells in 2012 to establish and begin implementing a detection monitoring system in accordance with WAC 173-303-645(9). The far-field downgradient wells will be identified in an installation schedule that would include joint DOE/Ecology decisions.

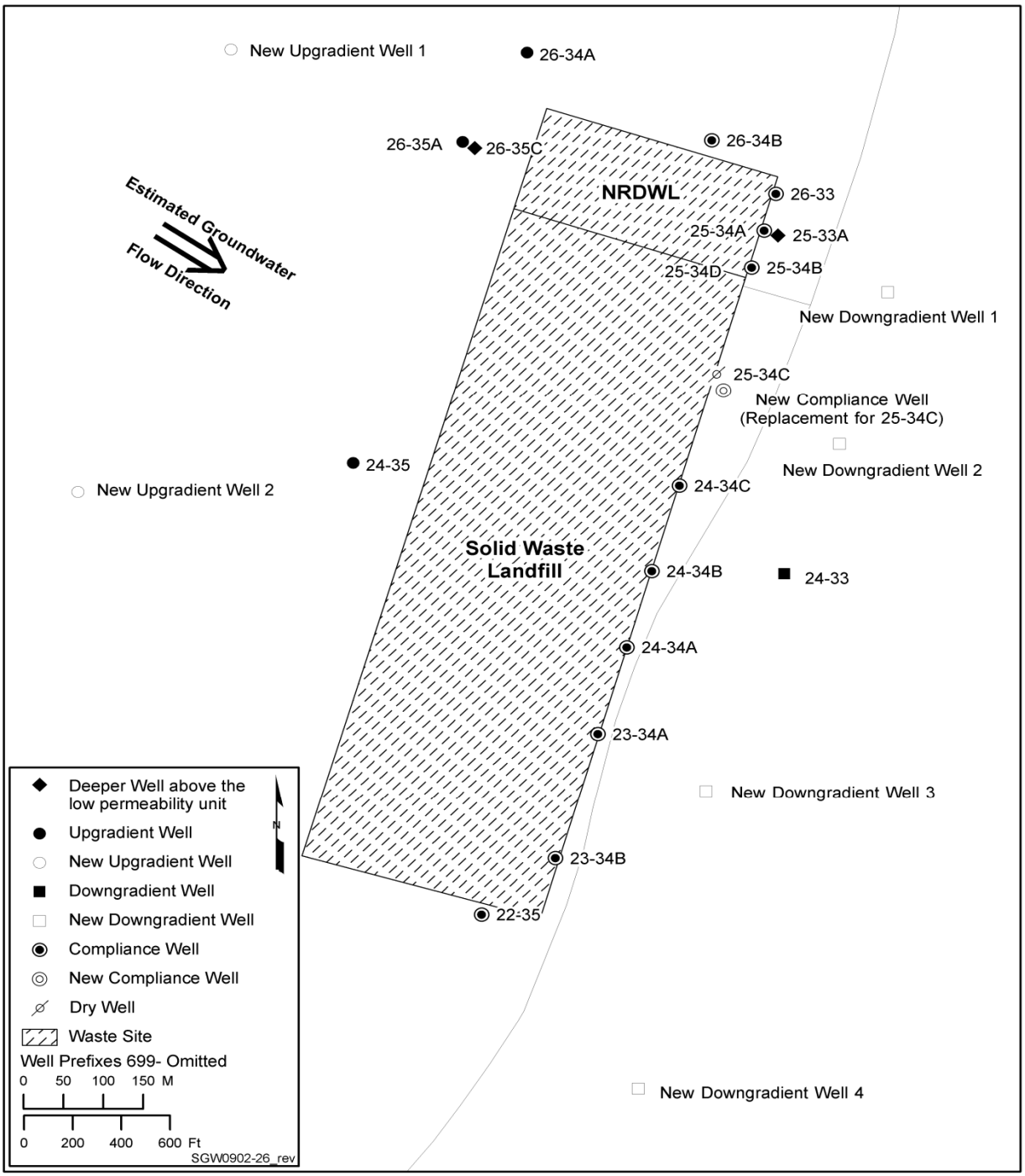


Figure 4-1. NRDWL/SWL WMA Groundwater Monitoring Well Locations and Purposes

The second phase will include installation of far-field downgradient well 3 in 2012 (downgradient of existing well 699-23-34A; Figure 4-1) and will begin sampling and analysis for the indicator parameters. This well is proposed as the first far-field downgradient well because its location is the most likely position to detect far-field contamination (if it exists) from the downgradient extension of known contaminant plumes (Figures 3-17 through 3-19). Once data from two sampling events have been

collected at far-field downgradient well 3, DOE will meet with Ecology to determine whether any of the additional far-field downgradient wells are needed based on the results from the first well. Until the two new upgradient wells are installed (when the first phase is complete), the NRDWL and SWL will continue to be monitored under their current groundwater monitoring plans (PNNL-12227, *Groundwater Monitoring Plan for the Nonradioactive Dangerous Waste Landfill*; and PNNL-13014, *Groundwater Monitoring Plan for the Solid Waste Landfill*, respectively) or similar plans implementing the same regulations.

4.2 Dangerous Constituents and Indicator Parameters

Dangerous constituents to which the groundwater protection standard applies are identified in accordance with WAC 173-303-645(4)(a). Also in accordance with WAC 173-303-645(4)(a) and WAC 173-303-645(9)(a), indicator parameters are then selected to provide a reliable indication of the presence of dangerous constituents in the groundwater.

Groundwater monitoring constituents relevant to monitoring at the NRDWL/SWL WMA are provided in Table 4-1. These constituents are included in Appendix 5 of Ecology Publication 97-407, as provided in WAC 173-303-110(7), "Sampling, Testing Methods and Analytes." These constituents have been, or may have been, disposed at the NRDWL based on the Dangerous Waste Permit Application, Part A (WA7890008967) and DOE/RL-90-17, Appendix B. Additionally, the constituents identified in Table 4-1 are based on SWL lysimeter leachate monitoring and testing results of the non-dangerous catch tank liquid. Table 4-1 also includes the sources of information for the chemical constituents identified therein.

Table 4-1. Groundwater Monitoring Constituents Identified for the NRDWL/SWL WMA and Source of Listing (Secondary Constituents)

Chemical Constituent	Source
1,2-Dichloroethane	1, 2
1,4-Dichlorobenzene	1, 3
1,4-Dioxane	2, 3
2,4-Dinitrophenol	1
Acetone	1, 3
Acetonitrile	1, 2
Acrylonitrile	1
Aniline	1
Arsenic	1, 2, 3
Barium	2, 3
Benzene	1, 2
Benzo(a)pyrene	1
Cadmium	2
Carbon disulfide	1
Carbon tetrachloride	1, 2, 4

Table 4-1. Groundwater Monitoring Constituents Identified for the NRDWL/SWL WMA and Source of Listing (Secondary Constituents)

Chemical Constituent	Source
Chlorobenzene	1
Chloroform	1, 2
Chromium	2
Copper	2
Cresol-m	1
Cresol-o	1
Cresol-p	1
Cresol-mixed isomers (cresylic acid) (sum of o-, m-, and p-cresol)	1
Cyanides (total)	1
Dibromomethane	1
1,1-Dichloroethane	2
Di-n-octyl phthalate	1
Ethyl benzene	1
Isobutyl alcohol	1
Kepone	1
Lead	1, 2
Mercury	1, 2
Methanol	1
Methyl ethyl ketone	1
Methyl isobutyl ketone	1
Methylene chloride	1, 2
Naphthalene	1
Nickel	2, 3
Nitrobenzene	1
p-Dimethylaminoazobenzene	1
Pentachlorophenol	1
Phenanthrene	1
Phenol	1

Table 4-1. Groundwater Monitoring Constituents Identified for the NRDWL/SWL WMA and Source of Listing (Secondary Constituents)

Chemical Constituent	Source
Pyrene	1
Pyridine	1
Selenium	2
Silver	2
PCE	1, 2, 4
Toluene	1
1,1,1-Trichloroethane	1, 2, 4
1,1,2-Trichloroethane	1
TCE	1, 2, 4
Trichlorofluoromethane	1
Xylenes-mixed isomers (sum of o-, m-, and p-xylene)	1
Zinc	2

Notes: The sources cited by number in this table correspond to the following references:

1. WA7890008967, Dangerous Waste Permit Application, Part A.

2. DOE/RL-90-17, *Nonradioactive Dangerous Waste Landfill/Solid Waste Landfill Closure/ Postclosure Plan*, Rev. 2.

3. DOE/RL-2008-54, *Hanford Site Solid Waste Landfill Closure Plan*; SWL lysimeter leachate sample analyses.

4. Chemical analysis of the 1100 Area non-dangerous catch liquid discharged to the SWL.

The groundwater monitoring constituents were evaluated to select dangerous waste indicator parameters that will be monitored in the compliance wells and that are subject to statistical evaluation. The evaluation was based on WAC 173-303-645(9)(a), which provides for identifying the constituents to be monitored after considering the types, quantities, and concentrations of wastes managed in the unit, as well as the mobility, stability, and persistence of waste constituents or their reaction products.

Constituents detected in the SWL lysimeter leachate collection system and the non-dangerous catch tank liquid were also considered in dangerous constituent indicator parameter selection. Dangerous constituents that have been frequently detected in lysimeter leachate above background and/or maximum contaminant levels include arsenic, barium, nickel, 1,4-dichlorobenzene, and acetone.

An optimal set of dangerous constituent indicator parameters is selected based on those that will provide reliable indication of contamination to groundwater and will also limit excessive analysis and statistical evaluation. The dangerous constituents selected as dangerous waste indicator parameters are listed in Table 4-2. Further discussion on monitoring and evaluation of the dangerous waste indicator parameters is provided in Sections 4.6 through 4.10.

Table 4-2. Indicators for Groundwater Contamination at the NRDWL/SWL WMA and Basis for Selection

Constituent	Basis for Selection
Acetone	Quantity, mobility, reported in leachate
TCE	Quantity, mobility, reported in groundwater
PCE	Quantity, mobility, reported in groundwater
Carbon tetrachloride	Quantity, mobility, reported in groundwater
1,1-Dichloroethane	Mobility, reported in groundwater
1,1,1-Trichloroethane	Mobility, reported in groundwater
Barium	Quantity, mobility, reported in leachate
Cadmium	Quantity
Mercury	Quantity
Nickel	Quantity, mobility, reported in leachate
Arsenic	Reported in leachate
TOX	Indicator of halogenated organics

Notes: The basis of selection definitions are as follows:

- "Quantity" pertains to waste volume.
- "Mobility" relates to solubility and transport.
- "Reported in leachate" refers to whether the constituent was detected in the SWL lysimeter leachate.
- "Reported in groundwater" refers to previous detection in groundwater under the NRDWL/SWL WMA.

After installation of the two proposed new upgradient wells, replacement for dry well 699-25-34C, and installation of the first far-field downgradient well (see Section 4.4), groundwater samples will be collected from the new upgradient wells, wells at the point of compliance, and the first new far-field well in the NRDWL/SWL groundwater monitoring system. These samples will be analyzed for the list of constituents in Appendix 5 of Ecology Publication 97-407.

Secondary constituents are those dangerous constituents identified in Table 4-1 that are not selected as dangerous waste indicator parameters, as well as major anions, cations, and alkalinity. These constituents are discussed further in Section 4.6.1 and in Table 4-3.

4.3 Detection Monitoring

After determining upgradient concentrations of the indicator parameters during eight sampling events, downgradient concentrations of indicator parameters at the wells along the facility boundary (point of compliance) will be compared statistically to the upgradient concentrations. If statistically significant evidence exists that concentrations of indicator parameters at downgradient wells exceed concentrations at upgradient wells (see Section 4.10), as required in WAC 173-303-645(9)(f), groundwater protection standards and concentration limits will subsequently be established in accordance with WAC 173-303-645(9)(g)(iv)(D). Section 4.12 of this plan provides the process and schedule for actions, notification, and permit modification, if necessary.

Table 4-3. Groundwater Water Monitoring Wells and Sample Frequency for NRDWL/SWL WMA Monitoring Parameters

Well	Dangerous Constituent Indicator Parameters	Secondary Constituents (Table 4-1)	Appendix 5 Analytes[a]
699-25-33A (deep)	Annually	A	1
699-25-34A	Quarterly	A	1
699-25-34B	Quarterly	A	1
699-26-33	Quarterly	A	1
699-26-34A	Annually	A	1
699-26-34B	Quarterly	A	1
699-26-35C (deep)	Annually	A	1
699-26-35A	Annually	A	1
699-22-35	Quarterly	A	1
699-23-34A	Quarterly	A	1
699-23-34B	Quarterly	A	1
699-24-33	Annually	A	1
699-24-34A	Quarterly	A	1
699-24-34B	Quarterly	A	1
699-24-34C	Quarterly	A	1
699-24-35	Annually	A	1
New downgradient 1	Semiannually[b]	A	1
New downgradient 2	Semiannually[b]	A	1
New downgradient 3	Semiannually[b]	A	1
New downgradient 4	Semiannually[b]	A	1
New upgradient 1	Annually	A	1
New upgradient 2	Quarterly	A	1
Replacement for 699-25-34C	Quarterly	A	1

Notes: Wells in bold are compliance wells; wells in italics are upgradient wells.

a. Appendix 5 of Ecology Publication 97-407, *Chemical Test Methods for Designating Dangerous Waste: WAC 173-303-090 and -100*.

b. Semiannually the first year and annually thereafter.

If a comparison value is exceeded at a statistically significant level, additional measurements shall be collected to verify that a detection event has occurred. If the detection of a dangerous constituent is verified (as discussed in Section 4.10), compliance monitoring will be implemented in accordance with WAC 173-303-645(10).

4.4 Groundwater Monitoring System

The groundwater monitoring system proposed for the NRDWL/SWL WMA will consist of 20 to 23 wells. The wells include 5 upgradient wells, 11 compliance wells, 2 to 5 far-field downgradient wells, and 2 deep wells, which are described below:

- Upgradient wells will be used to determine upgradient concentrations of detected groundwater constituents quarterly. These wells include the following:
  - Proposed upgradient well 1
  - Proposed upgradient well 2
  - Existing wells 699-24-35, 699-26-35A, and 699-26-34A will be only sampled annually and the data used for information purposes only (not for statistical comparisons)

- Compliance (point-of-compliance) wells will be monitored quarterly to determine if releases from the NRDWL/SWL WMA impact groundwater quality. Statistical analysis will be performed for these wells:
  - 699-22-35
  - 699-23-34B
  - 699-23-34A
  - 699-24-34A
  - 699-24-34B
  - 699-24-34C
  - 699-25-34B
  - 699-25-34A
  - 699-26-33
  - 699-26-34B
  - Proposed replacement for dry well 699-25-34C

  Several existing compliance wells may require replacement if the fringe of the barrier extends beyond the wells. These wells will be replaced with wells, as necessary, located just beyond the edge of the barrier. In addition, any compliance well going dry will be replaced. Well 699-25-34D, due to its current location between NRDWL and SWL, is anticipated to constrain closure construction and may be problematic for routine access during post-closure care. The well will be decommissioned and no longer used as part of the monitoring well network.

- Two to five far-field well will be monitored at least annually to evaluate whether contamination exists downgradient at distances up to 200 m (656 ft) from the NRDWL/SWL WMA. These wells will include the following:
  - Existing well 699-24-33
  - Proposed new far-field downgradient well 3
  - Proposed downgradient wells 1, 2, and 4 (if installed)

These one to four new far-field wells will be initially drilled to a depth of up to 35 m (115 ft) below the water table to determine whether the low-permeability unit is present beneath the SWL portion of the NRDWL/SWL WMA, and also to determine whether contamination is present at depths up to 35 m (115 ft) below the water table. Some of these wells may be completed at some depth below the water table if contamination is discovered in samples collected during drilling.

- Existing deep monitoring wells monitor the bottom of the uppermost aquifer under the NRDWL portion of the NRDWL/SWL WMA. These wells include the following:
  - 699-25-33A
  - 699-26-35C

  These wells will be sampled annually, and the data will be used for information purposes only (not for statistical comparisons).

Figure 4-1 shows the locations of the new wells. Two new upgradient wells (proposed upgradient wells 1 and 2) will be installed approximately 720 m (2,361 ft) upgradient of the line of wells along the point of compliance, on the east side of the NRDWL and SWL. The locations of the two proposed wells are planned to be distant enough upgradient of the landfill to avoid groundwater contamination by VOCs from the vadose zone at the landfill. The distance upgradient of these two well locations is based on the small amount of VOCs detected at the existing upgradient well 699-26-34A and its distance from the most concentrated portion of the PCE plume in 1991 (near well 699-24-34B).

A new compliance well will be installed to replace well 699-25-34C, which is dry.

One new far-field downgradient well (proposed downgradient well 3) will be installed approximately 190 m (623 ft) downgradient (east-southeast) of the SWL. This well will be used to detect potential contaminant plumes that may have moved beyond the point of compliance. After the well has been installed and sampled twice, DOE will meet with Ecology to discuss the concentration results, future sampling frequency, and whether the other three far-field wells (new far-field downgradient wells 1, 2, and 4) are needed. Soil samples will be collected from each of the new far-field downgradient wells approximately every 1.5 m (5 ft) (or less, depending on visual observation during drilling). Groundwater samples will be collected during drilling and will be analyzed on a rapid-turnaround basis to evaluate the presence and/or depth distribution of organic contaminants. The wells will be completed so the well screen is in an interval where the highest levels of contaminants are detected (above MDLs). If a well is completed deeper than at the water table, an adjacent well will be installed at the water table. Detailed borehole sampling and analysis plan, characterization and well completion criteria will be provided in a separate plan to be maintained in the Hanford Facility Operating Record. After the wells are installed, this monitoring plan will be modified to include the details on the new wells.

4.5 Point of Compliance

Wells will be monitored in accordance with the requirements provided in this monitoring plan. The point of compliance for the NRDWL/SWL WMA groundwater monitoring plan will be represented by the vertical surface between the 11 downgradient compliance monitoring wells along the northern, eastern, and southern facility boundary, and it extends down into the uppermost aquifer underlying the WMA, based on the requirements of WAC 173-303-645(6)(a).

4.6 Sampling and Analysis

The integrated groundwater monitoring system for the NRDWL/SWL WMA will consist of 20 to 23 wells; 6 wells will be upgradient, and 14 to17 wells will be downgradient (after all 4 of the new wells are installed). The 11 compliance wells will be sampled and analyzed for statistical evaluation. The wells

will be monitored in accordance with the requirements outlined in this section, which includes a description of the sampling and analysis program for the regulated unit (monitoring parameters, analytical methods, monitoring frequency, and sampling protocols).

4.6.1 Monitoring Parameters

Monitoring parameters include the dangerous waste indicator parameters (subject to statistical evaluation), secondary dangerous waste constituents, geochemical evaluation parameters, and field parameters. Water-level measurements are collected from each well every time the well is sampled.

Indicator parameters were derived from evaluating the dangerous constituents and are provided in Table 4-2 and discussed in Section 4.1. Indicator parameters were selected to provide a reliable indication of the presence of dangerous constituents in the groundwater; the indicator parameters were derived from Table 4-1 based on the rationale provided in Table 4-2. The constituents were retained as indicator parameters based on quantity, solubility, mobility, persistence, and/or detectability. These indicator parameters are subject to statistical evaluation (see Section 4.10). Additional dangerous waste constituent results are received from the laboratory as provided by the analytical method, but statistical analysis is not performed on these additional constituents; several of these are considered part of the secondary constituent list.

Geochemical parameters include major cations, anions, and alkalinity. These parameters will be used to evaluate the charge balance of the chemical analyses, as well as to evaluate general groundwater chemistry conditions. Field parameters are collected to determine that the sample collected (as well as is practicable) is representative of groundwater conditions. Both field and geochemical parameters are listed in Table 4-4.

Table 4-4. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Required Detection Limit (µg/L)
Metals Analyzed by Inductively Coupled Plasma Method – Unfiltered/Filtered (secondary constituents)			
Calcium	P, HNO_3 to pH <2	SW-846[c] Method 6010B/C, SW-846 Method 6020[d], or EPA/600 Method 200.8[d]	1,000
Sodium			500
Manganese			5
Potassium			4,000
Iron			50
Magnesium			750
Trace Metals – Unfiltered/Filtered (indicator parameters except chromium, which is a secondary constituent)			
Arsenic	P, HNO_3 to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	2
Barium			5
Cadmium			2
Chromium (total)			2
Mercury	G, HNO_3 to pH <2	SW-846 Method 7470A, EPA/600 Method 200.8	0.5

Table 4-4. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Required Detection Limit (µg/L)
Nickel	P, HNO_3 to pH <2	SW-846 Method 6020 or EPA/600 Method 200.8	40
Anions by Ion Chromatography (secondary constituents)			
Bromide	P	EPA/600 Method 300.0[e]	250
Chloride			200
Fluoride			500
Nitrate			250
Nitrite			250
Phosphate			500
Sulfate			500
Volatile Organic Analyses (indicator parameters)			
Acetone (by volatile organic analysis)	G, no headspace	SW-846 Method 8260C	20
Carbon tetrachloride			5
1,1,1-Trichloroethane			5
1,1-Dichloroethane			10
TCE			5
PCE			5
Semivolatile Organic Analyses (secondary constituents)			
Phenol	Amber glass	SW-846 Method 8270D	10
Toxaphene			20
1,4-Dioxane			500
2,4-Dinitrophenol			25
2,4,6-Trichlorophenol			10
Other (TOX is an indicator parameter; all others are secondary constituents)			
TOX	G, H_2SO_4 to pH <2, no head space	SW-846[c] Method 9020	10
TOC	G/P, HCL to pH <2	SW-846[c] Method 9060	1,000
Alkalinity	G/P	Standard Method[f] 2320, EPA/600 Method 310.1, EPA/600 Method 310.2	5,000
Conductivity, laboratory	P	Instrument/meter	1 µohm

Table 4-4. Preservation Techniques, Analytical Methods Used, and Current Method Quantitation Limits

Constituent	Collection and Preservation[a]	Analysis Methods[b]	Required Detection Limit (µg/L)
Conductivity, field	Field measurement	Instrument/meter	1 µohm
Dissolved oxygen, field	Field measurement	Instrument/meter	NA
pH, laboratory measurement	P	Instrument/meter	0.1
pH, field measurement	Field measurement	Instrument/meter	0.1
Temperature	Field measurement	Instrument/meter	NA
Total dissolved solids	P	EPA/600 Method 160.1	10,000
Turbidity, field measurement	Field measurement	Instrument/meter	0.1 NTU

a. All samples will be collected in plastic (P), glass (G), or amber glass containers and will be cooled to 4ºC upon collection.

b. Constituents grouped together are analyzed by the same method, unless otherwise indicated.

c. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

d. SW-846 Method 6010 is the preferred method; however, EPA Method 6020 or EPA/600 Method 200.8 may be used, as long as the method quantitation limit listed is met.

e. Analytical method adapted from *Method 300.0, Test Methods for Determination of Inorganic Anions in Water by Ion Chromatography* (EPA-600/4-84-017).

f. *Standard Methods for the Examination of Water and Wastewater*, 21st edition (AWWA et al., 2005).

4.6.2 Sampling Frequency

Table 4-3 provides the wells and constituent groups to be analyzed and the frequency of sampling. Samples will be collected quarterly for 2 years from upgradient and compliance wells to establish background conditions for the dangerous constituents identified in Section 4.5.1. After background data are obtained, samples will continue to be collected quarterly from the upgradient and compliance wells, and the data will be evaluated in accordance with the statistical methods presented in Section 4.10.

During the period when the barrier is constructed over the NRDWL and SWL, some wells may not be amenable for sampling. When this occurs, the missed sampling event will be documented in the Hanford Facility Operating Record and will be reported in the annual groundwater monitoring report.

4.6.3 Sampling Procedures

Groundwater sampling procedures, sample collection documentation, sample preservation and shipment, and chain-of-custody requirements are described in this subsection. For SWL lysimeter sampling and soil vapor monitoring, all current data quality objectives, methods, and parameter reporting will be maintained as documented in the respective reporting programs.

Samplers are required to fill out groundwater sample report forms as they purge and sample each well. Field personnel measure water levels in each well before sampling and then purge stagnant water from the well. Field personnel also record the time during which the sampling occurs. Water levels are typically measured with laminated-steel electrical sounding tapes with a precision of 2 mm (0.08 in.). Procedures require sample collection after three casing volumes of water have been purged from the well and after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. Field parameters are measured in a flow-through chamber. Unfiltered samples are collected for volatile

organic analysis; filtered and unfiltered samples are collected for trace metals analyses. Only the filtered analysis results are used for statistical analysis of trace metals data.

Sample preservation techniques will follow generally accepted practices (e.g., U.S. Environmental Protection Agency [EPA]-approved guidelines such as SW-846, *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, Third Edition; Final Update IV-B*, Table 11-1 [or equivalent]) and will be documented on sample authorization forms that are generated for each sampling event. If samples require preservatives, the preservatives are added to collection bottles before use in the field. A chemical preservative label is affixed to the sample container that lists the specific preservative used. The preservative's brand name, lot number, concentration, and date opened are recorded.

4.6.4 Sample Chain-of-Custody

Groundwater samplers use chain-of-custody forms to maintain and document the integrity of groundwater samples from the time of collection through data reporting. The forms are generated during scheduling and are managed through a documented procedure. Required information recorded on the chain-of-custody forms includes the following:

- Sampler's name
- Destination and method of shipment
- Collection date and time
- Sample identification number(s)
- Analysis method(s)
- Preservation method(s)

Samples are labeled and sealed with evidence tape, wrapped with bubble wrap, and placed in a U.S. Department of Transportation-approved container with ice, as appropriate. The packaging parameters for samples are determined by associated hazards. Samples for offsite laboratories are shipped in accordance with U.S. Department of Transportation regulations. A chain-of-custody form accompanies all samples. When samples are transferred from one custodian to another (e.g., from sampler to shipper, or from shipper to analytical laboratory), the receiving custodian inspects the chain-of-custody form and the samples, noting any deficiencies. Each transfer of custody is documented by the printed names and signatures of the custodian relinquishing the samples and the custodian receiving the samples, as well as the time and date of transfer. Commercial shippers do not sign chain-of-custody forms, but the forms are signed by the receiving laboratory, and sample integrity is verified by inspecting the bottle seals.

4.7 Decontamination of Sampling and Drilling Equipment

Monitoring wells for the NRDWL/SWL WMA shall be equipped with dedicated sampling pumps. Sample pumps are placed at approximately mid-depth within the screen interval. Water-level measuring tapes are cleaned with potable or deionized water and a clean towel. Single-use sample manifolds used at the wellhead require decontamination as follows:

1. Wash with a phosphate-free detergent.
2. Rinse three times in high-purity water.
3. Rinse in a 1M solution of nitric acid.
4. Rinse three more times in high-purity water, then rinse in hexane.
5. Dry in the drying chamber.

The decontamination process for sampling and drilling equipment is performed in accordance with established procedures.

The following information is included relative to well drilling equipment when the new wells are installed at the NRDWL/SWL WMA. Well drilling equipment is decontaminated using high-temperature pressure washing. The equipment is then rinsed with clean water.

The equipment used to collect soil samples during drilling for later chemical analysis is decontaminated as follows:

1. Wash with phosphate-free detergent, rinse three times with deionized water.
2. Rinse once with nitric acid (glass or stainless-steel equipment only).
3. Rinse three more times with deionized water, then rinse with hexane.
4. After heat drying, equipment is wrapped in unused aluminum foil and sealed with tape until needed. The tape shall not come into contact with the equipment to avoid any contamination from the materials on the tape.

4.8 Analytical Procedures and Quality Assurance

Instruments for field measurements (e.g., pH, specific conductance, temperature, and turbidity) are calibrated using standard solutions before use, including the following:

- For pH 4, 7, and 10, buffer/standard solutions
- For specific conductance, 445 µS/cm and 1,413 µS/cm solutions
- For turbidity, Gelex®[1] standards 0 to 10, 0 to 100, and 0 to 1,000 nephelometric turbidity units (NTU)

Instruments are operated in accordance with the manufacturer's instructions. Each instrument is assigned a unique number that is tracked via field and verification documentation.

Laboratory analytical methods are specified in Table 4-4 and are reflected in laboratory contracts. The laboratory analytical methods are standard methods from EPA SW-846 (2008, as revised); EPA-600/4-79-020, *Methods for Chemical Analysis of Water and Wastes* (as revised); and *Standard Methods for the Examination of Water and Wastewater*, 20th edition (AWWA et al., 1998). Table 4-4 identifies the analytes, analytical methods, and required maximum practical quantitation limits.

The quality control (QC) program is designed to assess and enhance the reliability and validity of groundwater data, and to document whether the resulting data are of the quantity and quality necessary for the intended decision-making purpose.

In groundwater detection monitoring, the primary decision-making purpose is to determine whether a statistically significant increase in a dangerous constituent concentration is observed in groundwater downgradient from the permitted site. Consequently, data quality is monitored by evaluating the results of QC samples, conducting audits, validating groundwater data, and comparing these results to data quality requirements established in this groundwater monitoring plan (Section 4.9.2). Accuracy, precision, and detection are the primary parameters used to assess data quality. Data for these parameters are obtained from two categories of QC samples: (1) those that provide checks on field and laboratory activities (field QC), and (2) those that monitor laboratory performance (laboratory QC). Table 4-5 summarizes the types of samples in each category and the sample frequencies and characteristics evaluated.

[1] Gelex® is a registered trademark of Hach Company, Loveland, Colorado.

Table 4-5. Quality Control Samples

Sample Type	Primary Characteristics Evaluated	Frequency
Field QC		
Full trip blank	Contamination from containers or transportation	One per 20 well trips
Field transfer blank	Airborne contamination from the sampling site	One each day VOCs samples are collected
Equipment blank	Contamination from non-dedicated sampling equipment	As needed[a]
Duplicate samples	Reproducibility	One per 20 well trips
Laboratory QC		
Method blank	Laboratory contamination	One per batch[c]
Laboratory duplicates	Laboratory reproducibility	[b]
Matrix spike	Matrix effects and laboratory accuracy	[b]
Matrix spike duplicate	Laboratory reproducibility and accuracy	[b]
Surrogates	Recovery/yield	[b]
Laboratory control sample	Method accuracy	One per batch

a. For portable Grundfos® (registered trademark of Grundfos Pumps Corporation, Colorado Springs, Colorado) pumps, equipment blanks are collected one per 10 well trips. Whenever a new type of non-dedicated equipment is used, an equipment blank is collected every time sampling occurs until it can be shown that less-frequent collection of equipment blanks is adequate to monitor the decontamination procedure for the non-dedicated equipment.

b. As defined in the laboratory contract or quality assurance plan and/or analysis procedures.

c. A "batch" is a number (25 to 75) of like analyses that are analyzed as a group for efficiency purposes.

The QC data are evaluated based on acceptance criteria for each QC sample type, as summarized by constituent identified in Table 4-6. These criteria limits are intended to provide confidence that the analytical and field methods are in control and provide reliable data. For field and method blanks, the acceptance limit is two times the instrument detection limit (metals) or MDL (other chemical parameters), except for the common laboratory contaminants acetone, methylene chloride, 2-butanone, and phthalate esters where the limit is five times the MDL. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks shall be flagged with a "Q" in the Hanford Environmental Information System (HEIS) database to indicate a potential problem, and then recorded in the Hanford Facility Operating Record.

Field duplicates must agree within 20 percent (as measured by relative percent difference) to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit shall be evaluated. In the case where one result is a non-detect, the detection limit is used to calculate the relative percent difference. Unacceptable field duplicate results are flagged with a "Q" in the database and recorded in the Hanford Facility Operating Record.

Table 4-6. Field and Laboratory QC Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
General Chemical Parameters			
Alkalinity Chemical oxygen demand Conductivity pH Total dissolved solids TOC TOX	MB[b]	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS[e]	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Ammonia and Anions			
Anions by IC	MB	<MDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	DUP	≤20% RPD[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
Metals			
Arsenic Cadmium Chromium Mercury ICP metals ICP/MS metals	MB	<CRDL	Flagged with "C"
	LCS	80-120% recovery[c]	Data reviewed[d]
	MS	75-125% recovery[c]	Flagged with "N"
	MSD	≤20% RPD[c]	Data reviewed[d]
	EB, FTB	<2 times MDL	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"
VOCs			
Volatiles by GC/MS	MB	<MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB, FXR	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

Table 4-6. Field and Laboratory QC Elements and Acceptance Criteria

Method[a]	QC Element	Acceptance Criteria	Corrective Action
SVOCs			
Phenols by GC Semivolatiles by GC/MS	MB	<2 times MDL	Flagged with "B"
	LCS	Statistically derived[g]	Data reviewed[d]
	MS	Statistically derived[g]	Flagged with "N"
	MSD	Statistically derived[g]	Data reviewed[d]
	SUR	Statistically derived[g]	Data reviewed[d]
	EB, FTB	<2 times MDL[h]	Flagged with "Q"
	Field duplicate	≤20% RPD[f]	Flagged with "Q"

a. Refer to Table 4-4 for specific analytical methods.

b. Does not apply to pH.

c. Laboratory-determined, statistically derived control limits may also be used. Such limits are reported with the data.

d. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data as suspect ("Y" flag) or rejected ("R" flag).

e. Applies to TOC and TOX only.

f. Applies only in cases where one or both results are greater than five times the detection limit.

g. Determined by the laboratory based on historical data. Control limits are reported with the data.

h. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is less than five times the MDL.

Data flags:

B, C = possible laboratory contamination (analyte was detected in the associated method blank)

N = result may be biased (associated matrix spike result was outside the acceptance limits)

Q = problem with associated field QC sample (blank and/or duplicate results were out of limits)

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are defined in Table 4-6 and are in accordance with EPA SW-846. The acceptance criteria for the associated parameter data shall be analyzed and recorded in accordance with Section 4.9.2.

Table 4-7 lists the analyses methods for Appendix 5 of Ecology Publication 97-407. This list is also Appendix IX (40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities"). These methods will be required once for each well in the NRDWL/SWL well system. The table provides the method number, collection and preservation requirements, and the required precision and accuracy for each method.

Table 4-7. Appendix 5 Constituent Analyses

Method Name	Method Number	Collection and Preservation	Precision	Accuracy
Semivolatile organic analyses	SW-846 Method 8270	Glass, no headspace	≤20%	±20%
Volatile organic analyses	SW-846 Method 8260	Amber glass	≤20%	±20%
Phenolics	SW-846 Method 8041	Amber glass	≤20%	±20%
Pesticides and PCBs	SW-846 Method 8081	Amber glass	≤20%	±20%
Herbicides	SW-846 Method 8150	Amber glass	≤20%	±20%
Dioxins	SW-846 Method 8280	Amber glass	≤20%	±20%
Metals	SW-846 Method 6010, 6020, or 200.8	Plastic, HNO_3 to pH <2	≤20%	±20%
Cyanide	SW-846 Method 9012 or 335.2	Glass or plastic, NaOH pH >12	≤20%	±20%
Sulfide	SW-846 Method 9030	Plastic, ZnAc+NaOH to pH >9	≤20%	±20%

Notes:

1. The constituents in this table are from 40 CFR 264, Appendix IX, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring List." (Also Appendix 5 of Ecology Publication 97-407, *Chemical Test Methods for Designating Waste: WAC 173-303-090 and -100]*.)

2. SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update IV-B.*

Table 4-8 lists the acceptable accuracy for the double-blind standards for carbon tetrachloride and TCE. These samples are prepared by spiking Hanford Site background well water (wells 699-19-88 and 699-49-100C) with known concentrations of constituents of interest. Spiking concentrations range from the detection limit to the upper limit of concentration determined in groundwater on the Hanford Site. Investigations shall be conducted for double-blind standards that are outside of acceptance limits in accordance with Section 4.9.2. The results from these standards shall be used to determine acceptability of the associated parameter data.

Recommended holding times depend on the analytical method, as specified in EPA SW-846 or EPA-600/4-79-020. The holding times shall be specified in laboratory contracts pursuant to Permit requirements. Data associated with missed holding times are flagged with an "H" in the HEIS database and noted in the Hanford Facility Operating Record. Data exceeding holding times shall be maintained but potentially may not be used in statistical analyses in accordance with Section 4.10.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies shall be incorporated into the Hanford Facility Operating Record, as appropriate to substantiate data quality objectives and data acceptance criteria.

Table 4-8. Blind Standard Constituents and Schedule

Constituents	Frequency	Accuracy (%)	Precision (% RSD)[a]
Carbon tetrachloride	Quarterly	±25%	≤25%
Chloroform	Quarterly	±25%	≤25%
TCE	Quarterly	±25%	≤25%
Fluoride	Quarterly	±25%	≤25%
Nitrate	Quarterly	±25%	≤25%
Cyanide	Quarterly	±25%	≤25%
Chromium	Annually	±20%	≤25%
TOC[b]	Quarterly	Varies according to spiking compound	Varies according to spiking compound
TOX[c]	Quarterly	Varies according to spiking compound	Varies according to spiking compound

a. If the results are less than five times the required detection limit, then the criterion is that the difference of the results of the replicates is less than the required detection limit.

b. The spiking compound generally used for TOC is potassium phthalate. Other spiking compounds may also be used.

c. Two sets of spikes for TOX will be used. The spiking compound for one set should be 2,4,5-trichlorophenol. The spiking compound for the second set should include the constituents used for the VOCs sample (carbon tetrachloride, chloroform, and TCE).

4.9 Data Management

This section describes data management practices, including data loading; data review, verification, validation, and usability; and data review corrective actions.

4.9.1 Loading Data

The contract laboratories report analytical results electronically and in hardcopy. The electronic results shall be loaded into the HEIS database as they are received from the laboratories. The appropriate sections of the HEIS shall be incorporated by reference into the Hanford Facility Operating Record. Field data (e.g., specific conductance, pH, temperature, turbidity, and depth to water) are recorded on field records (e.g., groundwater sample report forms). Data management staff enter this information into the HEIS database manually through data entry screens and verify each value against the hardcopy. When an electronic field data collection system is implemented, it will replace the manual field data collection and data entry process.

Data not available electronically may include well logbooks, borehole videos, geologic descriptions, field screening data, or other information.

4.9.2 Data Review, Verification, Validation, and Usability

A final data review shall determine whether data meet the following specific criteria. All work activities shall follow documented procedures and processes for data verification and validation, summarized as follows. Verification involves assessing data accuracy, completeness, consistency, availability, and internal control practices to determine overall reliability of the data collected. Other data quality

objectives that shall be met include the proper chain-of-custody, sample handling, use of proper analytical techniques for each constituent, and the quality and acceptability of the laboratory analyses conducted.

Groundwater monitoring staff perform checks on laboratory electronic data files for formatting, outlier values, data flagging (qualifiers), and completeness. Hardcopy results are verified to check for (1) completeness, (2) notes on condition of samples upon receipt by the laboratory, (3) notes on problems that arose during the analysis of the samples, and (4) correctly reporting results. If data are incomplete or deficient, staff will work with the laboratory to correct the problem discovered.

Validation of groundwater data involves assessing whether the data collected and measured truly reflect aquifer conditions. The data validation process provides the requirements and guidance for validating groundwater data that are routinely collected. Validation is a systematic process of reviewing verified data against a set of criteria (Table 4-6) to determine whether the data are acceptable for their intended use.

The results of laboratory and field QC evaluations, double-blind sample results, laboratory performance evaluation samples, and holding-time criteria are considered when determining data usability. Staff review the data to identify whether observed changes reflect changes in groundwater quality or potential data errors, and they may request data reviews of laboratory, field, or water-level data for usability purposes. The laboratory may be requested to check calculations or re-analyze the sample, or the well may be resampled. Results of the data reviews are used to flag the data appropriately in the HEIS database (e.g., “R” for reject, “Y” for suspect, or “G” for good) and/or to add comments.

Upon final data acceptance, both the raw data and the accepted/validated data shall be incorporated into the Hanford Facility Operating Record.

4.9.3 Data Review Corrective Actions

The responses to data quality defects are identified through the verification/validation process. Table 4-6 identifies the corrective actions.

4.10 Statistical Analysis of Groundwater Monitoring Data

This section summarizes the method of statistical evaluation and the statistical procedures to indicate whether dangerous waste or dangerous waste constituents from the NRDWL/SWL WMA might have entered the groundwater in the uppermost aquifer. To establish baseline conditions, eight samples will be collected during the first 2 years (i.e., quarterly sampling frequency) after the WMA is subject to the conditions of the Permit. After the baseline has been established, sample collection and analysis will continue on a quarterly basis. See Section 4.5.2 for discussion of the circumstances when closure activities could prevent sampling events. More details on specific statistical criteria will be available after the background data set is available and evaluated. Statistical evaluations will be made as soon as practicable after validation of the full data set from each quarterly sampling event.

Table 4-1 lists the dangerous constituents that have been identified for the NRDWL/SWL WMA. Table 4-2 identifies the dangerous constituents and indicator parameters used to indicate the presence of contamination (WAC 173-303-645[9][a]) and that are subject to statistical evaluation for the NRDWL/SWL WMA.

The monitoring program will periodically re-evaluate the statistical tests being used. The methods described will be reviewed during and after baseline data are collected to ensure that the methods are the most appropriate, considering site conditions.

The goal of a RCRA final status detection monitoring program (WAC 173-303-645[9]) is to monitor for indicator parameters that provide a reliable indication of the presence of dangerous constituents identified at a facility in groundwater in the uppermost aquifer beneath the site. This is accomplished by testing for statistically significant changes in concentrations of selected indicator parameters in downgradient wells relative to baseline values.

The statistical method of analysis of variance (ANOVA) is proposed for the detection monitoring program of the NRDWL/SWL WMA. The proposed statistical method is consistent with *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* (EPA 530-R-09-007) and WAC 173-303-645.

The ANOVA determines whether there are any statistically significant differences in mean concentrations among a set of wells. Applied to the NRDWL/SWL WMA, an ANOVA will detect differences between compliance wells and upgradient wells, as well as differences between upgradient wells and differences between compliance wells. The primary concern in groundwater monitoring is a change in any compliance well relative to upgradient wells, but the ANOVA will detect changes in any of the wells relative to the other wells, which will inform the analyst of changing upgradient conditions, as well as detecting any changes in downgradient conditions at the point of compliance.

The ANOVA applied at the NRDWL/SWL WMA consists of two analyses steps. The first step involves an F-test to determine any significant difference between the wells. If the F-test determines a significant difference between wells, the second step is performed, which is a series of T-tests to determine which wells are significantly different from others.

The F-test is a ratio of the differences between wells to the differences within wells. If there is a greater difference between wells than within wells, then there is statistically significant evidence of concentration differences between wells. If concentration variability within wells is large relative to differences between wells, then there is not significant evidence of differences between wells. This test will be used to determine whether there are any significant differences between wells, whether upgradient or downgradient. Testing at the NRDWL/SWL WMA will be performed at the 5 percent level, meaning that statistical evidence of differences between upgradient and downgradient conditions will be assumed if there is less than a 5 percent chance of the measured value occurring if upgradient and downgradient conditions are actually the same. This realizes a test-wise, false-positive rate of 5 percent in accordance with EPA 530-R-09-007.

The series of T-tests compares wells pair-wise. In the usual application of an ANOVA for groundwater monitoring, each downgradient well is compared to the mean of the upgradient wells. For the NRDWL/SWL WMA, this will be performed at an individual significance level of 0.01 in accordance with EPA 530-R-09-007. The approach compares all well pairs to determine which wells statistically group together, which provides a more comprehensive analysis. If upgradient wells differ significantly from one another, this analysis will detect that difference and determine which downgradient wells differ significantly from all upgradient wells, as well as which downgradient wells differ from which individual upgradient wells. A more comprehensive view of variability among all the wells of the system is provided compared to a simpler upgradient/downgradient comparison.

If any downgradient wells are found to statistically differ from upgradient wells, those wells will be immediately resampled and re-analyzed for the constituents. If the constituents are confirmed to be elevated, all downgradient wells will be resampled and analyzed for the constituents listed in Table 4-1 (WAC 173-303-645[9][g][ii]). If the elevated levels are not confirmed, detection monitoring will continue.

If it is thought that the data are not normally distributed, a non-parametric ANOVA (Kruskal-Wallis) technique can be applied. The Kruskal-Wallis procedure is an ANOVA applied to the ranks of the data rather than the actual measurements. This does not rely on the assumption that the underlying data are normally distributed.

If all measurements (both upgradient and downgradient) are non-detects, an ANOVA will not be applied since no differences will be found. In that case, evidence of detectable quantities in downgradient wells without corresponding detections in upgradient wells will be considered evidence of potential facility impact to groundwater.

4.11 Reporting and Recordkeeping

Reporting of monitoring results and statistical evaluations for the NRDWL/SWL WMA will be through the annual groundwater monitoring report (e.g., DOE/RL-2008-66).

Pertinent information for groundwater monitoring and electronic files for groundwater data shall be maintained in the Hanford Facility Operating Record. Records may be stored in either electronic or hardcopy format. The Hanford Facility Operating Record will also include groundwater sample reports, chain-of-custody forms, and sample receipt records.

4.12 Evaluation and Notification

Groundwater flow rate and direction in the uppermost aquifer will be evaluated and reported annually. After 2 years of background data collection, groundwater chemistry data collected under this monitoring plan will be analyzed semiannually to determine whether there is statistically significant evidence of contamination (in accordance with WAC 173-303-645[9][f]) using the statistical method provided in Section 4.10. The groundwater chemistry and statistical results will also be reported annually and maintained in the project file (WAC 173-303-645[9][c]).

If statistically significant evidence of contamination is determined for one or more of the dangerous constituents or indicator parameters at any monitoring well at the compliance point, the owner or operator may resample (for verification purposes) within one month and repeat the analysis for the compounds with elevated concentrations. If resampling confirms statistically significant evidence of contamination, the following will be performed in accordance with WAC 173-303-645(9)(g):

- Notify Ecology in writing within 7 days of the finding, indicating which chemical parameters have shown statistically significant evidence of contamination.
- Sample the groundwater in all monitoring wells and determine if the constituents identified in Table 4-1 are present, and if so, at what concentration. For any of these compounds detected, the owner or operator may resample within one month of receiving the results and repeat the analysis for those compounds detected in accordance with WAC 173-303-645(9)(g)(ii). If the constituents are detected in the second analysis, the constituents will form the basis for compliance monitoring.
- If dangerous constituent(s) are detected, submit an application for a Permit modification to Ecology within 90 days to establish a compliance monitoring program in accordance with WAC 173-303-645(9)(g)(iv).
- If dangerous constituents are not detected, continue to monitor in accordance with this detection monitoring program.

- In the case that a source other than the NRDWL/SWL WMA caused the contamination or the detection is an artifact caused by an error in sampling, analysis, or statistical evaluation or natural variation in groundwater (as allowed by WAC 173-303-645[9][g][vi]), the following will apply:
  - Notify Ecology in writing within 7 days of the finding, and indicate the intent to make a demonstration to this effect.
  - Submit a report to Ecology within 90 days. The report should demonstrate that a source other than the regulated unit caused the contamination, or that the contamination resulted from an error in sampling, analysis, statistical evaluation, or is a natural variation in groundwater chemistry.
  - Continue monitoring in accordance with this detection monitoring program.
  - If it is determined, in accordance with WAC 173-303-645(9)(h), that this detection monitoring program no longer satisfies the requirements of WAC 173-303-645(9), an application will be submitted to Ecology for a Permit modification within 90 days to make any appropriate changes to the program.

As part of the Permit, the groundwater monitoring system will be evaluated at a minimum every 5 years to determine if the number and locations of wells, analytical constituents, sampling frequency, and statistical evaluation methods are appropriate, especially for post-closure monitoring. Changes to the monitoring plan will be proposed through the Permit modification process.

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5 Compliance Monitoring Program

A compliance monitoring program that satisfies requirements set forth in WAC 173-303-645(10) will be established for the NRDWL/SWL WMA if detection-level monitoring reveals statistically significant evidence of dangerous waste/dangerous waste constituents from sources within the regulated unit. If compliance monitoring is required, DOE will submit a revised monitoring plan to Ecology specifying dangerous constituents to be monitored, sampling and analysis protocols, statistical evaluation methods, and so forth. In the compliance monitoring program, the dangerous constituents or parameters will be compared to concentration limits specified in the facility permit, as specified in WAC 173-303-645(5), during the compliance period.

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6 Corrective Action Program

When a compliance monitoring program is established as specified in Chapter 5, Chapter 6 will be updated to indicate how a compliance monitoring program would transition into a corrective action monitoring program in accordance with WAC 173-303-645(11).

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303-110, "Sampling, Testing Methods and Analytes."

303-400, "Interim Status Facility Standards."

303-645, "Releases from Regulated Units."

WAC 173-304, "Minimum Functional Standards for Solid Waste Handling," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-304.

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350-500, "Ground Water Monitoring."

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1

Distribution

	MS	Quantity
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1

Appendix A

SWL Deferral Application and Approval Letter from Ecology

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
3100 Port of Benton Blvd • Richland, WA 99354 • (509) 372-7950

July 14, 2010

Mr. David A. Brockman, Manager
United States Department of Energy
Richland Operations Office
P. O. Box 550, MSIN: A7-50
Richland, Washington 99352

Re: Application for Deferral for Final Closure of Solid Waste Landfill, Letter 10-AMCP-0166, from D. Brockman to J. Hedges, dated June 8, 2010 (Reissue)

Dear Mr. Brockman:

The Department of Ecology (Ecology) approves the United States Department of Energy's (USDOE) "Application for Deferral of Solid Waste Permit." This waives the requirement that a solid waste permit be issued under Washington Administrative Code (WAC) 173-350 for the Solid Waste Landfill (SWL) by deferring to a permit to be issued under Chapter 173-303 WAC. This will provide an equivalent or superior level of environmental protection.

Ecology is pleased with the well-prepared spreadsheet submitted with the application. We are satisfied that this deferral will allow USDOE to close the contiguous Nonradioactive Regulated Dangerous Waste Landfill (NRDWL) and SWL under the same closure/postclosure requirements and groundwater monitoring plan.

Ecology believes successful closure of the NRDWL and SWL using an engineered evapotranspiration (ET) cover will provide an opportunity to show the effectiveness of using ET covers at Hanford. To facilitate the demonstration, we will allow the project to go forward with conceptual engineering design. However, Ecology will require USDOE to complete the engineering design of the ET cover while the conceptual model-based closure/postclosure and groundwater monitoring plans are being prepared for public comment.

Sincerely,
Lois Dahmen
for

Jane A. Hedges
Program Manager
Nuclear Waste Program

cc: See page 2

Mr. David A. Brockman
July 14, 2010
Page 2

cc: Dave Bartus, EPA
Dennis Faulk, EPA
Kevin Leary, USDOE
Dale Black, CHPRC
Marty Doornbos, CHPRC
Moses Jaraysi, CHPRC
James Butner, CH2
Judy Vance, MSA
Lela Buck, Wanapum
Stuart Harris, CTUIR
Gabriel Bohnee, NPT
Russell Jim, YN
David Rowland, YN
Susan Leckband, HAB
Ken Niles, ODOE
Administrative Record
Environmental Portal

0088551

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

10-AMCP-0166

JUN 08 2010

Ms. J. A. Hedges, Program Manager
Nuclear Waste Program
State of Washington
Department of Ecology
3100 Port of Benton
Richland, Washington 99354

RECEIVED
JUN 10 2010
EDMC

Dear Ms. Hedges:

APPLICATION FOR DEFERRAL FOR FINAL CLOSURE OF SOLID WASTE LANDFILL

This letter responds to the May 7, 2010, determination for a regulatory path forward to the final closure of the Solid Waste Landfill. The U.S. Department of Energy Richland Operations Office (RL) concurs with the intent of the State of Washington Department of Ecology (Ecology) to waive the solid waste permit requirements for the Solid Waste Landfill in favor of the more protective requirements under the Hanford Dangerous Waste permit. RL believes this will allow us to efficiently close the Solid Waste Landfill along with the adjacent Nonradioactive Dangerous Waste Landfill (NRDWL), using a uniform approach for closure design, construction, groundwater monitoring program and post-closure care. Specifically, RL concurs with the following:

- The Solid Waste Landfill is subject to the regulatory requirements of WAC 173-350 Solid Waste Handling Standards which will be satisfied through the deferral option in WAC 173-350-710(8);
- By approval of the deferral application, Ecology will waive the solid waste permitting requirement by deferring to the corresponding requirements of the WAC 173-303 Dangerous Waste Regulations and implemented via the current Hanford Facility Permit WA7 89000 8967;
- The same closure/final cover, post closure care, groundwater monitoring requirements developed for the NRDWL will apply to Solid Waste Landfill to meet the solid waste management unit corrective action requirements pursuant to the Hanford Facility Resource Conservation and Recovery Act Permit Condition II.Y, which implements WAC 173-303-64620; and
- Since the closure/post closure and groundwater monitoring plan requirements will be common to the NRDWL and Solid Waste Landfill, RL will document them in a single closure/post-closure plan and a single groundwater monitoring plan.

D.6.1

Accordingly, transmitted with this letter is a completed Ecology form ECY 040-159 (11/03) for Application for Deferral of Solid Waste Permit per WAC 173-350-710(8). This application provides the demonstration that identifies each closure/post-closure requirement of Chapter 173-350 WAC and a detailed description of how the requirements of WAC 173-303, Dangerous Waste Regulations, will provide equivalent or superior level of environmental protection. Upon approval of the application, RL understands that the plans for closure of the NRDWL and Solid Waste Landfill will be included in the current Hanford Facility Permit.

In order to proceed with project development, RL requests that Ecology issue a letter following the public comment period indicating that the Closure/Post-closure plan is considered complete and ready for permitting. We look forward to your approval of the attached application and final approval of the related permitting documentation (Closure/Post Closure Plan, Groundwater Monitoring Plan) needed to implement Final Closure.

If you have any questions, please contact me, or your staff may contact Briant Charboneau, of my staff, on (509) 373-6137.

Sincerely,

Matthew S. McCormick, Assistant Manager
for the Central Plateau

AMCP:KDL

Attachment

cc: See Page 3

cc w/attach:
D. Bartus, EPA
D. G. Black, CHPRC
G. Bohnee, NPT
R. C. Brunke, CHPRC
L. Buck, Wanapum
J. R. Butner, CH2
G. P. Davis, Ecology
M. H. Doornbos, CHPRC
D. A. Faulk, EPA
S. Harris, CTUIR
M. N. Jaraysi, CHPRC
R. Jim, YN
S. L. Leckband, HAB
K. Niles, ODOE
D. L. Norman, CHPRC
A. A. Okemgbo, Ecology
R. E. Piippo, MSA
D. Rowland, YN
D. G. Singleton, Ecology
E. R. Skinnarland, Ecology
W. E. Toebe, CHPRC
J. G. Vance, MSA
Administrative Record
Environmental Portal

Application for Deferral of Solid Waste Permit
per *WAC 173-350-710(8)*

ECOLOGY

General Information

Application Date June 1, 2010	County where facility is located Benton County
Company Name, Government Entity, etc.: U.S. Department of Energy- Richland Name of Applicant (see *WAC 173-350.715(3)* for appropriate evidence of authority): Matthew S. McCormick c/o Kevin D. Leary Applicant's Position in Company or Government Entity:	Applicant is: [X] Facility owner [X] Facility operator [ ] Other(specify)_____
Applicant Mailing Address: U.S. Department of Energy P.O. Box 550, MS A6-38 Street: 825 Jadwin Avenue, MS A6-38 City: Richland State: WA Zip: 99352	Applicant phone: (Kevin Leary) (509) 373-7285 Fax: (509) 372-1926 e-mail address: Kevin_D_Leary@RL.gov

Facility Information

Name of Facility:

U.S. Department of Energy Hanford Facility

The specific location on the Hanford Facility is the Solid Waste Landfill (SWL), 3.5 miles southeast of the 200 East Area, located adjacent to NRDWL Landfill

Facility Address: (See location above) Street: City: State: Zip:	Facility Mailing Address (Not Applicable) Street: City: State: Zip:
Responsible Official: Kevin D. Leary Position at Facility: Project Manager	Facility phone: (Not applicable) Fax: e-mail address:

Facility Location, if known (at front gate) (SEE ATTACHED SITE MAP)

Section 20 Township T12N Range R27E Latitude: 46° 30' 30" Longitude 119° 27' 42"

Facility Site Zoning:

Hanford Federal Reservation

Description of the solid waste handling units for which the facility is requesting deferral: Solid Waste Landfill (Former 600 Area Landfill), which is regulated under 173-350 as a municipal limited purpose landfill, received a variety of waste including office and sanitary waste, construction debris, bulk items, asbestos and others items as detailed in the closure plan. Radioactive and dangerous waste disposal did not occur. This request is to defer to WAC 173-303 Dangerous Waste Regulations applicable to the NRDWL landfill closure, which is located adjacent to the SWL landfill. The closure of SWL will be conducted in coordination with the NRDWL closure with a uniform ET Barrier over both facilities.

Required or Existing Permits at the Facility Site

Type of permit *(check box)*	Consider for deferral	Need to Obtain	Existing Permit		
			Regulating Authority	Permit #	Expiration Date
☐ NPDES permit					
☐ Biosolids permit					
☐ State waste discharge permit					
☐ Conditional use permit					
☐ Stormwater permit					
☐ Hydraulic permit					
☐ DNR Surface mining permit					
☐ Flood control permit					
☐ Fire permit					
☐ Wetlands permit					
☐ Air operating permit					
☐ DNR Forest Practices					
X Hanford Facility RCRA Permit	X		State of Washington Department of Ecology	WA7890008967	In Continuance
☐ Other					

Addition Information Required

☒ Attach a demonstration that identifies each applicable requirement of chapter 173-350 WAC and a detailed description of how the other environmental permits will provide an equivalent or superior level of environmental protection. (SEE ATTACHED CROSSWALK TABLES DEMONSTRATING EQUIVALENT OR SUPERIOR PROTECTION)

☐ Attach evidence that the facility is in conformance with the approved comprehensive solid waste management plan and/or the approved hazardous waste management plan. (NOT APPLICABLE)

Groundwater Monitoring
The table below presents the groundwater monitoring requirements 173-350-500 for Landfills and the equivalent regulation under 173-303-645 Dangerous Waste Regulations. Where necessary a brief explanation

173-350-500 Groundwater Monitoring		Equivalent 173-303-645 Releases from regulated units	Abridged Text	NOTES
173-350-500 (1)	GW Monitoring Professional Quals	None found		Geologists licensed in the state of WA will prepare GW monitoring plan for NRDWL
173-350-500 (2)	Site Characterization	Not applicable	Unit already exists for characterizing site prior to permitting not possible.	NRDWL already closed, site characterization not possible
173-350-500 (3)	System Design	173-303-645 (8) (a) to (c)	Owner must comply with this requirement for any groundwater monitoring program to satisfy subsections (9), (10), and (11)	Equivalent
173-350-500 (4)	Sampling and Analysis Plan	173-303-645 (8) (d) to (g)	Department may specfy indicator parameters and may exclude specific constituents if certain requirements are met	Equivalent, in addition, RL is preparing a sampling and and analysis plan that will be reviewed and approved by the department
173-350-500 (5)	Data analysis, notifcation, reporting	173-303-645 (8) (h) and (i)	Multiple groundwater monitoring data statistical analysis methods are proposed including ANOVA	Equivalent, in addition, RL will perform ANOVA analyses on on indicator compounds

[X] Attach evidence of compliance with chapter 197-11 WAC, SEPA rules (SEPA checklist and Determination of Non-Significance) (A DNS SEPA DETERMINATION WAS ISSUED IN AUGUST 1990, AN UPDATED SEPA CHECKLIST IS CURRENTLY BEING PREPARED AND WILL BE SUBMITTED ONCE COMPLETE)

[ ] Attach other information that the jurisdictional health department or the Department of Ecology has required in accordance with WAC 173-350-710 (8)(d)(vi).

Signature and Verification of Applicant (Refer to *WAC 173-350.715(3)* for appropriate evidence of authority)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Matthew S. McCormick
(Applicant's Signature – printed)

Assistant Manager, for the Central Plateau
(Title)

(Applicant's Signature)

6/8/2010
(Date)

Notary Public Verification

State of Washington

County of Benton

Signed or attested before me on June 8, 2010

By

J. Jill Spargur
(Signature)

J. Jill Spargur

My appointment expires:

September 29, 2012
(Date)

(seal or stamp)

J. JILL SPARGUR NOTARY PUBLIC 9-29-12 STATE OF WASHINGTON

Table A-1 below presents the closure requirements under 173-350-400 for Limited Purpose Landfills and the equivalent regulation under 173-303 Dangerous Waste Regulations. Where necessary a brief explanation is provided to further elucidate how the 173-303 regulation is equivalent or provides greater protection.

Table A-2 below presents the closure requirements under 173-350-400 for Limited Purpose Landfills and the equivalent regulation under 173-303 Dangerous Waste Regulations. Where necessary a brief explanation is provided to further elucidate how the 173-303 regulation is equivalent or provides greater protection.

Table A-3 below presents the groundwater monitoring requirements 173-350-500 for Landfills and the equivalent regulation under 173-303-645 Dangerous Waste Regulations. Where necessary a brief explanation is provided to further elucidate how the 173-303-645 regulation is equivalent or provides greater protection than 173-350.

Table A-1. WAC 173-350-400 Closure Requirements and Equivalent WAC 173-303 Regulation

The sections referenced below from WAC 173-303 Dangerous Waste Regulations demonstrate equivalent to or greater Protection than those described in WAC 173-350-400 Closure Requirements for Limited Purpose Landfills				
173-350-400 (6) Limited Purpose Landfill Closure Requirements		**Equivalent WAC 173-303 Dangerous Waste Regulations**	**Abridged Text of Regulation**	**Notes**
(a)	Notification to jurisdictional health department of closure	173-303-610 (3) (c) (i)	The owner or operator must notify the department in writing at least 60 days prior to the date on which they expect to begin closure of a surface impoundment, waste pile, land treatment, or landfill unit, or final closure of a facility with such a unit. The owner operator must notify the department in writing at least 45 days prior to the date on which they expect to begin closure of a treatment or storage tank, container storage, or incinerator unit, or final closure of a facility with only such units.	Additional language is presented and appropriate notifications must still be made
i	Minimize need for further maintenance	173-303-665 (6) (ii) and 173-303-610 (2) (i)	Minimize the need for further maintenance.	Equivalent
ii	Controls, minimizes or eliminates threats to human health and environment from post closure escape	173-303-665 (6) and 173-303-610 (2) (ii)	Controls, minimizes or eliminates threats to human health and environment from post closure escape of dangerous waste, dangerous constituents, leachate, contaminated runoff, or dangerous waste decomposition products to the ground, surface water, groundwater, or the atmosphere.	Equivalent
(b)	Closure shall commence within 30 days of receipt of final waste volume	Not applicable, SWL is not operating	Not applicable.	NA
(c)	Owner shall not accept waste for disposal except as notified in closure plan approved by health dept	Not applicable, SWL is not operating	Not applicable.	NA
(d)	Owner shall develop, keep and abide by closure plan	173-303-610 (3) (a)	The owner or operator of a dangerous waste management unit facility must have a written closure plan. The approved closure plan will become a condition of any permit.	Owner must have plan approved by department

Table A-1. WAC 173-350-400 Closure Requirements and Equivalent WAC 173-303 Regulation

The sections referenced below from WAC 173-303 Dangerous Waste Regulations demonstrate equivalent to or greater Protection than those described in WAC 173-350-400 Closure Requirements for Limited Purpose Landfills					
173-350-400 (6) Limited Purpose Landfill Closure Requirements			**Equivalent WAC 173-303 Dangerous Waste Regulations**	**Abridged Text of Regulation**	**Notes**
	i	Final cover description	173-665 (6) (a)	Final cover must be designed and constructed to function with minimization of waste migration, minimum maintenance, promote drainage, accommodate settling.	Equivalent
	ii	Projected time intervals for closure	173-303-610 (3) (a) (vii)	Closure Plan must include a schedule for closure of the dangerous waste management unit.	Timelines are presented for achieving closure
	iii	Description of activities and procedures to comply with (a) thru (g)	173-303-610 (3) (a) (i) through (ix)	Owner must have written closure plan, approved by department.	Department approves plan
	iv	Identify closure cost estimates	Not applicable	Not applicable.	RL is required to meet financial assurance
(e)		Shall submit final engineering closure plans in accordance with closure plan	173-303-806 (4) (h) (v)	Detailed plans and an engineering report that describes the final cover.	Equivalent
(f)		When closure is completed in part or whole, owner shall submit:	173-303-610 (6)	Certification of closure.	Equivalent
	(i)	Closure plan sheets, stamped, as builts	173-303-610 (6)	Certification of closure.	Equivalent
	(ii)	Certification by owner that closed in accordance with plan	173-303-610 (6)	Certification of closure.	Equivalent
(g)		Owner shall record maps of landfill location with county auditor	173-303-610 (9) and (10)	Notice to local land authority and Notice in deed of property.	Equivalent

Table A-1. WAC 173-350-400 Closure Requirements and Equivalent WAC 173-303 Regulation

The sections referenced below from WAC 173-303 Dangerous Waste Regulations demonstrate equivalent to or greater Protection than those described in WAC 173-350-400 Closure Requirements for Limited Purpose Landfills				
173-350-400 (6) Limited Purpose Landfill Closure Requirements		**Equivalent WAC 173-303 Dangerous Waste Regulations**	**Abridged Text of Regulation**	**Notes**
(h)	Regulators shall notify owner when landfill is closed in accordance with plan	No equivalent, see notes	Not applicable.	RL will notify department when closure is complete
(7) Limited Purpose Landfill Post Closure Requirements				
(a)	Post closure activities (maintenance and monitoring) shall extend 20 years	173-303-610 (7) (a)	Post closure care shall continue for 30 years.	Post closure extends 30 years versus 20 years
i	Maintain integrity and effectiveness of final cover	173-303-665 (6) (b) (i) and 173-303-610 (8) (b) (ii) (A)	The integrity of the cap and final cover and other containment structures. [shall be part of planned maintenance]	Equivalent
ii	General maintenance of facility	173-303-665 (6) (b) (i) and 173-303-610 (8) (b) (ii) (A)	The integrity of the cap and final cover and other containment structures. [shall be part of planned maintenance]	Equivalent
iii	Monitor GW, leachate in accordance with WAC 173-350-500	173-303-665 (6) (b) (iv) and 173-303-610 (7) (a) (i)	Groundwater monitoring and reporting will be performed.	Equivalent
iv	Monitor LF gas and maintain LFG collection system	173-303-665 (6) and 173-303-610 (7) (a) (ii)	Maintenance and monitoring of waste containment systems as applicable and the function of the facility monitoring equipment. [shall be part of planned maintenance]	Equivalent
v	Maintain hydraulic controls	173-303-665 (6) and 173-303-610 (7) (a) (ii)	Maintenance and monitoring of waste containment systems as applicable and the function of the facility monitoring equipment. [shall be part of planned maintenance]	Equivalent
vi	Monitor settlement	173-303-665 (6) (a) (iv)	Accommodate settling and subsidence so that the cover's integrity is maintained.	Equivalent
vii	Any other activities	No equivalent	Not applicable.	

Table A-1. WAC 173-350-400 Closure Requirements and Equivalent WAC 173-303 Regulation

The sections referenced below from WAC 173-303 Dangerous Waste Regulations demonstrate equivalent to or greater Protection than those described in WAC 173-350-400 Closure Requirements for Limited Purpose Landfills				
173-350-400 (6) Limited Purpose Landfill Closure Requirements		**Equivalent WAC 173-303 Dangerous Waste Regulations**	**Abridged Text of Regulation**	**Notes**
(b)	Post closure activities shall commence after closure activities are complete	173-303-610 (8)	Post closure plan must be submitted within 90 days of when landfill is closed.	Deadlines will be set in closure plan
(c)	Owner shall develop a post closure plan	173-303-610 (8)	Post closure plan; amendment of plan.	Equivalent
i	Monitor for 20 years or until stable for GW, LFG, settlement surface water	173-303-610 (8) (b) (i) and (ii)	Post closure plan shall include: GW monitoring, and planned maintenance activities.	Equivalent
ii	Project time intervals when post closure will start, identify Post closure cost estimates, and project fund withdrawal	173-303-610 (8) (b) (i) and (ii)	Post closure activities must identify activities and frequencies of monitoring.	DOE is not subject to fulfilling financial assurance requirements
(d)	Owner shall follow post closure activities in accordance with post closure plan and schedule	173-303-610 (8)	Post closure activities must identify activities and frequencies of monitoring.	Equivalent

Table A-1. WAC 173-350-400 Closure Requirements and Equivalent WAC 173-303 Regulation

The sections referenced below from WAC 173-303 Dangerous Waste Regulations demonstrate equivalent to or greater Protection than those described in WAC 173-350-400 Closure Requirements for Limited Purpose Landfills				
173-350-400 (6) Limited Purpose Landfill Closure Requirements		**Equivalent WAC 173-303 Dangerous Waste Regulations**	**Abridged Text of Regulation**	**Notes**
(e)	When post closure activities are complete, owner shall submit certificate to regulators stating why post closure no longer needed	173-303-610 (11)	Certification of Completion of Post-closure care.	Equivalent
(f)	If regulators concur with (e) owner may discontinue post closure activities	173-303-610 (7) (b) and (c)	May shorten post closure if reduced period is protective or may extend period of post closure.	Department, at their discretion, may adjust post closure
(g)	Regulators shall notify appropriate authorities when post closure activities are complete and certified	No equivalent, see notes	Not applicable.	DOE will notify department when post closure is complete, therefore equivalent

Table A-2. WAC 173-350 Closure Cover Requirement and Equivalent WAC 173-303 Regulation

173-350-400 Limited Purpose Landfills			Equivalent 173-303- Dangerous Waste Regulation		
			The sections referenced below from WAC 173-303 dangerous waste regulations demonstrate equivalent to or greater requirements than those described in WAC 173-350		
173-350-400 (3) (e) Final Closure System Design			WAC 173-303	Abridged Text	Notes
i	**Final Cover Performance Standard**				
	(A)	Prevents Exposure of Waste	173-303-665 (6) (a) (iii)	Minimize erosion and abrasion of the cover.	Equivalent
	(B)	Minimizes infiltration (at a minimum, design will prevent generation of significant quantities of leachate to eliminate need for leachate removal system	173-303-665 (6) (a) (i); 173-303-665 (6) (b) (v)	Provide long-term minimization of liquids through closed landfill; Prevent run-on and runoff from eroding or damaging the final cover.	Equivalent
	(C)	Prevents erosion from wind and water	173-303-665 (6) (a) (iii)	Promote drainage and minimize erosion or abrasion of cover.	Equivalent
	(D)	Is capable of sustaining native vegetation	173-303-610 (2) (a) (iii)	Returns land to appearance and use of surrounding land areas to degree possible given nature of previous dangerous waste activity.	Beyond native vegetation required by 173-350, land must also match surrounding area
	(E)	Addresses anticipated settlement	173-303-665 (6) (b) (i)	Maintain integrity and effectiveness of final cover, including making repairs as necessary to correct effects of settling, subsidence, erosion.	Equivalent
	(F)	Provides sufficient stability and mechanical strength and addresses freeze thaw and desiccation	173-303-665 (6) (b) (i)	Maintain integrity and effectiveness of final cover, including making repairs as necessary to correct effects of settling, subsidence, erosion, or other events.	Equivalent
	(G)	Provides for management of run-on and run-off	173-303-665 (6) (b) (i); 173-303-665 (6) (b) (v)	Maintain integrity and effectiveness of final cover; Prevents run-on and run-off from eroding or damaging the final cover.	Equivalent
	(H)	Minimizes need for post closure maintenance	173-303-610 (2) (a) (i)	Minimize need for further maintenance.	Equivalent

Table A-2. WAC 173-350 Closure Cover Requirement and Equivalent WAC 173-303 Regulation

173-350-400 Limited Purpose Landfills		**Equivalent 173-303- Dangerous Waste Regulation**		
		The sections referenced below from WAC 173-303 dangerous waste regulations demonstrate equivalent to or greater requirements than those described in WAC 173-350		
173-350-400 (3) (e) Final Closure System Design		**WAC 173-303**	**Abridged Text**	**Notes**
(I)	Provides for collection and removal of methane and other gased generated in landfill	173-303-610 (2) (a) (i) and (ii)	Controls, minimizes or eliminates to the extent necessary to protect human health and the environment escape of dangerous waste, dangerous constituents, decomposition products to groundwater, surface water or atmosphere.	See above, Including testing if necessary based on changes outlined above
(J)	Meets requirements of regulations, permit and polices administered by air pollution control authority	No equivalent WAC Code	All applicable air pollution control requirements apply equally regardless.	Equivalent

Table A-3. Groundwater Monitoring

173-350-500 Groundwater Monitoring		Equivalent 173-303-645 Releases from Regulated Units	Abridged Text	Notes
173-350-500 (1)	GW Monitoring Professional Quals	None found		Geologists licensed in the state of WA will prepare GW monitoring plan for NRDWL
173-350-500 (2)	Site Characterization	Not applicable	Unit already exists for characterizing site prior to permitting not possible.	NRDWL already closed, site characterization not possible
173-350-500 (3)	System Design	173-303-645 (8) (a) to (c)	Owner must comply with this requirement for any groundwater monitoring program to satisfy subsections (9), (10), and (11).	Equivalent
173-350-500 (4)	Sampling and Analysis Plan	173-303-645 (8) (d) to (g)	Department may specify indicator parameters and may exclude specific constituents if certain requirements are met.	Equivalent, in addition, RL is preparing a sampling and analysis plan that will be reviewed and approved by the department
173-350-500 (5)	Data analysis, notification, reporting	173-303-645 (8) (h) and (i)	Multiple groundwater monitoring data statistical analysis methods are proposed including ANOVA.	Equivalent, in addition, RL will perform ANOVA analyses on indicator compounds

Appendix B

Reprint of
Appendix 4B—Waste Designation Database from DOE/RL-90-17,
Nonradioactive Dangerous Waste Landfill Closure/PostClosure Plan
Published 1990

and

Summary of Chemicals from
Appendix 4B—Waste Designation Database from DOE/RL-90-17,
with Supplemental Information

and

Waste Inventory—Developed from Manifests of Disposal of Chemicals
Disposed of at NRDWL (893-1303, Golder Associates)

1

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Table B-8. Trademark Information B-114

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B1 Waste Characterization Database

Appendix B1, The Waste Designation Database, was originally titled "*Appendix 4B-Waste Designation Database*" was part of the NRDWL closure plan (DOE/RL-90-17, Rev. 0—*Closure and Postclosure Plan Nonradioactive Dangerous Waste Landfill*), submitted in 1990. The database listed all the known waste disposed at NRDWL that was categorized as a dangerous waste. In addition, the applicable waste designation code or potentially applicable WAC 173-303-070 (3) waste category was provided for each waste material. Waste Materials were included in the database if they met the following criteria: the quantity exceeded 1 kg, and if the material was designated as a dangerous waste in accordance with WAC 173-303. Additionally, other waste materials were listed in the data base for information purposes, but did not receive a dangerous waste designation code. This database was derived from a Master Inventory List (Section B4, described below) of all known waste materials disposed of at NRDWL. The Waste Designation Database (i.e., Appendix B1) was used to develop the quantities of waste disposed at NRDWL as summarized in the *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington* report (DOE/EIS-0391), U.S. Department of Energy, Richland Operations, Richland, Washington, October 2009.

Section B3 (Table B-1) summarizes those chemicals that did not receive a waste designation in the Waste Designation Database but were still included in the database for information purposes. Where possible, the use of the chemical, the major constituents, and the CAS number are presented for these compounds. No attempt was made to determine the waste designation.

The Master Inventory List (Appendix B4) was used to develop the Waste Designation Database (Appendix B1) in the 1990 closure plan (DOE/RL-90-17, Rev 0). Appendix B4 was developed by Golder Associates (893-1303) and is based on a detailed review of manifests of all small quantity laboratory chemicals and other chemical wastes placed in the landfill between 1975 and 1988, which documented the disposal of materials at NRDWL. Some compounds are listed in the Master Inventory List but are not shown in the Waste Designation Database. This is because the compounds did not meet database criteria, for example, were less than 1kg, were clearly benign (concrete for example), or the containers were labeled as a particular compound, but were lists as empty or contained de minimus quantities on the manifest.

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APPENDIX 4B

WASTE DESIGNATION DATABASE

APPENDIX 4B

WASTE DESIGNATION DATABASE

COLUMN HEADER	DESCRIPTION
COMPOUND	The waste name as listed on the original source inventory list.
QTY	The mass of waste present in kilograms.
TR NO	The trench number where the waste is located.
DESIGNATION	Wastes that are designated under applicable or potentially applicable WAC 173-303-070(3) categories. All designations were made following the definitions in WAC 173-303.

EHW WT01	extremely hazardous toxic waste
DW WT02	dangerous toxic waste
EHW WP01	extremely hazardous persistent waste
DW WP02	dangerous persistent waste
EHW WP03	extremely hazardous persistent polycyclic aromatic hydrocarbon waste
EHW WC01	extremely hazardous carcinogenic waste
DW WC02	dangerous carcinogenic waste
DW D001	dangerous ignitable waste
DW D002	dangerous corrosive waste
DW D003	dangerous reactive waste
EP TOX	extraction procedure toxic wastes D004 - D017
P/U	P or U listed - discarded chemical product list (WAC 173-303-9930)
F	F listed - dangerous waste sources list (WAC 173-303-9904).

FL	Flammable--wastes exhibiting a flash point less than 100 °F (38 °C) (49 CFR 173.115).
CO	Combustible--wastes exhibiting a flash point between 100 °F (38 °C) and 200 °F (76 °C) (49 CFR 173.115).
OX	Oxidizer--wastes that are oxidizers (Sax 1984, Merck 1976).
TOX	Toxicity--the oral rat LD_{50} in mg/kg.

APPENDIX 4B

WASTE DESIGNATION DATABASE

COLUMN HEADER	DESCRIPTION
OC	Occurrence--the number of separate occurrences of the waste in the respective trench. This value is an estimate of the number of separate containers holding quantities of the waste. If the number of containers was not given in the master lists, the waste was assumed to be in 55-gallon drums and the number of occurrences was estimated assuming a maximum of 200 kilograms per drum.

Blank column spaces indicate a lack of information.

WASTE DESIGNATION DATABASE

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
AMMONIUM OXALATE	2	19	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	375	1
CALCIUM NITRATE WASTE	600	19	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y		
NAPHTHA	4	19	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	N		1
NICKEL, HYDRATED	2200	19	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		11
SODIUM HYDROXIDE	2.5	19	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
SODIUM NITRATE	88.5	19	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		2
SODIUM NITRATE WASTE	200	19	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
SODIUM NITRITE	4073	19	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	85	21
SODIUM NITRITE	2860	26	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	85	13
ALUMINUM, ACTIVATED	50	28	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
AMMONIUM HYDROXIDE	140	28	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
AMYL ALCOHOL	1	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	3030	1
BORAX	1220	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		7
BORIC ACID	1940	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2660	10
BROMINE	1	28	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
BUTYL ALCOHOL	3	28	N	Y	N	Y	N	N	N	N	Y	N	N	N	U031	F003	Y	N	N	790	1
BUTYL ETHER	3	28	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	11000	1
CERIC OXIDE	315	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
CESIUM CARBONATE	48	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
CONCENTRATED CHEMICAL A/B	8	28																			1
DICHLOROMETHANE	20	28	Y	N	Y	N	N	N	N	Y	N	N	N	N	U080	N	N	N	N	167	1
DIMETHYL FORMAMIDE	4	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	2800	1
ETHYLACETATE	1	28	N	Y	N	N	N	N	N	N	Y	N	N	N	U122	F003	Y	N	N	11000	1
FORMIC ACID, PICROLONIC ACID, WASTE	80	28	Y	N	N	N	N	N	N	N	Y	Y	N	N	U123	N	N	Y	N	1210	1
GLYCERYL TRIACETATE	1	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3000	1
HEXANOL	1	28	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	720	1
HEXONE	1.5	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	2080	1
ISOPENTYL ALCOHOL	5	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	1300	1
KAOWOOL CEMENT	20	28																			1
LACTIC ACID	2.5	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3730	1
LANTHANUM NITRATE	3800	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4500	19

WASTE DESIGNATION DATABASE

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
MAGNESIUM NITRATE	125	28	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		1
MEK	3	28	N	Y	N	N	N	N	N	N	Y	N	N	N	U159	F005	N	N	N	3400	1
NICKLE, HYDRATED	41	28	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		1
OCTYL ALCOHOL	1.5	28	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
PLEXIGLASS CEMENT	1	28																			1
PROPIONITRILE, 2,2OA2O-BIS-2-METHYL	1	28												N	N	N					1
SODA ASH	12.5	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
SODIUM CARBONATE SLUDGE, SPIKED	1100	28	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		6
SODIUM FLUORIDE	15	28	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	180	1
SODIUM HYDROXIDE	5	28	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
SODIUM NITRATE	1057.	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		6
SODIUM NITRATE SLUDGE	440	28	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
SODIUM NITRITE	3555	28	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		18
SULFURIC ACID	3.8	28	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	2140	1
SULFUROUS ACID	11	28	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
TRICHLOROETHANE	3000	28	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	10300	15
URETHANE COMPONENT A	8	28	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		1
2,4-DINITROPHENOL	5	31	Y	N	N	N	N	N	N	N	N	N	N	N	P048	N	N	N	N	30	1
ACRYLONITRILE 99%	1	31	Y	N	N	N	N	N	N	N	Y	N	N	N	U009	N	Y	N	N	82	1
ALCOHOL, ISO AMYL	1	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	1300	1
ALTREX METAL CLEANER	3187.	31	Y																		16
ALUMINUM CLEANER	1	31																			1
ALUMINUM NITRATE	1	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	4280	2
AMMONIUM ACETATE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMMONIUM BIFLUORIDE	24.5	31	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		2
AMMONIUM CITRATE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMMONIUM FLUORIDE	8	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMMONIUM MOLYBDATE	1	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	330	1
AMMONIUM OXALATE	3	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	375	2
AMMONIUM SULFATE	1	31	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	3000	1
ANILINE	2	31	N	Y	N	N	N	N	N	Y	N	N	N	N	U012	N	N	Y	N	250	5

WASTE DESIGNATION DATABASE

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
BARIUM CHLORIDE	4	31	Y	N	N	N	N	N	N	N	Y	N	Y	D005	N	N	N	N	N	118	1
BERYLLIUM COPPER	283	31	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		2
BUTANOL	1	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	790	2
BUTOXYETHANOL, 2-	4.5	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	1480	1
BUTYL ACETATE, N-	4	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	14000	1
CALCIUM FLUORIDE	13	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4250	1
CARBON TETRACHLORIDE	4	31	N	Y	Y	N	N	Y	N	N	N	N	N	N	U211	F001	N	N	N	2800	1
CARBONATE, RARE EARTH	600	31												N	N	N					3
CHLOROFORM	4	31	Y	N	Y	N	N	Y	N	N	N	N	N	N	U044	N	N	N	N	800	1
COPPER SULFATE CRYSTALS	80	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	300	1
CROTONALDEHYDE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	U053	N	N	N	N		1
CUPRIC NITRATE	38.2	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
CUPRIC SULFATE	2.5	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
CYCLOHEXANE	1	31	Y	N	N	N	N	N	N	N	Y	N	N	N	U056	N	Y	N	N	29820	1
DIOCTYL SEBACATE	223	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1280	2
DIOXANE	9.5	31	Y	N	N	N	N	Y	N	N	Y	N	N	N	U108	N	Y	N	N	4200	2
ETHANOLAMINE	1.5	31	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	2100	1
ETHYL ACETATE	1.5	31	N	Y	N	N	N	N	N	N	Y	N	N	N	U122	F003	Y	N	N	11000	1
ETHYLENE DICHLORIDE	8	31	N	N	N	Y	N	N	N	N	Y	N	N	N	U077	N	Y	N	N	1120	1
FERROUS AMMONIUM SULFATE	4.5	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
FERROUS HYDROXIDE	2940	31	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		15
FERROUS SULFAMATE	63.1	31												N	N	N					2
FLOCCULANT	150	31																			1
FLOCCULANT, TOL FLOC COAG	60	31																			1
FORMALDEHYDE	4	31	Y	N	N	N	N	Y	N	N	Y	N	N	N	U122	N	N	Y	N	800	1
HERBICIDE MISC. RAGS	2	31																			1
HYDROFLUORIC ACID	4.5	31	Y	N	N	N	N	N	N	N	N	Y	N	N	U134	N	N	N	N		2
HYDROIODIC ACID	15	31	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
HYDROXYLAMINE HYDROCHLORIDE	6.2	31	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	408	2
LEAD ACID GEL IN BATTERY	105	31												D008	N	N					1

WASTE DESIGNATION DATABASE

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
LITHIUM NITRITE AND REACTION DEBRIS	570	31																			3
MAGNESIUM NITRATE CRYSTAL OXIDIZER	200	31	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		9
METHANOL	9	31	N	Y	N	N	N	N	N	N	Y	N	N	N	U154	F003	Y	N	N	13000	1
METHYLENE CHLORIDE	1	31	Y	N	Y	N	N	N	N	Y	N	N	N	N	U080	F001F002	N	N	N	167	1
METHYMETHOCYLATE	4	31												N	N	N					1
MIBK	3.5	31	Y	N	N	N	N	N	N	N	Y	N	N	N	U161	F003	Y	N	N	2080	1
MURIATIC ACID	20	31	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N		1
NALCO 5 - SODIUM ALUMINATE	200	31	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		4
NITRILOTRIACETIC ACID	200	31	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	1470	4
OLIN 5004 CLAY, COAGULANT AID, PWD	175	31																			1
PAINT WASTE, THINNER & RAGS	163	31																			1
PETROLEUM DISTILLATES	13	31	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	N		1
PHOSPHORIC ACID	5	31	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	1530	1
POTASSIUM BROMATE	1.5	31	Y	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N		1
POTASSIUM CARBONATE	2	31	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	1870	2
POTASSIUM CHLORIDE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
POTASSIUM HYDROGEN SULFATE	2	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2340	1
POTASSIUM NITRATE	2	31	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	Y		2
POTASSIUM PERMANGANATE	1.75	31	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	1090	2
POTASSIUM PERSULFATE	1	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		2
PROPYLENE CARBONATE	4	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	29000	1
RETORT WATER	18	31																			1
SODIUM ACETATE	1.75	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3530	3
SODIUM AMIDE	2	31	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		4
SODIUM BICARBONATE	1	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4220	2
SODIUM BISULFATE	0.5	31	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
SODIUM CARBONATE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
SODIUM CHLORIDE	9	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3000	3
SODIUM DITHIONITE	2	31	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
SODIUM FLUORIDE	4	31	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	180	1
SODIUM HYDROXIDE	3.5	31	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		3

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
SODIUM META BISULFATE	6.5	31	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N		1
SODIUM METASILICATE	1.5	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
SODIUM NITRATE	8	31	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		2
SODIUM PHOSPHATE	1	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
SODIUM SALT	100	31																			1
SULFAMIC ACID	2.7	31	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		3
SULFANILAMIDE	4	31	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N		1
SULFANILIC ACID	5.5	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	12000	1
TETRABROMO-METHANE, 1,1,2,2-	5	31	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N		1
TETRACHLOROETHYLENE	5	31	N	N	Y	N	N	Y	N	N	N	N	N	N	U210	F001F002	N	N	N	8850	2
TETRAHYDROFURAN	4	31	N	N	N	N	N	N	N	N	Y	N	N	N	U213	N	Y	N	N		1
TOLUENE	1	31	Y	N	N	N	N	N	N	N	Y	N	N	N	U220	F005	Y	N	N	5000	1
TRIBUTYLPHOSPHATE	4	31	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3000	1
TRICHLOROACETIC ACID	1	31	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
TRICHLOROBENZENE, 1,2,4-	20	31	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	756	1
TRITON X-100	2	31																			1
TURCO 4502 (HAS EP METALS)	63	31	Y					Y			Y	Y	N	Y	N	N	N	N	N		1
XYLENE	4	31	Y	N	N	N	N	N	N	N	N	N	N	N	U239	F003	N	Y	N	4300	1
2-4-D AMINE, DIMETHYLINE	220	33																			1
310-B-6126	1	33																			1
ACETALDEHYDE	3.1	33	N	Y	N	N	N	N	N	N	Y	N	N	N	U001	N	Y	N	N	1930	2
ACETIC ACID	7	33	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	3310	8
ACETONE	24.5	33	N	Y	N	N	N	N	N	N	Y	N	N	N	U002	N	Y	N	N	9750	2
ACID	9	33																			3
AEROSOL OT CLEANER	1	33																			1
ALIZARIN BLACK ACID	0.01	33												N	N	N					1
ALKALINE METAL CLEANER	350	33																			2
ALUMINUM	1.3	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		4
ALUMINUM NITRATE	1	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		2
AMERZINE	4.6	33																			2
AMMONIUM ACETATE	2.25	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
AMMONIUM CARBONATE	2	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		4
AMMONIUM CHLORIDE	1.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1650	3
AMMONIUM FLUORIDE	4	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMMONIUM HYDROXIDE	2.5	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	350	5
AMMONIUM MOLYBDATE	1	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	330	3
AMMONIUM NITRATE	1.9	33	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	Y		3
AMMONIUM OXALATE	3.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	375	2
AMMONIUM PERSULFATE	5.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	820	7
AMMONIUM SULFATE	4.88	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	3000	4
AMMONIUM TETRASULFATE CERATE	1	33												N	N	N					1
AMMONIUM THIOCYANATE	1.88	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
ANHYDRONE	0.67	33	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y		2
APC	1	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1000	1
APDC	1	33												N	N	N					3
AROPOL WEP 666P	4	33																			1
BARIUM CHLORIDE	2.13	33	Y	N	N	N	N	N	N	N	N	N	N	D005	N	N	N	N	N	118	4
BARIUM HYDROXIDE	3.7	33	N	N	N	N	N	N	N	N	N	N	N	D005	N	N	N	N	N		3
BARIUM NITRATE	1.5	33	Y	N	N	N	N	N	N	N	Y	N	N	D005	N	N	N	N	Y	355	2
BENZALPHAPYRENE	180	33	Y	N	Y	N	N	Y	N	N	N	N	N	N	U022	N	N	N	N		1
BENZENE	41.25	33	Y	N	N	N	N	Y	N	N	Y	N	N	N	U019	N	Y	N	N	3800	11
BENZENE, CONCRETED	52	33	Y	N	N	N	N	Y	N	N	Y	N	N	N	U019	N	Y	N	N	3800	1
BENZENE,MONOBROME	0.5	33	Y	N	N	N	N	Y	N	N	Y	N	N	N	N	N	Y	N	N	3800	1
BENZYL-PARA-AMINOPHENOL	180	33												N	N	N					1
BERYLLIUM NITRATE	0.5	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
BETZ 403	22	33																			2
BIOFLUOR	1	33																			1
BORIC ACID	127.3	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2660	4
BROMICIDE	28.5	33	N	Y	N	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	790	1
CALCI-SOLVE	16	33																			1
CALCIUM CHLORIDE	4.58	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1000	5
CALCIUM PHYTATE	7	33												N	N	N					1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
CALGON CL-162	3	33																			1
CALGON CL-246	1	33																			1
CALGON CL-77	220	33																			2
CALGON D-26 DEPOSIT INH	22	33																			1
CALGON H230 WATER MICROBIOCIDE	19	33																			1
CAR BOPOL 941	22	33																			1
CARBON TETRACHLORIDE	2	33	N	Y	Y	N	N	Y	N	N	N	N	N	N	U211	F001	N	N	N	2800	3
CARCINOGENS, MIXED CONCRETED	12	33																			1
CAUSTIC SODA FLAKES	35	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
CERIC SULFATE	1	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		2
CESIUM CHLORIDE	2.76	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		4
CESIUM NITRATE	1	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		2
CHLOROFORM	13.75	33	Y	N	Y	N	N	Y	N	N	N	N	N	N	U044	N	N	N	N	800	11
CHLOROSULFAMIC ACID	2	33												N	N	N					1
CHLOROTRIMETHYL SILANE	3.5	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
CHROMIC NITRATE	120	33	N	Y	N	N	N	Y	N	N	N	N	N	D007	N	N	N	N	N		1
CHROMIUM,AL,MN,S,FE PWDR	20	33												D007	N	N					1
CHROMIUM NITRATE	8	33	N	Y	N	N	N	Y	N	N	N	N	N	D007	N	N	N	N	N		2
CHROMIUM TRIOXIDE	1.2	33	Y	N	N	N	N	N	N	N	N	N	N	D007	N	N	N	N	Y		2
CL-162	3	33																			1
CL-246	3	33																			1
COBALT NITRATE	1.7	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		4
COPPER	1.2	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
COPPER BERYLLIUM	400	33												N	N	N					2
CORROSIVE MIXTURE	80	33																			2
CUPRIC SULFATE	76.83	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	300	7
CYANIDE	0.5	33	Y	N	N	N	N	N	N	N	N	N	Y	N	P030	N	N	N	N		1
CYCLOHEXANE	1	33	Y	N	N	N	N	N	N	N	Y	N	N	N	U056	N	N	N	N	29820	2
DDTC	1	33																			2
DIBENZOYL PEROXIDE	1.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	*	7710	1
DIISOBUTYL PHTHALATE	2.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	20000	2

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
DIMETHYL FORMAMIDE	1.5	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	2800	2
DIOCTYL PHTHALATE	120	33	N	N	N	N	N	N	N	N	N	N	N	N	U107	N	N	N	N		1
DIOCTYL SEBACATE	1066	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1280	6
DIOXANE	70	33	Y	N	N	N	N	Y	N	N	Y	N	N	N	U108	N	Y	N	N	4200	5
DONNAGEL SUSPENSION	29	33																			1
DOWEX	1.5	33																			3
DRIERITE,USED	2.27	33																			1
D-26 INHIBITOR	20	33																			1
ETHANOL	7.25	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	7060	7
ETHER	3.2	33	N	N	N	N	N	N	N	N	N	N	N	N	U117	F003	N	N	N		2
ETHONE	1.75	33												N	N	N					1
ETHONE NL-62	1	33												N	N	N					1
ETHYL ETHER	7	33	N	Y	N	N	N	N	N	N	Y	N	N	N	U117	F003	Y	N	N	1700	3
ETHYL HEXYLAMINE	1	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	450	1
ETHYLENE GLYCOL	4	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	3930	3
ETHYLENE GLYCOL MONOMETHYL ETHER	1	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	3930	1
FENEMINE	900	33																			5
FERRIC AMMONIUM SULFATE	1.26	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
FERROUS HYDROXIDE	2200	33												N	N	N					11
FORMALDEHYDE	3.75	33	Y	N	N	N	N	Y	N	N	Y	N	N	N	U122	N	N	Y	N	800	6
FORMIC ACID	2	33	Y	N	N	N	N	N	N	N	Y	Y	N	N	U123	N	N	Y	N	1210	1
GREENSHIELD ADJUVENT	220	33																			1
HERBICIDE, BANVIL	200	33																			1
HEXANE	17.5	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	28700	7
HEXANOL	1	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	720	2
HYAMINE HYDROXIDE	1	33																			2
HYDRAZINE	12.83	33	Y	N	N	N	N	Y	N	N	Y	N	Y	N	U133	N	N	Y	N		4
HYDRAZINE, 35% SONBED	112	33	Y	N	N	N	N	Y	N	N	Y	N	Y	N	U133	N	N	Y	N		1
HYDRAZINE, AMERZINE-TM-35 CATALYZED	180	33	Y	N	N	N	N	Y	N	N	Y	N	Y	N	U133	N	N	Y	N		1
HYDRIODIC ACID	1.53	33												N	N	N					3
HYDROCHLORIC ACID	12.8	33	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N		19

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
HYDROCHLORIC ACID, JENNY COIL CMPD #80	4	33	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N		1
HYDROFLUORIC ACID	1.1	33	Y	N	N	N	N	N	N	N	N	Y	N	N	U134	N	N	N	N		3
HYDROGEN PEROXIDE	3	33	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y		6
HYDROQUINONE	1.03	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	320	3
HYDROXYLAMINE HYDROCHLORIDE	3.05	33	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	408	6
HYDROXYQUINOLINE	3	33	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	1200	4
H-230 BIOCIDE	20	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	26	1
IODINE	1.81	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	14000	6
IRON (II) NITRATE	216	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3250	2
KEPONE	1	33	Y	N	N	N	N	Y	N	N	N	N	N	N	U142	N	N	N	N	95	1
KHC8O4	1	33																			2
KODAK RAPID FIX SOLN	1	33																			1
LANTHANUM AMMONIUM NITRATE	1.5	33												N	N	N					1
LANTHANUM NITRATE	0.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4500	1
LEAD ACETATE	1	33	Y	N	N	N	N	Y	N	N	N	N	N	D008	U144	N	N	N	Y		3
LEAD NITRATE	6.03	33	Y	N	N	N	N	Y	N	N	N	N	N	D008	U144	N	N	N	Y		4
LECITHIN, L-A-	1	33																			1
LITHIUM HYDROCHLORIDE	1	33												N	N	N					1
MAGNESIUM CHLORIDE	4.2	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2800	3
MALCO 310(B-6126)	1	33																			1
MANGANESE DIOXIDE	1	33	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y		2
MECL2	4	33	Y	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	167	1
MERCURIC CHLORIDE	2	33	Y	N	N	N	N	N	N	N	N	N	N	D009	N	N	N	N	N		4
MERCURY	3.6	33	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		5
MERCURY, CONCRETED	25	33	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
MERCURY CONT. MATERIAL	10	33	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
METHANOL	10	33	N	Y	N	N	N	N	N	N	Y	N	N	N	U154	F003	Y	N	N	13000	9
METHYL FORMAMIDE	4	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		1
METHYL ORANGE	1	33	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	60	4
METHYLENE CHLORIDE	27	33	Y	N	Y	N	N	N	N	Y	N	N	N	N	U080	F001F002	N	N	N	167	3
METYL SILANE	1	33												N	N	N					1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
MIBK	4	33	N	Y	N	N	N	N	N	N	Y	N	N	N	U161	F003	Y	N	N	2080	1
MOLYBDATE REAGENT	2	33												N	N	N					2
NALCLEAN-68 SCALE REMOVER	200	33																			1
NITRIC ACID	40.48	33	Y	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	Y		22
NITRILOTRIACETIC ACID	9.5	33	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	1470	3
OIL	5	33																			2
OROCOL	280	33																			2
ORSAT SOLN	1	33																			1
OXALIC ACID	16.93	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	375	4
PEPERDIME	1	33																			1
PERCHLORIC ACID	12	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	1100	9
PHENOL	3	33	Y	N	N	N	N	N	N	N	Y	N	N	N	U188	N	N	N	N	414	5
PHOSPHORIC ACID	10	33	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	1530	7
PHOSPHOROUS ACID	2.9	33												N	N	N					3
PHOSPHOROUS TRICHLORIDE	2.5	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	550	2
PICRIC ACID	0.16	33	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
POLYETHYLENE GLYCOL	4	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	33750	1
POLY-OXYETHYLENE-23-LAURYLETHER	1	33												N	N	N					1
POTASSIUM BROMATE	1.1	33	Y	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N		3
POTASSIUM CHLORIDE	3.2	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		6
POTASSIUM CYANIDE	2.4	33	Y	N	N	N	N	N	N	N	N	N	Y	N	P098	N	N	N	N	10	7
POTASSIUM DICHROMATE	2	33	Y	N	N	N	N	Y	N	N	Y	N	N	D007	N	N	N	N	Y		1
POTASSIUM FLUORIDE	2	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	245	3
POTASSIUM HYDROXIDE	1.25	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	365	3
POTASSIUM NITRATE	1.3	33	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	Y		3
POTASSIUM PERMANGANATE	8	33	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	1090	7
POTASSIUM PYROSULFATE	1.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
POTASSIUM SODIUM TARTRATE	1.5	33												N	N	N					3
POTASSIUM SULFIDE	7	33	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
POTASSIUM THIOCYANATE	3.5	33	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	854	3
POZZALON 300	8	33																			2

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
PUMP OIL	20	33																			1
PYROGALLIC ACID	2.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	789	1
READY-SOLV SOLUTION	4	33																			1
REAGENTS,MISC.	2	33																			1
RESORCINOL	1	33	Y	N	N	N	N	Y	N	N	N	N	N	N	U201	N	N	N	N	301	3
RINGER'S SOLN, LACTATED	11	33																			1
RODINE 82A ACID INH	16	33																			1
RODINE 82-A	16	33																			1
SAMPLE 3, PROJECT #1086	10	33																			1
SODIUM ACETATE	2	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3530	4
SODIUM BROMATE	1	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		2
SODIUM BROMIDE	1	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3500	2
SODIUM CYANIDE	1	33	Y	N	N	N	N	N	N	N	N	N	Y	N	P106	N	N	N	N	6440	3
SODIUM DITHIONATE	2.5	33	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
SODIUM FLUORIDE	2.5	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	180	5
SODIUM HYDROXIDE	43	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		10
SODIUM HYPOBROMITE	2	33												N	N	N					2
SODIUM HYPOCHLORITE	1.5	33	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
SODIUM IODIDE	1	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4340	3
SODIUM NITRATE	12.9	33	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		7
SODIUM NITRITE	2.5	33	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	85	2
SODIUM PEROXIDE	1	33	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y		1
SODIUM PHOSPHATE	4	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		5
SODIUM SULFIDE	1	33	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N		2
SODIUM THIOCYANATE	1	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	764	2
SOLVENT,REFINED COAL	270	33																			2
SOLVENT,SPILL CLEANUP	20	33																			1
SOLVENTS,THINNER,OIL, PAINT	8795	33																			45
SOLVENTS: ACETONE, TOLUENE, ETC.	364	33												N	N	F003F005					7
STANNOUS CHLORIDE	1	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	700	1
SULFURIC ACID	14	33	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	2140	12

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
SULFURIC ACID,POTASSIUM HYDROXIDE	200	33												N	N	N					1
TETRACHLOROETHYLENE	20	33	N	N	Y	N	N	Y	N	N	N	N	N	N	U210	F001F002	N	N	N	8850	1
TETRAHYDROFURAN	130	33	N	N	N	N	N	N	N	N	N	N	N	N	U213	N	Y	N	N		5
TOLUENE	2.25	33	Y	N	N	N	N	N	N	N	Y	N	N	N	U220	F005	Y	N	N	5000	1
TRANSFORMER OIL	8	33																			1
TRIBUTYL PHOSPHATE	6.5	33	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3000	4
TRICHLOROETHANE,111	1	33	N	Y	N	N	N	N	N	Y	N	N	N	N	U226	F001F002	N	N	N	10300	1
TRICHLOROETHYLENE	221	33	Y	N	Y	N	N	Y	N	N	Y	N	N	N	U228	F001F002	Y	N	N	4920	1
TUNGSTIC ACID	2	33												N	N	N					6
TURCO-4502	55	33	Y	N	N	N	N	Y	N	N	N	Y	N	Y	N	N	N	N	N		2
TURCO-4521	95	33																			2
UNION FLUID LO500	28	33																			1
UNKNOWN	13	33																			2
WOOD FOR DERIVATIVES	40	33																			1
XYLENE	4.5	33	Y	N	N	N	N	N	N	N	Y	N	N	N	U239	F003	N	Y	N	4300	5
ZINC	1.5	33	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		3
2,6-DIMETHYL-4-HEPTANOL	4	34												N	N	N					1
ACETATE, 2-BUTOXYETHYL	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	6500	1
ACETATE, N-BUTYL	4	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	14000	1
ACETIC ACID	2.25	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	3310	2
ACETONITRILE	4.5	34	N	N	N	N	N	N	N	N	Y	N	Y	N	U003	N	N	N	N	3800	2
ALAMINE 304	10	34																			2
ALCOHOL DERIVATIVE, THINNER #92	4	34																			1
ALFA BROMONAPHTHALENE	16	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
ALUMINUM NITRATE	203	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	4280	2
ALUMINUM SULFATE	0.75	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	6207	1
AMBERLYST A-26 ANION STRONG BASIC RESIN	20	34																			1
AMINOPHENOL, O-	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1300	2
AMMONIA	16	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4950	1
AMMONIA	8	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	350	4
AMMONIUM CITRATE DIBASIC	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
AMMONIUM FLUORIDE	0.5	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMMONIUM HYDROXIDE	29	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	350	2
AMMONIUM OXALATE	0.25	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	375	1
AMMONIUM PERSULFATE	5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	820	2
AMMONIUM SULFIDE	1.5	34	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		3
AMMONIUM THIOCYANATE	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
AMYL ACETATE	5.5	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	4950	1
ANILINE	1.5	34	N	Y	N	N	N	N	N	Y	N	N	N	N	U012	N	Y	N	N	250	1
ARSENIC ACID	0.2	34	Y	N	N	N	N	Y	N	N	N	N	N	D004	P010	N	N	N	N		1
ARSENIC TRIOXIDE	0.2	34	Y	N	N	N	N	Y	N	N	N	N	N	D004	P012	N	N	N	N	20	1
BARIUM HYDROXIDE	0.25	34	N	N	N	N	N	N	N	N	N	N	N	D005	N	N	N	N	N		1
BARIUM NITRATE	0.5	34	Y	N	N	N	N	N	N	N	Y	N	N	D005	N	N	N	N	Y	355	1
BENZENE	13	34	Y	N	N	N	N	Y	N	N	Y	N	N	N	U019	N	N	N	N	3800	6
BENZENE, PYRENE CONCRETED	250	34	Y	N	N	N	N	Y	N	N	N	N	N	N	U019	N	N	N	N	3800	2
BERYLLIUM	5	34	N	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		3
BERYLLIUM SULFATE	0.25	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	88	1
BIRD-X	1.5	34																			1
BOILER TREATMENT COLN	15	34																			1
BROMOBENZENE	4.5	34												N	N	N					1
BUTANOL	3	34	N	Y	N	Y	N	N	N	N	Y	N	N	N	N	N	Y	N	N	790	1
BUTVAR BR	30	34																			1
BUTYL ACETATE	2.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	14000	2
BUTYL ALCOHOL	3	34	N	Y	N	Y	N	N	N	N	Y	N	N	N	U031	F003	Y	N	N	790	1
BUTYL CELLOSOLVE	4	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	1480	1
BUTYL ETHYL ACETATE	4	34												N	N	N					1
CADMIUM	1.5	34	Y	N	N	N	N	Y	N	N	N	N	N	D006	N	N	N	N	N	225	1
CADMIUM CHLORIDE	0.5	34	Y	N	N	N	N	Y	N	N	N	N	N	D006	N	N	N	N	N	88	1
CADMIUM NITRATE	0.15	34	N	N	N	N	N	N	N	N	N	N	N	D006	N	N	N	N	N		1
CADMIUM NITRATE SOLUTION	930	34	Y	N	N	N	N	Y	N	N	N	N	N	D006	N	N	N	N	N	300	6
CALCIUM CHLORIDE	1.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	1000	1
CALCIUM HYDROXIDE	2.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
CALCIUM HYPOCHLORITE	60	34	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y		1
CALCIUM NITRATE	0.1	34	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y		1
CARBOLINE THINNER 2J	4	34																			1
CARBON DISULFIDE	2	34	Y	N	N	N	N	N	N	N	Y	N	Y	N	P022	F005	Y	N	N		1
CARBON TETRACHLORIDE	88	34	N	Y	Y	N	N	Y	N	N	N	N	N	N	U211	F001	N	N	N	2800	6
CARCINOGENS, BENZENE,BENZYL-PARA-AMINOPH	440	34																			3
CATALYST	1	34																			1
CAUSTIC	5	34																			1
CERIC AMMONIUM SULFATE	6	34												N	N	N					2
CERIC SULFATE	2.5	34												N	N	N					1
CESIUM NITRATE	0.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
CHEMICALS, LAB PACKS	625	34																			4
CHLOROFORM	27	34	Y	N	Y	N	N	Y	N	N	N	N	N	N	U044	N	N	N	N	800	5
CHROMIUM COMPOUNDS	8	34	Y	N	N	N	N	N	N	Y	N	Y	Y	D007	N	N	N	N	N		1
CHROMIUM OXIDE	1	34	Y	N	N	N	N	N	N	N	Y	N	N	D007	N	N	N	N	Y		1
CHROMIUM TRIOXIDE	5.5	34	Y	N	N	N	N	N	N	N	Y	N	N	D007	N	N	N	N	Y		2
COAL TAR /WATER	50	34	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	Y	N		1
COBALT NITRATE	0.1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
COPPER METAL	0.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
COPPER TURNINGS	0.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
CRESCO SULPHUR	5	34												N	N	N					1
CRUDE OIL	4	34																			4
CRUDE SLUDGE	8	34																			1
CRYOLITE	2.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	200	1
CUPRIC CHLORIDE	0.5	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	140	1
CUPRIC NITRATE	0.1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
CUPRIC SULFATE	8	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	300	3
CYCLOHEXANE	13	34	Y	N	N	N	N	N	N	N	Y	N	N	N	U056	N	Y	N	N	29820	7
DECON SOLN, POTASSIUM PERMANGANATE	4	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	1090	1
DECON-4306C (TURCO)	46459	34																			234
DEXTROSE	1	34	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	25800	1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
DIBUTYL CARBITOL	200	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3900	1
DIBUTYL PHTHALATE	3	34	N	Y	N	N	N	N	N	N	N	N	N	N	U069	N	N	N	N	12000	1
DICHLOROBENZENE, O-	1.5	34	Y	N	N	N	Y	Y	N	N	N	N	N	N	U070	F002	N	Y	N	500	2
DICHLOROETHANE	3	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	1120	1
DICHLOROMETHANE	1	34	Y	N	Y	N	N	N	N	Y	N	N	N	N	U080	N	N	N	N	167	1
DIMETHYL FORMAMIDE	3.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	2800	2
DIMETHYL FORMAMIDE	0.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	2800	1
DIMETHYL PHOSPHATE	4	34												N	N	N					1
DIMETHYLAMINE, 2,4- (DILUTE)	6800	34	Y	N	N	N	N	N	N	N	Y	Y	N	N	U092	N	Y	N	N	698	34
DIMETHYLAMINO BENZALDHYDE, P-	6	34	N	N	N	N	N	N	N	N	N	N	N	N	U093	N	N	N	N		1
DIMETHYLSULFOXIDE	16	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	19700	2
DI-N-BUTYL PHOSPHATE	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3200	1
EASY OFF OVEN CLEANER	2	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
EDTA	0.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
EDTA, DISODIUM	2	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2000	1
ELECTROLYTE	4	34																			1
EPOXY RESIN	4	34																			1
ETHYL ACETATE	5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	U122	F003	Y	N	N	11000	1
ETHYLENE DICHLORIDE	2	34	N	N	N	Y	N	N	N	N	Y	N	N	N	U077	N	Y	N	N	1120	1
ETHYLENE GLYCOL	48	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	3930	7
FERRIC CHLORIDE	1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
FERRIC NITRATE	400.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3250	3
FERRIC SULFATE	4	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
FERROUS SULFATE, 1,10-PHERZATHROLIE	10	34												N	N	N					2
FERROUS SULFIDE	0.5	34	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
FLUOROCHEMICAL INERT	7	34																			1
FOAM CONCENTRATE	40	34																			1
FORMALDEHYDE	15	34	Y	N	N	N	N	Y	N	N	Y	N	N	N	U122	N	N	Y	N	800	4
FORMAMIDE	3.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	7500	2
FREON	4	34	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	43000	1
GLYCERINE	5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	12600	1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
GLYCEROL	6.5	34												N	N	N					2
HEPTANE	24	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		3
HEXANE	25	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	28700	3
HEXANOL	9	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	2080	3
HI-EX FOAM	200	34																			1
HYDRAZINE SOLN	10	34	Y	N	N	N	N	Y	N	N	Y	N	Y	N	U133	N	N	Y	N		1
HYDRAZINE SULFATE	0.5	34	N	Y	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	N	601	1
HYDRIODIC ACID	15	34	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
HYDROCHLORIC ACID	7	34	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N		4
HYDROFLUORIC ACID	33	34	Y	N	N	N	N	N	N	N	N	Y	N	N	U134	N	N	N	N		2
HYDROGEN PEROXIDE	9	34	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y		2
HYDROGEN PHOSPHATE, BIS(2-ETHYLHEXYL)	11	34	Y	N	N	N	N	N	N	N	N	Y	N	N	P096	N	N	N	N	4940	1
HYDROQUINONE	1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	320	2
IODINE	0.3	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	14000	1
ISOOCTANE	4	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		2
ISOPROPYL ETHER	5	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	8470	1
ISO-AMYL ACETATE	4	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		1
ISO-AMYL ALCOHOL	11	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N	1300	2
KETONE	4	34																			1
LANTHANUM NITRATE	2	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4500	1
LEAD	1	34	Y	N	N	N	N	Y	N	N	N	N	N	D008	N	N	N	N	N		2
LEAD DIOXIDE	1	34	Y	N	N	N	N	N	N	N	Y	N	N	D008	N	N	N	N	Y		1
LEAD METAL	3	34	Y	N	N	N	N	Y	N	N	N	N	N	D008	N	N	N	N	N		1
LEAD NITRATE	1	34	Y	N	N	N	N	Y	N	N	N	N	N	D008	U144	N	N	N	Y		1
LEAD PERCHLORATE	1	34												D008	N	N					1
LIQUID HEAT MIXTURE (53% BACL2, 14% NACL	40	34																			1
LIQUID PENETRANTS	52	34																			41
MAGNESIUM CHLORIDE	0.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	2800	1
MAGNESIUM OXIDE	1	34	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N		2
MAGNESIUM TURNINGS	0.5	34	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N		1
MANGANESE NITRATE	20	34												N	N	N					1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
MANGANOUS CHLORIDE	2.4	34	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	72	3
MEK, MINERAL SPIRITS AND ADSORBENT	200	34	N	Y	N	N	N	N	N	N	Y	N	N	N	U159	F005	Y	N	N	3400	1
MERCURIC NITRATE	4.5	34	Y	N	N	N	N	N	N	N	Y	N	N	D009	N	N	N	N	N		3
MERCURIC OXIDE RED	0.1	34	Y	N	N	N	N	N	N	N	Y	N	N	D009	N	N	N	N	Y	18	1
MERCURY	5	34	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
MERCURY, BALLARDS TRIPLE DISTILLED	4	34	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		2
MERCURY, DOUBLE CONTAINED + CONCRETE	10	34	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
MERCURY, ORGANICS,HCL SOLN	12	34	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
MERCURY WITH DISCASORB	62.5	34	Y	N	N	N	N	N	N	N	N	N	N	D009	U151	N	N	N	N		1
MESITYL OXIDE	2	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	1120	1
METHANOL	2	34	N	Y	N	N	N	N	N	N	Y	N	N	N	U154	F003	Y	N	N	13000	2
METHYL VIOLET	5	34												N	N	N					1
MIBK	2	34	N	Y	N	N	N	N	N	N	Y	N	N	N	U161	F003	Y	N	N	2080	1
MICRODDIOCIDE	20	34												N	N	N					1
NHY MB	1	34																			1
NICKEL CHLORIDE	2.5	34	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N		1
NINALK B ACID	60	34																			1
NITRIC ACID	2.45	34	Y	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	Y		1
NITROBENZENE	8	34	Y	N	N	N	N	N	N	N	Y	N	N	N	U169	F004	N	N	N	640	2
NITROGEN FERTILIZER	25	34																			1
NPH	2	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
OCTYL ALCOHOL	1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
OIL BLUE A	7.5	34	N	Y	N	N	N	N	N	Y	N	N	N	N	U012	N	N	Y	N	250	1
OIL SHALE (ROCK)	400	34																			2
ORGANICS, FLAMMABLE	1	34																			1
ORGANICS, UNKNOWN	30	34																			1
OS LUBRICANT	3	34																			1
OSPHO ACID METAL PREPCINT CONDITIONER	6	34																			1
OXALIC ACID	61.5	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	375	5
OXALIC ACID DIHYDRATE	5	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	375	1
PAINT	750	34																			4

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
PAPER CEMENT	1.3	34																			1
PARAQUAT	3	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	57	1
PENTANE, 2,2,4-TRIMETHYL	16	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		2
PERCHLORIC ACID	2	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	1100	1
PESTICIDES	4.7	34																			2
PETROGON	28	34																			1
PETROLEUM ETHER	4.2	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N		2
PHENOL PHOSPHONATE, DI (SECOBUTYL)	1.2	34												N	N	N					1
PHENOLINE 300 CATALYST	30	34																			6
PHOSPHATE, DI-N-BUTYL	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3200	1
PHOSPHORIC ACID	16	34	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	1530	2
PHOSPHOROUS PENTOXIDE	11	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		3
PHOTO RESIST	1	34																			1
PLUCONIC ACID	40	34																			1
POLYVINYL SULFONATED BENZENE CATION EXCH	315	34												N	N	N					2
POTASSIUM BROMATE	0.1	34	Y	N	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	N	N		1
POTASSIUM CARBONATE	1.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
POTASSIUM CHLORIDE	0.1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
POTASSIUM DICHROMATE	3	34	Y	N	N	N	N	Y	N	N	Y	N	N	D007	N	N	N	N	Y		1
POTASSIUM FERRICYANIDE	2.5	34	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		2
POTASSIUM FERROCYANIDE	0.1	34	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
POTASSIUM GOLD CYANIDE	1	34	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		1
POTASSIUM HYDROXIDE	15	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	365	1
POTASSIUM NITRATE	0.5	34	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	Y		1
POTASSIUM PERMANGANATE	5	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	1090	3
POTASSIUM SODIUM TARTRATE	2.2	34												N	N	N					2
POTASSIUM SULFATE	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
POTASSIUM THIOCYANATE	1.5	34	N	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	854	3
POTASSSIUM DITHIO OXALATE	0.03	34												N	N	N					1
PROPANOL	15	34	N	Y	N	N	N	N	N	Y	Y	N	N	N	N	N	Y	N	N	5400	2
PYRIDINE	12	34	Y	N	N	N	N	N	N	N	Y	N	N	N	U196	F005	Y	N	N	891	4

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
RESIN, UNKNOWN	4	34																			1
RINGERS SOLN, LACTATED	16	34																			1
RODINE 92-A	2	34																			1
RODINE #214	45	34																			2
SAIRSET BONDING MORTAR	50	34																			1
SALICYLALDEHYDE	4	34	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	520	1
SCALE CLEANER	50	34																			1
SCINTILLATION VIALS	10	34																			1
SEDIMENT	10	34																			1
SILICA GEL	12.5	34												N	N	N					1
SILICONE FLUID, DOW CORNING 710	60	34																			1
SILVER NITRATE	0.2	34	Y	N	N	N	N	N	N	N	Y	N	N	D011	N	N	N	N	Y		2
SODA LIME	0.5	34	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		1
SODIUM ARSENATE	1	34	Y	N	N	N	N	N	N	N	N	N	N	D004	N	N	N	N	N		2
SODIUM CARBONATE	217	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
SODIUM CYANIDE	0.75	34	Y	N	N	N	N	N	N	N	N	N	Y	N	P106	N	N	N	N	6440	3
SODIUM DICHROMATE	3	34	Y	N	N	N	N	Y	N	N	N	N	N	D007	N	N	N	N	Y	50	2
SODIUM DITHIONATE	1	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
SODIUM DITHIONITE	660	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		4
SODIUM HYDROXIDE	325	34	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		6
SODIUM NITRATE	51	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		2
SODIUM NITRITE	22.5	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	85	2
SODIUM OXIDE WASTE	8935	34	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N		45
SODIUM OXIDES	5200	34	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N		26
SODIUM PERCHLORATE	3	34	N	Y	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	Y	2100	3
SODIUM PERSULFATE SWEEPINGS	400	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		2
SODIUM PHOSPHATE TERABASIC	0.5	34												N	N	N					1
SODIUM PHOSPHATE TRIBASIC	50.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		2
SODIUM SILICATE	20	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
SODIUM SULFIDE	0.5	34	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N		1
SOLVENT, HOPPE'S #9	3	34																			1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
SOLVENT, REFINED COAL	440	34	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N		3
SOLVENT EXTRACTS	21.6	34																			1
SOLVENTS, OIL WASTE	80	34																			1
SPRAY PAINT	13	34																			1
STANNOUS SULFATE	1	34												N	N	N					1
STRONTIUM NITRATE	0.1	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	2750	1
SULFAMIC ACID	220	34	N	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N		2
SULFANILIC ACID	5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	12000	1
SULFURIC ACID	6.5	34	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	2140	1
TETRACHLOROETHYLENE	180	34	N	N	Y	N	N	Y	N	N	N	N	N	N	U210	F001F002	N	N	N	8850	1
TETRAHYDROFURAN	23	34	N	N	N	N	N	N	N	N	N	N	N	N	U213	N	Y	N	N		2
TOLUENE/ISOPROPANOL ALCOHOL 50/50	3703	34	Y	N	N	N	N	N	N	N	Y	N	N	N	U220	F005	Y	N	N	5000	18
TRANSFORMER OIL	20	34																			1
TRICHLOROETHYLENE	410	34	Y	N	Y	N	N	Y	N	N	Y	N	N	N	U228	F001F002	Y	N	N	4920	3
TRIETHANOLAMINE	7	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	8680	2
TTA, TRIBUTYL PHOSPHATE IN HEXANE	1	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	3000	1
TURCO 430GB	50	34																			1
TURCO 430GC	200	34																			1
TURCO 430GD	850	34																			5
TURCO 4521	1690	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		9
TURCO DESEN IT II	120	34																			1
TURCO FABRIFILM	200	34	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N		1
UNKNOWN	135	34																			5
VERSENEX 80	200	34																			1
XYLENE	25	34	Y	N	N	N	N	N	N	N	Y	N	N	N	U239	F003	N	Y	N	4300	3
YELLOW DYE	250	34																			2
ZEF-PURE	6	34																			1
ZINC	0.1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
ZINC ACETATE	1	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1
ZINC CHLORIDE	0.5	34	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	350	1
ZINC NITRATE	0.5	34	N	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y		1

COMPOUND	QTY* (kg)	TR* NO	EHW* WT01	DW* WT02	EHW WP01	DW WP02	EHW WP03	EHW WC01	EHW WC02	DW WC02	DW D001	DW D002	DW D003	EP* TOX	P/U* LIST	F* LIST	FL*	CO*	OX*	TOX*	OC*
ZINC OXIDE	0.5	34	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N		1

*QTY = quantity
TR = trench number
EHW = extremely hazardous waste
DW = dangerous waste
EP = extraction procedure
P/U = discarded chemical products list (WAC 173-303-9930)
F = dangerous waste sources list (WAC 173-303-9904)
FL = flammable
CO = combustible
OX = oxidizer
TOX = toxicity
OC = occurrence

B2 Summary of Chemicals from Appendix 4B-Waste Designation Database from DOE/RL-90-17, with Supplemental Information

This section contains a summary of chemicals from Appendix B1 with supplemental information on chemicals that did not receive waste designation but were included in Waste Designation Database

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Calcium Nitrate Waste	600	19	Fertilizer additive	Calcium Nitrate (98-100%)	CAS: 10124-37-5
Kaowool Cement	20	28	Low viscosity, premium grade cement	Alumino silicate (10-30%); Silica (10-20%); Water (5-20%); Mullite (10-30%); Alumina (0-5%)	NA
Concentrated Chemical A/B	8	28	Unknown	Unknown	NA
Plexiglass Cement	1	28	Weld-On: Solvent-type acrylic cement	Methyl Ethyl Ketone, Methylene Chloride, Methyl Methacrylate Manomer	NA
Propionitrile, 2,20A20-bis-2-methyl	1	28	Pharmaceutical intermediate	Methyl groups	NA
Carbonate, Rare Earth	600	31	Unknown	Unknown	NA
Ferrous Sulfamate	63.1	31	Iron Plating	Iron, Sulfamate	CAS: 7720-78-7
Flocculant	150	31	Flocculant	Unknown	NA
Flocculant, TOL FLOC COAG	60	31	Unknown	Unknown	NA
Lead Acid Gel in Battery	105	31	Battery acid	Lead (50%); Lead dioxide (21%); Sulfuric acid (22%); Case material (6%); Lead sulfate (1%)	NA
Lithium Nitrite and Reaction Debris	570	31	Corrosion inhibitor	Lithium and nitrite	CAS: 13568-33-7
Olin 5004 Clay, Coagulant Aid, PWD	175	31	Unknown	Coagulant Aid	NA
Paint Waste, Thinner & Rags	163	31	Analytical reagent	Unknown	NA
Retort Water	18	31	Unknown	Unknown	NA
Sodium Salt	100	31	Unknown	Sodium and other anion	NA
Methymethocylate	4	31	Unknown	May be spelled wrong	NA
Herbicide Misc. Rags	2	31	Unknown	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Triton X-100	2	31	Nonionic detergent	Polyethylene Glycol Octylphenyl Ether (>97%); Polyethylene Glycol (<3%); Dioxane (< 0.0055%); Ethylene Oxide (<0.001%)	CAS: 9002-93-1
Aluminum Cleaner	1	31	Aluminum cleaner	Hydrochloric acid; Hydrofluoric acid; Phosphoric acid	
2-4-D Amine, Dimethyline	220	33	Phenoxy Herbicide	Dimethlamine salt of 2,4-D 2,4-D Acid (46.5%); Inert Ingredients (53.5%)	EPA Reg #: 34704-120
Alkaline Metal Cleaner	350	33	Metal cleaner	Unknown	NA
Benzyl-Para-Aminophenol	180	33	Film developing agent	Unknown	NA
Betz 403	22	33	Unknown	Citric Acid; Sodium Tripolyphosphate	NA
Calc1-Solve	16	33	Unknown	Unknown	NA
Calgon CL-77	220	33	Wash down solution	Phosphonate	NA
Calgon D-26 Deposit INH	22	33	Unknown	Unknown	NA
Calgon H230 Water Microbiocide	19	33	Algaecide	Dioctyl dimethyl ammonium chloride (50%); Ethyl alcohol (10%); Inert ingredients	EPA Product reg no. 10445-16
Car Bopol 941	22	33	Thickening agent	Carbomer 910, 934,934P, 940,941	CAS: 9003-01-4
Carcinogens, Mixed Concreted	12	33	Unknown	Unknown	NA
Chromium, AL, MN, S, FE PWDR	20	33	Unknown	Unknown	NA
Copper Beryllium	400	33	Tools, instruments, electrical connections	Beryllium; Cobalt; Copper	NA
Corrosive Mixture	80	33	Unknown	Unknown	NA
D-26 Inhibitor	20	33	Unknown	Unknown	NA
Dioctyl Phthalate	120	33	Resin plasticizer	Dioctyl phthalate (100%)	CAS: 117-81-7

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Donnagel Suspension	29	33	Anti- diarrhea medication	Kaolin; Pectin; Hyoscyamine sulfate; Atropine sulfate; Hyoscine hydrobromide; Alcohol	NA
Ferrous Hydroxide	2200	33	Ion reducer	Ferrous Sulphate (>98%); Heptahydrate Sulphuric Acid (<2%)	NA
Greenshield Adjuvent	220	33	Disinfectant and algacide	Unknown	NA
Herbicide, Banvil	200	33	Heribicide	Dicamba based	NA
Nalclean-68 Scale Remover	200	33	Unknown	Sulfamic acid (70-100%); Sodium mercaptobenzothiazole (1-5%)	NA
Orocol	280	33	Unknown	Unknown	NA
Pump Oil	20	33	Unknown	Petroleum Compounds	CAS: 64742-54-7
Ringer's Soln, Lactated	11	33	Saline fluid	Sodium chloride; Potassium chloride; Calcium chloride	NA
Rodine 82-A	16	33	Rust inhibitor	Unknown	NA
Rodine 82A Acid INH	16	33	Rust inhibitor	Unknown	NA
Solvent, Refined Coal	270	33	Unknown	Unknown	NA
Solvent, Spill Cleanup	20	33	Unknown	Unknown	NA
Solvents, Thinner, Oil, Paint	8795	33	Unknown	Unknown	NA
Solvents: Acetone, Toluene, Etc.	364	33	Unknown	Unknown	NA
Sulfuric Acid, Potassium Hydroxide	200	33	pH adjustment	Hydrogem Sulfate, Potassium, Hydroxide	NA
Tetrahydrofuran	130	33	Solvent	Tetrahydrofuran	CAS: 109-99-9
Turco-4521	95	33	Decontamination soln.	Unknown	NA
Union Fluid L0500	28	33	Unknown	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Unknown	13	33	Unknown	Unknown	NA
Wood for Derivatives	40	33	Unknown	Unknown	NA
Sample 3, Project #1086	10	33	Unknown	Unknown	NA
Acid	9	33	Unknown	Unknown	NA
Pozzalon 300	8	33	Enhance performance of concrete	Aluminum silicate	NA
Transformer Oil	8	33	Mineral oil, insulating oil	Light napthenic hydrotreated distillate (>99%)	
Calcium Phytate	7	33	Unknown	Inositol Hexaphosphate Calcium salt (100%)	CAS: 7776-28-5
Oil	5	33	Unknown	Unknown	NA
Amerzine	4.6	33	Corrosion inhibitor	Hydrazine based oxygen scavenger	CAS: 302-01-2
Aropol WEP 666P	4	33	Plastic resin	Polyester based	NA
Ready-Solv Solution	4	33	Liquid Scintillation Reagent	1,2,4-Trimethylbenzene (Pseudocumene) (60-90%); Alkylphenol Ethoxylate (10-20%); Sodium dihexyl sulfosuccinate (5-10%)	NA
Barium Hydroxide	3.7	33	Thermoplastic additive	BaCO3 (0.5%); Cl (1.0%); Insolubles in HCl (0.05%); Fe (2ppm)	CAS: 17194-00-2 (Anhydrous); 22326-55-2 (Monohydrate); 12230-71-6 (Octahydrate)
Ether	3.2	33		Ethyl ether (100%)	CAS: 60-29-7
Calgon CL-162	3	33	Water softener, corrosion inhibitor	Carbonic acid, sodium salt [2:3] (40-60%); Sodium citrate (20-40%); Sodium sulfate (20-40%)	No CAS# (Mixture)
CL-162	3	33	Calgon water softener	Unknown	NA
CL-246	3	33	Calgon water softener	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Phosphorous Acid	2.9	33	Reducing agent	Unknown	CAS: 13598-36-2
Drierite, Used	2.27	33	All purpose drying agent	Calcium Sulfate, Anhydrous (97%); Cobalt Chloride (3%)	CAS: 7778-18-9
Chlorosulfamic Acid	2	33	Pesticide		CAS: 17172-27-9
Molybdate Reagent	2	33	Analytical reagent	Sulfuric Acid (8%); Sodium Moolybdate (1%)	NA
Reagents, Misc.	2	33	Unknown	Unknown	NA
Sodium Hypobromite	2	33	Germicide	Sodium bromine oxide	CAS: 13824-96-9
Tungstic Acid	2	33	Polymer additive	Hydrated tungten trioscide	CAS: 7783-03-1
Ethone	1.75	33	Orthoformic acid, triethyl ester		CAS: 122-51-0
Hydroidic Acid	1.53	33	Reducing agent	Hydroiodic Acid (40-60%); Water (40-60%)	CAS: 10034-85-2
Dowex	1.5	33	Anion exchange resin	Unknown	CAS: 69011-20-7
Lanthanum Ammonium Nitrate	1.5	33	Unknown	Ammonium, Nitrate and Lanthanum	CAS: 10169-00-3
Potassium Sodium Tartrate	1.5	33	Unknown	Potassium Sodium Tartrate	CAS: 304-59-6 (Anhydrous); 6381-59-5 (Tetrahydrate)
310-B-6126	1	33	NA	Unknown	NA
Aerosol OT Cleaner	1	33	Wetting agent	Sodium Dioctyl, Sulfosuccinate	NA
Ammonium Tetrasulfate Cerate	1	33	Unknown	Ammonium, Sulafte,	NA
APDC	1	33	Ammonium 1-Pyrrolidinecarbodithioic Acid	1-Pyrrolidinecarbodithioic Acid Ammonium Salt 90-100%	CAS: 5108-96-3 MSDS: A6132

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Biofluor	1	33	Pseudocumene based LSC cocktail	1,2,4-trimethylbenzene (60-80%); secondary alcohol ethoxylate (10-20%); sodium di-octyl sulphosuccinate (2.5-10%); 2,5-Diphenyloxazole (PPO) ≤ 2.5%; 1,4-Bis-(2-methylstyryl)-benzene (MSB) ≤2.5%	NA
Calgon CL-246	1	33	Polyacrylic acid formulation	Unknown	NA
DDTC	1	33	Unknown	Sodium	CAS 148-18-5
Ethone NL-62	1	33	NA	Unknown	CAS 122-51-0
Fenemine	900	33	Unknown	Unknown	NA
Hyamine Hydroxide	1	33	Hydroxide of Hyamine 10-X	Methanol (40-50%); quartenary ammonium hydroxide (40-50%	NA
KHC804	1	33	Unknown	Unknown	NA
Kodak Rapid Fix Soln	1	33		Water (40-45%); Ammonium Thiosulfate; Acetic Acid, Sodium Salt (5-10%); Boric Acid, Diammonium Salt (1-5%); Acetic Acid (1-5%); Sulfurous Acid, Monosodium Salt (<1%)	CAS No. 7732185
Lecithin, L-A-	1	33	Unknown	Lechithin (100%)	CAS: 8002-43-5
Lithium Hydrochloride	1	33	NA	Lithium and hydrochloride	NA
Malco 310(B-6126)	1	33	Unknown	Unknown	NA
Manganese Dioxide	1	33	Oxidizing agent in organic synthesis	Manganese Dioxide (72-80%); Quartz (1-3%); Barium (1-2%); Nonhazardous Ingredients (15-25%); Lead (0-0.2%)	CAS: 1313-13-9
Methyl Orange	1	33	pH indicator	4-dimethylaminoazobenzene-4'-sulfonic acid sodium salt	CAS: 547-58-0
Metyl Silane	1	33	Compressed gas	Methylsilane (>99%)	CAS: 992-94-9
Orsat Soln	1	33	Unknown	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Peperdime	1	33	Unknown	Unknown	NA
Poly-Oxyethylene-23-Laurylether	1	33	Brij 35	Poly-Oxyethylene-23-Laurylether (>99%)	CAS: 9002-92-0
Sodium Peroxide	1	33	Oxidizing agent	Sodium Peroxide (100%)	CAS: 1313-60-6
Amberlyst A-26 Anion Strong Basic Resin	20	34	Acid and cyanides removal	Quat amine divinylbenzene/styrene copolymer, OH ion form (35-55%); Water (45-65%)	NA
Boiler Treatment Coln	15	34	Unknown	Unknown	NA
Butvar BR	30	34	Aqueous Dispersion	Water (49%); Polyvinyl butyral (34%); Butyl ricinoleate (15%); Potassium oleate (2%)	NA
Calcium Hypochlorite	60	34	Oxidizer	Calcium Hypochlorite (100%)	CAS: 7778-54-3
Carcinogens, Benzene, Benzyl-Para-Aminoph	440	34	Miscellaneous	Unknown	NA
Chemicals, Lab Packs	625	34	Unknown	Unknown	NA
Decon-4306C (Turco)	46459	34	Decontamination chemical	Sulfamic Acid, Sodium Disulfate	NA
Foam Concentrate	40	34	Firefighting foam	Hydrocarbon surfactants; Organic salts; Water (>50%); Diehtylene Glycol Monobutyl Ether (15%)	CAS: Mixture
Hi-Ex Foam	200	34	High expansion foam, firefighting	Diethylene glycol monobutyl ether; Ethylene glycol; Hydrocarbon surfactant; Lauryl alcohol; Water	CAS: Mixture
Liquid Heat Mixture (53% BALC2, 14% NACL)	40	34	Unknown	Barium chloride and sodium chloride	NA
Liquid Penetrants	52	34	Unknown	Unknown	NA
Manganese Nitrate	20	34	Activator to vulcanize oil and materials of resistance	Manganese nitrate (50%); Water (50%)	CAS: Mixture

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Microdoiocide	20	34	Unknown	Unknown	NA
Ninalk B Acid	60	34	Unknown	Unknown	NA
Nitrogen Fertilizer	25	34	Fertilizer	Ammonium nitrate (37-47%); Urea (29-37%); Water (16-34%); Free ammonia (0.05%)	NA
Oil Shale (Rock)	400	34	Unknown	Petroleum Products	NA
Organics, Unknown	30	34	Unknown	Unknown	NA
Paint	750	34	Unknown	Unknown	NA
Petrogon	28	34	Unknown	Unknown	NA
Phenoline 300 Catalyst	30	34	Primer	Mica (40%); Bisphenol A diglycidyl ether (40%); Epoxy phenol novolac resin (5%); Triphenyl phosphinate (5%); Dibutyl phthalate (5%); Meta-xylene (5%); Toluene (5%); Methyl isobutyl ketone (5%); Ethyl benzene (0.8%); Carbon black (0.3%)	NA
Pluconic Acid	40	34	Microbiological applications	Unknown	NA
Polyvinyl Sulfonated Benzene Cation Exch	315	34	Unknown	Unknown	NA
Ringers Soln, Lactated	16	34	Saline fluid	Sodium chloride; Potassium chloride; Calcium chloride	NA
Rodine #214	45	34	Solvent	Nonylphenol (10-30%); Keto-amine-hydrochloride (10-30%); 2-propanol (10-30%); Alkylphenol ethoxylate (5-10%); Propargyl alcohol (5-10%); Butenone (1-5%); Acetone (1-5%); Acetophenone (0.1-1%)	NA
Sairset Bonding Mortar	50	34	Mortar	Aluminum silicate; Calcined bauxite; Aluminum silicate; Clay; Quartz silica; Cristobalite silica; Fused silica; Alumina; Diatomaceous silica; Sodium hexameta; Ethylene glycol; Water	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Scale Cleaner	50	34	Cleaner	Phosphoric acid; Hydrochloric acid; Non-hazardous detergent	NA
Silica Gel	12.5	34	Moisture absorbent	Silica gel (99-100%)	CAS: 63231-67-4
Silicone Fluid, Dow Corning 710	60	34	Heat transfer silicone	Phenylmethyl siloxane, trimethyl-terminated (>60%)	NA
Solvent Extracts	21.6	34	Unknown	Unknown	NA
Solvents, Oil Waste	80	34	Unknown	Unknown	NA
Spray Paint	13	34	Unknown	Unknown	NA
Tetrahydrofuran	23	34	Solvent	Tetrahydrofuran	CAS: 109-99-9
Transformer Oil	20	34	Mineral oil, insulating oil	Light napthenic hydrotreated distillate (>99%)	NA
Turco 430GB	50	34	Decontaminate reactor parts (s/b 4306-B)	Unknown	NA
Turco 430GC	200	34	Decontaminate reactor parts (s/b 4306-C)	Unknown	NA
Turco 430GD	850	34	Decontaminate reactor parts (s/b 4306-D)	Unknown	NA
Turco Desen IT II	120	34	Unknown	Unknown	NA
Unknown	135	34	Unknown	Unknown	NA
Versenex 80	200	34	Chelating agent	Pentasodium DTPA	CAS: 140-01-2
Yellow Dye	250	34	Unknown	Unknown	NA
Alamine 304	10	34	Organic acid recovery	Tridodecylamine (95%); Dodecanol-1 (5%); Dilaurylamine (≤ 0.5%); Lauryl Amine (≤ 0.5%)	CAS: 102-87-4
Ferrous Sulfate, 1,10-Pherzathrolie	10	34	Reagent	o-Phenanthroline (~ 1%); Ferrous sulfate (0,4%)	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Scintillation Vials	10	34	Unknown	Unknown	NA
Sediment	10	34	Unknown	Unknown	NA
Crude Sludge	8	34	Unknown	Unknown	NA
Fluorochemical Inert	7	34	Unknown	Unknown	NA
Glycerol	6.5	34	Evaporative fogging agent	Glycerin (90-100%)	CAS: 56-81-5
Ceric Ammonium Sulfate	6	34	Oxidising agent in titrations	Cerric Ammonium Sulfate (90-100%)	CAS: 13840-04-5
Dimethylamino Benzaldhyde, P-	6	34	Unknown	[P-]Dimethylaminobenzaldehyde	CAS: 100-10-7
Ospho Acid Metal Prepcint Conditioner	6	34	Metal conditioner	Phosphoric acid solution (45%);	NA
Zef-Pure	6	34	Unknown	Unknown	NA
Caustic	5	34	Unknown	Unknown	NA
Cresco Sulphur	5	34	Sulphur used for agricultural purposes, fertilizer	Sulfur and other compounds	NA
Methyl Violet	5	34	Dye, pH indicator	Methyl Violet (100%)	CAS: 8004-87-3
Pesticides	4.7	34	Unknown	Unknown	NA
Bromobenzene	4.5	34	Unknown	Bromobenzene (99-100%)	CAS: 108-86-1
2,6-Dimethyl-4-Heptanol	4	34	Unknown	2,6-Dimethyl-4-Heptanol (82%)	CAS: 108-82-7
Alcohol Derivative, Thinner #92	4	34	NA	NA	
Butyl Ethyl Acetate	4	34	Solvent and dilutant	2-Ethylbutyl acetate (≥98%)	CAS: 10031-87-5
Carboline Thinner 2J	4	34	Thinner	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Crude Oil	4	34	NA	Crude Petroleum; Saturates (80-90%); Aromatics (8-15%); Polars (1-5%); Sulfur Compounds (0-2%); Asphaltene Content (0-2%); Benzene (0-0.1%); Limestone	NA
Dimethyl Phosphate	4	34	Breakdown product, used in pesticides	Phosphoric Acid, Diethyl Ester (100%)	CAS: 598-02-7
Electrolyte	4	34	Ionic solute, battery electrolite	Water (60-70%); Sulfuric acid (30-40%)	CAS; 7664-93-9
Epoxy Resin	4	34	Adhesives	Bisphenol-A type epoxy resin (>50%); Benzyl alcohol (<20%); Bisphenol-F type epoxy resin (<20%); Ethylene glycol monobutyl ether (<0.3%)	
Ketone	4	34	Methyl Ethyl Ketone	Methyl Ethyl Ketone (100%)	CAS: 78-93-3
Resin, Unknown	4	34	Unknown	Unknown	NA
OS Lubricant	3	34	Oil Soluble Lubricating fluid	Unknown	NA
Solvent, Hoppe's #9	3	34	Solvent	Kerosene (30-40%); Ethyl Alcohol (30-40%); Xylene (<10%); Amyl Acetate (<10%); Ammonium Hydroxide (<10%); Citronella (<10%)	
Ceric Sulfate	2.5	34	Oxidizer	Ceric Sulfate (85-100%)	CAS: 13590-82-4
Potassium Sodium Tartrate	2.2	34	See Above	See above	See above
Rodine 92-A	2	34	Unknown	Unknown	NA
Bird-X	1.5	34	Bird repellent	Methyl Anthranilate (25%); 2-Aminobenzoic acid methyl ester; Intert ingredients (75%)	CAS: 134-20-3
Paper Cement	1.3	34	Adhesive	Hexane (87%); Non hazardous ingredients (13%)	NA
Phenol Phosphonate, DI (Secobutyl)	1.2	34	Unknown	phenol and phosphanate	NA
Catalyst	1	34	Unknown	Unknown	NA

Table B-1. Summary of Chemicals from Appendix B

Compound	Quantity (kgs)	Trench	Use	Major Components	CAS number
Dextrose	1	34	Sugar	Dextrose (99-100%)	CAS: 50-99-7
Lead Perchlorate	1	34	Unknown	Lead Perchlorate (100%)	CAS: 13637-76-8
NHY MB	1	34	Unknown	Unknown	NA
Organics, Flammable	1	34	Unknown	Unknown	NA
Photo Resist	1	34	Microposit S1813 Photo Resist	Electronic grade polypylene glycol moomethyl ether acetate (71-76%); mixed cresol novolak resin (10-20%); diazo photoactive compound (1-10%); fluoroaliphatic polyer esters (0.01-1%); cresol (0.01-0.99%)	NA
Stannous Sulfate	1	34	Tin salt, plating chemical	Stannous sulfate (100%)	CAS: 7488-55-3

B3 Waste Inventory

This section contains manifests of chemicals disposed of at NRDWL by trench.

Waste inventory consists of a listing of the chemical waste placed in the Nonradioactive Dangerous Waste Landfill. The inventory is organized by trench number, date of disposal, and type and quantity.

Table B-2. Trench 19N

Date	Quantity	Chemical
11-08-85	3 drums, 55 gal	Waste calcium nitrate
	1 drum, 55 gal	Waste sodium nitrate
	22 lb	Sodium nitrate
	1 pt	Ethyl acetate
	8 pt	Toluene
	1 pt	Xylene
	3 pt	Methyl alcohol
	5 pt	Benzene
	2 qt	Isopropanol
	1 lb	Potassium permanganate
	1 lb	Ammonium nitrate
	3 lb	Sodium nitrate
	1 lb	Ammonium chloride
	1 lb	Sodium chromate
	1 qt	1-1-1 Trichloroethane
	2 qt	Ammonium hydroxide
	1 pt	37% Formaldehyde solution
	5 lb	Sodium hydroxide, dry solid
	1 gal	Naphtha
	2 qt	Ammonium oxalate (TURCO 4521*)

Table B-3. Trench 26

Date	Quantity	Chemical
01-11-85	13 drums, 55 gal	Sodium nitrite
04-17-85	114 drums, 55 gal	Oil soaked sand
	8 drums, 55 gal	

Table B-4. Trench 28

Date	Quantity	Chemical
02-03-84	6 lb	Sodium hydrogen sulfide
	1 lb	Sodium chromate
	1 lb	Sodium bichromate
	0.5 lb	Potassium chromate
	10 oz	1-Ethylquinelinium iodide
	1 lb	Sodium metabisulfite
	1 lb	Ferrous sulfate
	0.5 lb	Nickel chloride
	1 kg	Calgon*
	1 lb	Gelatine powder
	1 pt	Flexible collodion
	1 L	Polyelectrolytes
	1 lb	Ammonium sulfate
	1 lb	Aluminum oxide
	32 oz	Glycenyl triacetate
	800 g	Weldon 28 component C
	32 oz	Ammonium sulfide
	250 mL	Castor oil
	1 pt	Photo-flo 200
	100 g	Creosote
02-09-84	110 gal	Anhydrous borax
	255 gal	Sodium nitrate
	170 gal	Boric acid
	240 gal	Sodium nitrite
	145 gal	Sodium nitrite, borax, frit, sand, gravel
	22 gal	Boric acid, frit, soda ash, silica, and warehouse sweepings
	120 gal	Boric acid, anhydrous borax, brown sand
	175 gal	Boric acid, borax, potassium nitrate
	165 gal	Boric acid, sand, fine frit, borax, sodium nitrate
	220 gal	Boric acid, frit, borax, sodium nitrate
	195 gal	Borax, sand, frit, empty chemical bags
	55 gal	Low sodium nitrate sludge
	55 gal	Normal sodium nitrate sludge
	275 gal	Sodium carbonate sludge spiked
02-22-84	18 gal	Ammonium hydroxide
03-16-84	200 mL	Butyl alcohol
	1 pt	2-Propanol

Date	Quantity	Chemical
03-16-84 (cont)	0.5 pt	Butyl ether
	1 L	Amyl alcohol
	0.5 kg	n-Octylalcohol
	0.5 pt	Normal paraffin hydrocarbon
	1,000 mL	Plexiglass* cement
	1 pt	Iodobenzene
	2/3 pt	Combustible liquid, n.o.s.
	0.5 L	Phosphenylchloride, dichlorophenyl phosphine
	500 mL	Indene
	1/8 pt	Diazald
	1 L	Tris (hydroxymethyl) amino-methane
	1 pt	Hypophosphorus acid
	250 g	Antimonypentachloride
	1 L	Bromine
	1 pt	Hydriodic acid
	1 pt	Dinoylnapthalenesulfonic acid
	450 g	Benzoyl peroxide
	1 L	2,2-$A_2$0-bis-2-Methyl propionitrile
	315 kg	Ceric oxide
	54 ft^3	Cerous oxalate
	1 pt	Butyl ether
	11 qt	Sulfurous acid
	250 lb	Magnesium nitrate
	100 lb	Bismuth nitrate
	75 lb	Sodium nitrate
	950 lb	Sodium nitrite
	75 lb	Disodium phosphate
	96 lb	Cesium carbonate
	25 lb	Soda ash
	5 gal	Kaowool* cement
	100 lb	Activated aluminum
	30 lb	Sodium fluoride
05-01-84	2 gal	Urethane component A
	1 pt	Urethane component B
	2 gal	Concentrated chemical A/B
05-23-84	20 gal	Waste corrosive liquid, n.o.s. (Picrolonic acid, formic acid, and vanadous formate all absorbed)
06-13-84	10 lb	Sodium hydroxide

Date	Quantity	Chemical
06-14-84	17 gal	Ammonium hydroxide
06-20-84	0.5 kg	Zirconium hydride
06-22-84	1,140 gal	Lanthanum nitrate
	825 gal	Trichloroethane
07-19-84	90 lb	Nickel, hydrated
08-23-84	1 pt	Ammonium sulfide
	1 pt	Ehtylacetate
	0.5 gal	Hexone
	6 pt	Butyl alcohol
	1 qt	Hexone
	1 pt	Amyl acetate
	1 pt	Ethyl acetate
	3 kg	Methyl ethyl ketone
	1 pt	Hexone
	1 qt	Tetrahydrofuran
	1 pt	Perchloric acid (70%)
	1 pt	Hydrogen peroxide (30%)
	5 gal	Dichloromethane
	1 qt	Bis(2-ethylhexyl)2-hexylphosphonate
	1 qt	Mono-2-ethyl hexylacid orthophosphate
	1 kg	Octyl alcohol
	5 L	Isopentyl alcohol
	1 qt	Acetyl acetone
	1 gal	Dimethyl formamide
	1 L	Hexanol
	5 lb	Lactic acid
	1 qt	Diisopropyl ketone
	1 gal	Sulfuric acid (93%)
01-11-85	520 gal	Dry salt cake: $NaNO_3$, $NaNO_2$, NaOH

Table B-5. Trench 31

Date	Quantity	Chemical
11-05-82	210 lb	Lead acid gel in battery
12-10-82	1 lb	Mercury absorbed and contained
12-17-82	4 ft^3	Beryllium copper
02-03-83	1,440 lb	Lithium nitrite and reaction debris
03-21-83	10 lb	Phosphoric acid
	170 mL	Gasoline
	4,000 mL	Xylene
	1,000 mL	Toluene
	1,000 mL	Cyclohexane
	40 mL	tetra-N-Propyl ammonium hydroxide
	400 mL	di-N-Butyl sulfoxide
	100 mL	2,4-D Amine
	200 mL	Dicamba
	200 mL	Teflon*
	200 mL	Tordon*
	500 mL	50% hydrogen peroxide
	200 mL	Type B polymer
	200 mL	Type A polymer
	2 gal	Ammonium fluoride
04-12-83	2 bags	Misc. (herbicide contaminated rags, respirator cartridges, etc.)
04-14-83	11 lb	Sulfanilic acid
	4 kg	Sulfanilamide
	500 g	Potassium persulfate reduced
	250 g	Chloramine T
05-04-83	5 gal	Muriatic acid
	1 gal	Hydrofluoric acid
05-05-83	2 gal	p-Dioxane
	4 kg	1-Octanol
	2 qt	Triton x-100 (alkyl-lanyl-polyether alcohol)
	20 kg	1,2,4-Trichlorobenzene
	10 pts	Tetrachloroethylene

Date	Quantity	Chemical
05-12-83	48 lb	Ammonium bifluoride
	25 lb	Calcium fluoride
	600 lb	(Chel. DTPA 41) sodium salt*
	200 lb	Sodium salt
	1,200 lb	Rare earth carbonate
	250 lb	Sodium sulfate
	300 lb	Strontium carbonate
	300 lb	Floculant
	15 gal	Tol floc coag. floculant
	350 lb	Powdered clay olin 5004* coagulant aid
	55 gal	Magnesium nitrate Crystal oxidizer
	55 gal	Nitrilotriacetic acid
	55 gal	Nalco 5* - sodium Aluminate
	55 gal	Nickelous nitrate oxidizer
	55 gal	Silica gel - actuated desiccant
	100 lbs	Silica gel
06-01-83	1 lb	Oxalic acid
	1 lb	Sodium hydroxide
	1 lb	Aluminum chloride
	1 lb	Aluminum nitrate
	3 pt	Hypo-phosphorus acid
	1 lb	Magnesium perchlorate
	1 lb	Arsenic acid
	25 mL	Petroleum ether
	3 lb	Magnesium perchlorate
	10 pt	Hydroodic acid
	20 pt	Hydroodic acid
	0.25 lb	Potassium hydrogen phthalate
	1 lb	Potassium persulfate
	1 lb	Bromine
	1 pt	Cerric sulfate in sulfuric acid
	1 lb	Sodium hydroxide
	1 lb	Sodium acetate
	5 lb	Ammonium oxalate
	1 lb	Potassium iodide
	1 lb	Potassium chloride
	1 lb	Potassium carbonate

Date	Quantity	Chemical
06-01-83 (cont)	6.25 lb	Potassium sodium tartrate
	1 lb	Potassium bromide
	1 lb	Potassium carbonate
	2 lb	Potassium phosphate
	5 lb	Cupric sulfate
	500 mL	Ferric ammonium sulfate
	0.25 lb	Ammonium iodide
	8 lb	Barium chloride
	0.25 lb	Cerium nitrate
	0.25 lb	Lanthanum nitrate
	1 lb	Mercuric thiocyanate
	1 lb	Ammonium oxalite
	12 lb, 1 lb	Sodium meta bisulfate
	10 lb	Sodium bisulfate monohydrate
	1 oz	Cupferron
	1 gal	Propylene carbonate
	1 lb	Sodium bicarbonate
	1 lb	Sodium arsenite
	1 lb	Sodium sulfate
	3 lb	Sodium metasilicate
	1 lb	Sodium phosphate
	0.25 lb, 0.25 lb	Sodium iodide
	1 lb	Sodium hydrosulfate
	4 lb	Sodium dithionite
	1 lb	Sodium bromate
	1 lb, 1 lb	Sodium oxalate
	1 lb	Sodium chloride
	250 mL	Sodium acetate
	1 lb, 7 lb	Sodium fluoride
	1 lb	Sodium sulfite
	1 lb	Ferrous ammonium sulfate
	2 lb	Ammonium acetate
	1 lb	Ammonium bifluoride
	2 lb	Ammonium molybdate
	1 lb	Ammonium phosphate
	2 lb	Ammonium sulfate
	9 lb	Ascorbic acid powder
	1 lb	Sodium acetate
	1 lb	Ferric chloride
	1 lb	Cerric nitrate
	1 lb	Sodium carbonate
	2 lb	Ferrous ammonium sulfate

Date	Quantity	Chemical
06-01-83 (cont)	25 mL	Tri-Sil Z*
	50 mL	Ferrous sulfamate
	1 qt	Potassium permangate
	1 qt	Potassium hydrogen sulfate
	1 qt	Potassium hydrogen sulfate
	3 lb	Potassium nitrate
	1 lb	Potassium chloride
	1 lb	Potassium carbonate
	0.25 lb	Cupric nitrate
	1 lb, 0.25 lb	Ferric nitrate
	1 lb	Sodium oxalate
	250 mL	Potassium permanganate
	5 g	Bromo cresol purple sodium
	2 lb	Ammonium citrate
	25 g	Tetrapropylammonium hydroxide
	1 lb	Sodium bisulfate
	3 lb	Sodium bisulfate monohydrate
	1 lb	Sodium carbonate
	6 lb	Sodium chloride
	1 lb	Sodium chromate
	15 lb	Sodium nitrate
	0.25 lb	Sodium tartrate
	1 lb	Sodium thiosulfate
	1 lb	Urea
	0.25 lb	Acid potassium phthalate
	1 lb	Cuprous chloride
	6 lb	Ferrous ammonium sulfate
	2 lb	Lithium fluoride
	1 lb	Magnesium chloride
	1 lb	Nickel nitrate
	3 lb	Potassium bromate
	1 lb	Potassium fluoride
	250 g	Potassium iodide
	100 g (top of drum)	Sulfamic acid
	115 g	Hydroxylamine hydrochloride
	125 mL	Dibutyl phosphonate
	250 mL	Collodion
	1 pt	Methyl isobutyl ketone
	1 pt	Agle sulanilic acid in acetic acid
	125 mL	Lithium-10-phenanthroline ferrous sulfate

Date	Quantity	Chemical
06-01-83 (cont)	5 lb (top of drum)	Sulfamic acid
	1 lb	o-Tolidine dihydrochloride
	12 lb	Ascarite
	0.25 lb (top of drum)	Glycolic acid
	8 lb	Hydroxylamine hydrochloride
	0.25 lb	Diethylene-triamine-penta-acetic acid
	1 lb	Hydroxylamine hydrochloride
	200 mL, 500 mL	Dibutyl phosphonate
	200 mL	Dichlorodimethylsilane
	125 mL	n-Tridecane
	250 mL, 250 mL (bottom of barrel)	Formic acid
	1 pt	Isoamyl alcohol
	1 pt	Amyl acetate
	1 gal	Methymethocylate
	1 gal	Tributylphosphate
	2 gal	Butylstearate
	1 pt	Isoamyl alcohol
	5 pt	Methylisobutyl ketone
06-06-83	46 lb	Dioctyl sebacate (absorbed)
	8,835 g	Petroleum distillates
	1,500 cc	Ethyl acetate
	16.5 oz	Petroleum solvent and alcohol
	12 oz	Metal check remover E-59
	3 oz	Petroleum distillate and diethyl ether
06-22-83	125 lb	TURCO 4502
06-27-83	24 oz	Sulfuric acid
	8 oz	Potassium hydroxide solution
	8 oz	Sulfate solution
07-10-83	125 lb	Ferrous sulfamate
	325 lb	Painters' waste (rags, thinner, etc.)
07-27-83	735 gal	Ferrous hydroxide
	230 gal	Floor sweepings [calcium carbonate, silica, lithium hydroxide (solid)]

Date	Quantity	Chemical
07-27-83 (cont)	75 lb	Cupric nitrate
09-08-83	4.5 gal	Retort water [organic carbon 30,000-40,000 ppm C inorganic carbon 1,000-3,000 ppm C ammonium ion 36,000 ppm (as ammonium ion)] Ammonium Anions: Sulfate = 23,000 ppm Disulfite = 46,000 ppm Sulfite = up to 2,000 ppm Elements: (ppm) Arsenic - 7 Boron - 45 Barium - 0.2 Calcium - 35 Cadmium - 0.4 Chromium - 0.1 Cobalt - 0.25 Copper - 2 to 24 Iron - 1 Lithium - 4 Magnesium - 1,000 Manganese - 0.1 Molybdenum - 0.5 Potassium - up to 70 Sodium - 520 Silicone - 20 Strontium - 1.5 Zinc - 3.5
	3 pt	1,4 Dioxane
	1 pt	Nitromethane
	2 pt	Methylene chloride
	1 lb	Anhydrone
	4,500 mL	2-Butoxyethanol
	2 gal	Ethylene dichloride
	5 kg	1,1,2,2-Tetrabromo-methane
	1 gal	Micro resist rinse (N-butyl acetate)
	1 gal	Micro resist developer (petroleum distillates)
	0.5 pt	Ditridecyl amine
	0.5 pt	Malachite Green hydrochloride
	0.25 pt	Cobalt molybdenate

Date	Quantity	Chemical
09-08-83 (cont)	0.25 pt	Calcium sulfate
	1 pt	Quinizarin
	0.5 pt	Copper oleate
	1 pt	Ethoxyquin
	1 lb	Dipentamethylene thiuram hexasulfide
	0.5 pt	Ethylene glycol
	500 g	Tetramethyl thiceram disulfide
	1.5 kg	Guaiacol
	1 lb	Citric acid crystals
	0.5 gal	Sorbitan monooleate
	0.5 lb	Diphenyl-phosphoric sulfide
	3 lb	Hydroxylamine hydrochloride
	0.25 pt	N,N-Dimethyl-p-phenylene diamine sulfate
	160 lb	Copper sulfate crystals
	1 pt	Heptane
	1 pt	1-Butanol
	1 gal	Tetrahydrofuran
	1,500 g	Ethanolamine
	0.25 pt	Benzaldehyde
	1 kg	Acrylonitrile 99%
	5 pt	Aniline
	2 L	Sodium amide
	1 gal	Chloroform
	1 gal	Formaldehyde
	1 gal	Carbon tetrachloride
	1 pt	Aluminum cleaner
	1 kg	Crotonaldehyde
	11 lbs	2, 4-Dinitrophenol
09-20-83	1 pt	Acetone
	1 lb	Butyl alcohol
	1 pt	Glycerine (alcohol n.o.s.)
	1 lb	Dextrose anhydrous
	1 lb	Potassium dichloride
	5 lb	Sodium chloride
	1 lb	Sodium silica
	1 lb	Hydrofluoric acid
	100 g	Sulfamic acid (corrosive solid n.o.s.)
	1 lb	Trichloroacetate (corrosive solid n.o.s.)
	1 lb	Lithium hydroxide (corrosive solid n.o.s.)
	5 lb	Sodium hydroxide
	1 lb	Aluminum nitrate

Date	Quantity	Chemical
09-20-83 (cont)	0.25 lb	Cupric nitrate
	1 lb	Magnesium nitrate
	1 lb	Magnesium oxide
	1 lb	Potassium nitrate
	1 lb	Potassium permanganate
	4 oz	Silver nitrate
	1 lb	Sodium nitrate
	1 lb	Strontium nitrate
	1 oz	Zirconium nitrate
	1 lb	Calcium carbonate
	1 lb	Ferric oxide
	1 lb	Potassium phosphate
	1 lb	Potassium phosphate
	1 lb	Sodium acetate
	1 lb	Sodium bicarbonate
	1 lb	Aluminum oxide (ORMA n.o.s.)
	1 lb	Ammonium carbonate
	1 lb	Potassium hydrogen sulfate
	1 lb	Ammonium chloride
	1 lb	Sodium phosphate
10-04-83	6,375 lb	Altrex* metal cleaner
10-17-83	50 gal	Doctyl sebacate (absorbed)
10-27-83	2 pt	Trichloroacetic acid
	9 pt	Methyl alcohol
	6 lbs	Chloroform

Table B-6. Trench 33

Date	Quantity	Chemical
11-07-80	110 gal	Copper beryllium
11-13-80	110 gal	Chemical solution: Acetone, Touluene Methylene chloride and Pyrolytic compounds
11-26-80	4 gal	Waste organic solvents: Methyl isobutyl ketone, Hexane, Methylene chloride (absorbed on vermiculite)
12-26-80	4 gal	Waste solvents: Methyl isobutyl ketone, Hexane Methylene chloride, Ethanol double canned on vermiculite in 25- and 50-lb tin cans (could be absorbed)
12-29-80	Small quantity laboratory reagents, quantity less than 1 kg	Oxalate reagent Rhodium Sulfa salt Hydroquinone Cadmium oxide Potassium sulfate Ammonium compound Ammonium oxalate Versenol 120* Dibutyl hydrogen phosphate N-phenylbenzoyl-dioxanic-acid Dicyandiamide 5-sulfosalicylic acid Quinaldine Bathophenarthvoline disalfonic acid, disodium salt Alizarin Ammonium molybdate Potassium hydroxyacetate Potassium chloride Ammonium citrate Ammonium persulfate Sodium hydrogen carbonate Oxalic acid

Date	Quantity	Chemical
12-29-80 (cont)		Cesium nitrate
		Sodium nitrate
		Ethyldianthic acid
		Ferrous ammonium sulfate
		Benzoic oxaine
		Potassium nitrate
		N-phenylbenzo hydroxamic acid
		Sodium nitrate
		Sodium iodide
		α-Benzoic oxime
		Potassium sodium tartrate
		Sodium bromide
		Sodium nitrate
		Sodium suflate
		Phosphorous acid
		Sodium bisulfate
		Potassium cyanide
		Potassium periodate
		Potassium citrate
		2-Potassium permanganate
		Magnesium sulfate .7 water
		Bismuth metal
		Strontium nitrate
		Lead nitrate
		Phosphomolybdic acid, 48 hydrate
		Potassium colbalticycubude
		Acid tungstic
		Potassium iodide
		Ceric sulfate
		Dimethylglyoxime
		Barium chloride
		Barium chloride
		Diphenylthiocarbenzone
		Mercuric sulfate
		Sodium fluoride
		Ammonium persulfate
		Diethyldithiocarbonic acid
		Lead hydrate
		Antimony potassium tartrate
		Na_2SO_4
		8-Quinolinal-8-hydroxyquinoline
		Ammonium persulfate

Date	Quantity	Chemical
12-29-80 (cont)		Ammonium carbonate
		Calcium carbonate
		Citric acid
		Potassium sodium tartrate
		Potassium hydroxide
		Cupric nitrate
		Potassium hydroxide flakes
		Cupric sulfate
		Kaolin
		Sodium phosphate, monobasic
		Copper metal
		Hydrous citric acid
		Sodium bismuthate
		Ammonium chloride
		Cupric sulfate
		Ammonium sulfate
		Calcium chloride
		Anhydrone
		Cesium sulfate
		Cesium nitrate
		Beryllium nitrate
		Cesium chloride
		Lithium sulfate
		Potassium bichromate
		Potassium pyrosulfate
		Iodine
		Potassium nitrate
		Lead iodide
		Potassium iodide
		Iodic acid
		Silica tungsten acid
		Potassium pyrosulfate
		Potassium bisulfate
		Sodium sulfide
		Sodium tungstate
		Sodium bromate
		Tin metal
		Sodium nitrate
		Sodium formate
		Sodium phosphate, tribasic
		Acid tungstic
		Sodium phosphate, dibasic

Date	Quantity	Chemical
12-29-80 (cont)		Sodium phosphate
		Sodium vanadate
		Sodium thiocyanate
		Zirconyl nitrate
		Tungstic acid
		Chromium chloride
		Versenex 80*
		Versenex 120
		2-Versenex 100
		4-Hydroxylamine . hydrochloric acid
		Sodium acetate
		Citric acid
		Vinyl spray
		Zinc oxide
		2-Thionyltrifluoroacetone
		Alizarine
		Benzoin-oxime
		2,4-Dinotrodrphenylamine
		Thymolphthalein
		2-Dimethylgloxime
		M-Cresolsulfonthalien -hydroxy-isohatynic acid
		Acid sulfosulicylic
		3,5-Diiodo-4-pyriodone-N-acetic acid
		5-Cp-dimethylammobenzyladine rhodamine
		Quinalizarin
		4,7-Dibromo-8-hydroxyquinoline
		Violuric acid hydroxy-iso-butyric acid
		2-Carminin acid
		Rhodizonic acid potassium salt
		Phosphorus acid
		Sodium nitrate
		Nitric acid
		Titanium chloride
		Ammonium bifluoride
		Potassium iron (III) cyanide
		Hydroquinone
		Hydroxyethylethylenediaminetriacetic acid
		DOWEX-2*
		Potassium permanganate

Date	Quantity	Chemical
12-29-80 (cont)		Lanthanum nitrate
		Sodium suflate
		Manganese metal chips
		Nickel carbonate
		DOWEX SOW-X8
		Sodium sulfide
		Potassium permanganate
		Calcium nitrate
		Mercury nitrate
		Diisobutylphthalate
		10% Ammonium persulfate
		Dimethylglyoxime in ethanol
		0.1N Sodium hydroxide
		pH 4.4 buffer
		Potassium hydride phthalate buffer
		Acetic acid in trichloromethane
		Water extracted with PCT
		2:1 n-Butanol/ethyl acetate
		0.05% Xylenol orange in methanol
		10% Ammonium molybdate
		DDTC in carbon tetrachloride
		Iron in methanol
		0.1N Trichlorochromate
		3 g Cobalt nitrate - nitric acid
		1N-2N 22.1 mg Water
		1% Triethanol
		E3426
		P2246
		W-2N Methanol
		TTA acetone
		4450 in methanol
		Par water
		"AKS"
		E2942
		RO in water
		Spent methanol
		E238
		Ortho-Phenol
		E3092
		EBT
		E2106
		0.5% PAN in ethanol

Date	Quantity	Chemical
12-29-80 (cont)		P7302 in water
		PAN in hexane
		PAN in ethanol
		5.69N Tributyl phosphate
		Eosin
		KD
		P+PA
		Mercury solution
		Phenyl acetate
		10% DIEPPA
		TTA solution 5M in xylene
		Hydroxyethylethylenediaminetriacetic acid
		TTA in benzene
		Amyl acetate spent
		Ethylene dichloride
		Hydrochloric acid and ammonium hydroxide
		0.1% Carminic acid
		0.4M D12 EHPA
		Ammonium carbonate strong in DDH_2O
		TOPO wash
		Benzene spent
		Sulfamic acid
		Dimethylglyoxime
		Methyl orange
		d-Tartaric acid
		Periodic acid
		Hydroxylamine hydrochloride
		pH 10 buffer
		Chloran hydrate
		1% APDC
		$(NH_4)_2\ C_6H_5O_7$
		8N Sodium hydroxide
		1% Sodium hydrogen sulfate
		50% Sodium hydroxide
		6M Sulfuric acid
		6N Ammonium hydroxide
		Methyl orange
		Ammonium hydroxide
		Hydrogen peroxide
		50% Sodium hydroxide
		0.5M Ammonium sulfate
		0.2N Hydrochloric acid

Date	Quantity	Chemical
12-29-80 (cont)		10.0 g/L iron
		1% Citric acid
		-N Nitric acid
		pH 2.5 acid spent
		2N Nitric acid
		0.45M HDEHP in isooctane
		1N Sulfuric acid
		12M Nitric acid
		DTPP
		Concentrated phosphoric acid
		1N Nitric acid
		8M Ammonium nitrate and 0.1M nitric acid
		Di2 EHPA
		0.4M Nitric acid
		Acetic acid
		3N Hydrochloric acid
		1M Phosphoric acid
		0.5M Hydrochloric acid
		0.6M Nitrate and sulfate
		100 g/L Sodium sulfate
		10M Nitric acid
		Saturated oxalic acid
		10% Ammonium hydroxide . hydrochloric acid
		Concentrated hydrochloric acid
		Hydrogen peroxide
		0.2N Nitric acid
		Sodium acetal and acetic acid
		Hydrogen peroxide
		0.05M Sulfuric acid
		0.05M Ammonium formate
		Nitric acid
		0.1M KHC_8O_4
		2M Ammonium acetate
		8N Hydrochloric acid
		Butyl alcohol
		0.05% Quinalizarin
		0.01M Nitric acid
		4N Nitric acid
		pH 3.5 Chromium-tungsten
		8.5M Perchloric acid + 0.5M hydrochloric acid
		1N Nitric acid + 90% H_3ON
		0.2M Hydrochloric acid + 40% ethanol

Date	Quantity	Chemical
12-29-80 (cont)		Bromcresol green in 0.1% ethanol
		3M Hydrochloric acid 20% ethanol
		Bromcresol purple
		0.1M Ammonium chloride
		1 g/L Boron
		0.5 g/L Boron
		50% Phosphoric acid
		1N Phosphoric acid
		2M Ammonium hydrogen citrate
		0.1M Ortho-phenol
		8.5M Perchloric acid + 0.5M hydrochloric acid + 0.1M hydrofluoric acid
		3M Acetic acid
		0.01% Methyl orange
		Sulfuric acid
		0.5M Nitric acid - 70% methanol
		Lead 1 g/L
		8.5M Perchloric acid + 0.5M hydrochloric acid + 0.1M hydrofluoric acid
		3M Acetic acid
		0.01% Methyl orange
		Sulfuric acid
		0.5M Nitric acid - 70% methanol
		Lead 1 g/L
		Dorex 50 acetate
		1 ppm lead
		10 g/L Ammonium molybdate in 10% sulfuric acid . 5 mL
		8N Sodium hydroxide - 20% sodium oxygen hydroxide
		0.1N Sulfuric acid
		10M Hydrochloric acid
		0.2M Ammonium chloride
		0.2N Hydrochloric acid
		30% Ammonium tartrate
		8 - Hydroxyquinoline (8-HQ)
		5% Hydroxyquinoline in water
		1% Niobium + acetic acid in chloroform
		Diphenylthiocarbazone (dithizone) in carbontectrachloride
		0.005M Azure carbon
		1M Hydrochloride acid + 0.1M hydriodic acid

Date	Quantity	Chemical
12-29-80 (cont)		APDC in hydrochloric acid
		5% Na Tungsten
		Hydroquinone solution
		Hydrogen peroxide
		Benzene
		1% Methyl glyoxime in ammonium hydroxide
		Solutions:
		Gold
		Copper
		Europium
		Potassium iron (III) cyanide
		Aluminum
		Barium chloride
		Bromocresol purple
		Cromium (III) cation
		8-Hydroxyquinoline
		Selenium 10 mg/L
		Aluminum 1 g/L
		Selenium (VI) cation in 10 g/L
		Butyl cellosolve
		1M Sulfasulacylic acid
		0.1% Alizarine in hexanol
		0.2% PCT in hexane
		30.7 g Manganese chloride hydrate/1 L water
		11.1N Phosphoric acid
		0.5N Phosphoric acid
		TTA 0.5N in Xylene
		DDTC in chloroform
		Hydroxide of hyamin 1M
		10% Acetylacetate in hexanol
		15% Potassium cyanide
		Ethylene glycol
		D,D 1N Hydrochloric acid
		Ludox* stock solution
		2.5M Dimethylglyoxime
		20% TOPO in benzene
		1.6N Nitrilotriacetic acid
		5% TOPO in cyclohexane
		Dowex, chloroform
		Phosphoric acid in water
		DHDECMP
		33% in cyclohexane

Date	Quantity	Chemical
12-29-80 (cont)		1% Boron
		Selenium (VI) in tap water
		Tin (dilute)
		Cold saturated niobium 1 g/L
		Silver 10 mg/mL
		Manganese g/L
		Iron (III) cation
		Methyl violet
		Titanium saturated 1 g/L
		Nickel (II) ion 10 mg/mL
		0.1% Phenyl red
		1% NPHA in chloroform
		Barium (II) ion 10 g/L
		Mercury
		Thymol phthalein
		Zinc (II) ion
		La Carrier 5 mg/mL
		Copper selenium oxide hydrate 1.001 g selenium/l
		3% APDC
		11 ppm titanium in sulfuric acid
		Titanium 1 mg/mL
		3.3 ppm Cadmium and 6.7 ppm cadmium and beryllium 10 mg/mL
		Strontium (II) ion 10 mg/mL
		1 g/L Nickel
		Saturated ammonium carbonate
		Carbamic acid
		$Na_4P_2O_2.10H_2O$ 200 g/L
	4 L	1N Sodium hydroxide solution
	1 pt	Triethanolamine
	1 pt	Dimethyl formamide
	1 L	Piperidime
	2 L	Diisobutyl phthalate
	1 L	Biofluor
	1 L	10% T10A
	1 pt	1/1 by volume ethoxyethanol - ethanol
	1 pt	Anisole
	1 L	2-Ethyl hexylamine
	1 pt	p-Cymene
	1 pt	Ethylene glycol
	1 pt	Benzonitrile

Date	Quantity	Chemical
12-29-80 (cont)	1 pt	Chlorobenzene
	1 pt	Monobromobenzene
	1 gal	Aropol WEP 666P*
	1 gal	Ready-Solv solution VI
	5 L	p-Dioxane
	1 pt	Hyamine hydroxide
	1 pt	Aquosol
	1 gal	Unknown
	1 gal	Unknown
	1 gal	Oil
	1 pt	Formaldehyde solution
01-02-81	15 gal (90 lb)	Dioctyl phthalate on vermiculite
01-02-81	20 gal (120 lb)	Monoplex DOS, dioctyl sebacate
01-02-81	90 lb	Dioctyl phthalate absorbed with vermiculite
01-02-81	120 lb	Dioctyl sebacate in vermiculite
01-06-81	4 lb	Ethyl ether
	2 pt	Toluene
	12 gal	Tetrahydrofuran mixture
	4 kg	Tetrahydrofuran
02-0 -81	1 gal (10 lb)	DTPA in water absorbed on vermiculite
02-11-81	1 gal (10 lb)	Nitrilotriacetic acid in water on vermiculite
02-11-81	1 gal (4 lb)	1AX solvent NPH/tributyl phosphate on vermiculite
02-11-81	1 gal (8 lb)	Used mineral oil on vermiculite
02-11-81	2 gal (10 lb)	Used transformer oil on vermiculite
02-11-81	1 gal	Polyethylene glycol
02-11-81	4 lb	NPH/tributyl phosphate in vermiculite
02-11-81	10 lb	DTPA in water in vermiculite

Date	Quantity	Chemical
02-11-81	10 lb	Nitrilotriacetic acid in water in vermiculite
02-16-81	1 L	10 ppm beryllium liquid
02-25-81	1 L	Oil
	500 mL	TTA, tributyl phosphate
02-25-81	2.5 L	Methylene chloride Tetrahydrofuran Xylenes Chloroform hexane
03-05-81	1 lb	Potassium chloride solution
	1 pt	Dimethyl amino benzaldehyde solution
	0.5 pt	Hexone
	3 lb	Dibenzoyl peroxide
	125 lb	Dioctyl sebacate with vermiculite
	500 mL	TTA and tributyl phosphate mixtures
	2500 mL	Mixture: Methylene chloride, Tetrahydrofuran, Xylene's, Chloroform, Hexane
03-12-81	12.5 gal (125 lb)	Monoplex* DOS dioctyle sebacate
03-16-81	4 lb	Potassium dichromate
	24 pt	Methyl alcohol
	0.5 lb	Silver nitrate
	0.25 lb	Ferrous sulfate
	1 lb	Iodine
	2 lb	Potassium iodate
	250 g	Dimethylamine benzaldehyde
	0.25 lb	Starch
	2 lb	Sodium metavanadate
	2 lb	Potassium iodide
	1 lb	Aluminum metal
	75 g	Resorcinol
	1.5 lb	Sodium hydroxide (pellets)
	40 lb	Sodium hydroxide
	70 lb	Flake caustic soda
	1 lb	Potassium chloride saturate with silver chloride

Date	Quantity	Chemical
03-16-81 (cont)	0.5 pt	p-Dimethylamine benzaldehyde
	0.5 pt	Hexone
	400 g	Hydrazine dihydrochloride
	1 lb	Aluminum nitrate
	1 lb	Potassium permanganate
	1.25 lb	Sodium sulfate
	2 lb	Sodium thiosulfate
	2 oz	Cerium nitrate
	2 oz	Sulfamic acid
	0.25 lb	Strontium nitrate
	0.5 lb	Sodium acetate
	3 lb	Boric acid
	1 lb	Sodium chloride
	4 lb	Sodium sulfite
	1 lb	Magnesium
	5 lb	Calcium chloride
	250 lb	Boric acid
	560 lb	Orocol*
04-01-81	350 lb	Alkaline metal cleaner
	1 pt	pH 7 butter solution
04-01-81	350 lb	Alkaline metal cleaner
	22 lb	Sodium hydroxide
	6 lb	Sodium hydroxide pellets
	4 lb	Sodium nitrite
	9 lb	Sulfuric acid
04-15-81	105 lb	Cupric sulfate
	7 lb	Chromium nitrate
	14 lb	Potassium sulfide
	8 lb	Sodium acetate
	10 lb	Sodium nitrate
	1 lb	Ammonium nitrate
	1 lb	Potassium fluoride
	12 oz	Sodium peroxide
	2 qt	Hydrazine (64% in water)
	1 L	Acetaldehyde
	1 pt	Perchloric acid
	1 pt	Methyl iodide
	1 kg	Chlorosulfamic acid

Date	Quantity	Chemical
04-16-81	1 L	Acetaldehyde
	45 lb	Cupric sulfate
	7 lb	Chromium nitrate
	14 lb	Potassium iodide
	8 lb	Sodium acetate
	10 lb	Sodium nitrate
	1 lb	Ammonium nitrate
	1 lb	Potassium fluoride
	1 lb	Sodium peroxide
	1 lb	Potassium fluoride
	12 oz	Sodium peroxide
	2 qt	Hydrazine (65% in water)
	1 L	Acetaldehyde
	1 pt	Perchloric acid
	1 pt	Methyl iodide
	1 kg	Chlorosulfamic acid
04-21-81	240 lb	Dioctyl sebacate with vermiculite
	40 gal (240 lb)	Monoplex DOS dioctyl sebacate
07-09-81	1 pt	Hydrogen peroxide
	few drops	Chlorotrimethylsilane
	4 oz	Unknown
	50 mL	Unknown
	100 mL	Hydrofluoric acid
	1 pt	Ethyl acetoacetate
	1 qt	Methyl silane (leaking bottle)
	100 mL	Ultrex nitric acid
	1 L	Sulfuric acid
	250 mL	
	500-1000 mL	Perchloric acid
	700 mL & 1 pt	Sodium hypochlorite
	300 mL	Hydrochloric acid
	150 mL	Hydriodic acid
	500 mL	Hydriodic acid
	400 mL	Sulfuric acid
	2 pt	Trichloroethylene
	0.75 gal	Ethyl ether
	5 pt	Ethylene glycol
	0.5 pt	Chloroform

Date	Quantity	Chemical
07-09-81 (cont)	1 gal	Methylformamide
	1 pt	Benzene
	8 lb	Ammonium fluoride
	6 lb	Ammonium oxalate
	7 lb	Magnesium chloride
	45 gal	Benzyl-para-aminophenol
	1,200 mLs	Mercury
	250 mL	Formalydehyde
	500 mL	Iodine solution
	250 mL	Formalin
	0.5 pt	Iodine solution
07-16-81	8 kg	Beryllium-liquid-10 ppm
	1200 mL	Mercury
	30 gal	Solvent refined coal
	45 gal	Benzalphapyrene
07-21-81	2,772 lb total	Reacted lithium & sodium products
08-13-81	30 g	Mercuric nitrate
	1 L	Molybdate reagent
	0.75 L	Phosphorous acid
	0.75 L	Phosphorous acid
	0.5 L	Phorphorous trichloride
	0.75 L	Ethone N: enplate solution (electroless plating)
	1 L	Ethone NL-62 enplate solution (electroless plating)
	1 L	NA hypobromite solution
	0.66 lb	Molybdic acid
	1 lb	Barium hydroxide
	70 g	Bismuth nitrate
	1 g	Elemental boron
	70 g	Cadmium nitrate (hydrate)
	0.33 lb	Cadmium chloride
	45 g	Cerium nitrate (hydrate)
	0.33 lb	Chromium chloride
	40 g	Chromium oxide
	760 g	Cobalt nitrate (hydrate)
	0.8 lb	Ammonium nitrate
	1 lb	Cupric chloride (hydrate)
	0.4 lb	Cupric sulfate (hydrate)

Date	Quantity	Chemical
08-13-81 (cont)	70 g	Cuprous oxide
	75 g	Lithium fluoride
	3 lb	Lanthanium ammonium nitrate . water
	0.9 lb	Magnesium sulfate
	100 g	Manganese chloride
	30 g	Mercuric nitrate
	1 lb	Nickel acetate
	160 g	Magnesium base alloy (chips)
	75 g	Lead acetate . 3 water
	0.9 lb	Lead dioxide
	80 g	Acid phosphomolybdic
	1 L	Molybdate reagent
	0.25 lb	Phosphorus
	0.75 lb	Phosphorous acid
	0.75 lb	Phosphorous acid
	0.75 lb	Phosphorous trichloride
	0.8 lb	Ammonium hydrogen phosphate
	1 lb	Potassium hydrogen phosphate
	1 lb	Sodium hydrogen phosphate
	1 lb	Disodium hydrogen phosphate
	0.75 lb	Trisodium phosphate (tribasic)
	0.66 lb	Sodium hypophosphite
	0.33 lb	Potassium chloride
	0.66 lb	Potassium fluoride
	0.9 lb	Potassium bromate
	0.2 lb	Potassium hydroxide
	0.5 lb	Potassium iodide
	0.66 lb	Potassium nitrate
	70 g	Potassium meta-periodate
	0.75 lb	Potassium thiocyanate
	1 L	Enthone NL-62
	0.4 lb	Sodium bismuthate
	1 lb	Sodium bromide
	1 lb	Sodium fluoride
	1 L	Sodium hypobromite solution
	1 lb	Sodium iodide
	1 lb	Sodium nitrite
	0.75 lb	Sodium nitrate
	15 g	Sodium stannate
	1 lb	Sodium thiosulfate
	70 g	Sodium vanadate
	100 g	Selenious acid

Date	Quantity	Chemical
08-13-81 (cont)	35 g	Silver nitrate
	1 lb	Sulfur
	0.75 lb	Zinc metal
	10 g	Thallous acetate
	40 g	Stannic chloride
	0.75 lb	Trichloroacetic acid
	1 lb	Zinc nitrate
	1 lb	Barium nitrate
	0.5 lb	Oakite*
	4 lb	Ammonium persulfate
	0.75 lb	Ceric sulfate
	1 lb	Magnesium perchlorate
	0.75 lb	Manganese dioxide
08-24-81	200 gal (20 lb)	Fenemine
09-17-81	19,350 lb (~45 drums)	Solvents, oils, paint, and paint thinner mixed and unknown names. Material absorbed with speedy dry
	1 pt	Methyl chloroform
	13 L	Benzene
	5 pt	Dye in methanol
	1 pt	Ether
	Small bottle	Chloroform
	200 mL	Mercury
	500 mL	Formaldehyde
	6 pt	Benzene
	7 pt	Benzene/chlorotrimethyl silane
	1 pt	p-Dioxane
	1 pt	Methylchloroform
	2 gal	Potassium permanganate/sodium hydroxide
	13 L	Benzene
	5 pt	Dye in methanol
	1 pt	Ether
	1 pt	Chloroform (methyl chloroform)
	Petri dish	Iodine crystals
	Empty bottle	Dye grains
	5 gal	Chromium-aluminum-manganese-sulfur-iron powder
	3 gal	Nickel powder
	200 mL	Mercury (in concrete)
	500 mL	Formaldehyde
	6 pt	Benzene

Date	Quantity	Chemical
09-17-81 (cont)	7 pt	Benzene/chlorotrimethylsilone mix
	1 pt	p-Dioxane
	0.25 ft^3	Mercury batteries (in concrete)
	0.5 ft^3	Mercury contaminated material (in concrete)
09-21-81	1 metal container	Banvel* herbicide
	1 metal container	2-4-D Amine, dimethylamine
	1 metal container	Greenshield adjuvant
09-24-81	200 lb	Feremire
10-22-81	1 55 gal drum (350 lb)	Solvent refined cool (clean up from chemical spill) heavy fraction
	0.25 lb	Silver chloride
	0.25 lb	Silica powder
	0.25 lb	Chromic oxide
	0.25 lb	Iron (II) oxide
	1 lb	Potassium cyanide (P098)
	0.25 lb	Sodium arsenate
	1 lb	Mercury chloride
	1 lb	Sodium perchlorate
	1 lb	Arsenic oxide (P012)
	1 lb	Borium perchlorate
	0.25 lb	Thallous formate
	2 lb	Nickel chloride
	1 lb	Mercuric chloride
11-16-81	4 gal	Nitric acid
	5 L	Lead nitrate
	1 qt	Benzene
	8 gal	Dioxone & water
	0.5 gal	Misc. unlabeled reagents
11-23-81	0.5 pt	Benzene
	500 mL	Hexane
	8 gal	Dioxane mixture
	5 gal	40% nitric acid
	1 L	72% perchloric acid
12-17-81	4 lb	Ethyl ether
	2 pt	Toluene
	12 gal	Tetrahydrofuran with pump oil

Date	Quantity	Chemical
12-17-81 (cont)	10 gal	Wood for derivatives
	3 lb	Potassium bromide
	10 lb	Sodium sulfite
	7 gal	Union fluid LO500
	1 qt	Paraffin oil
	1 pt	Perchloric acid
	5 gal	Pump oil
	1 pt	Xylene
12-23-81	1 55 gal drum	Dioctyl sebacate with vermiculite
	40 gal (150 lb)	Dioctyl sebacate with vermiculite
	40 gal (150 lb)	Dioctyl sebacate (Monoplex DOS)
	20 gal (120 lb)	Dioctyl sebacate (DOS) Monoplex DOS plasticizer
01-07-82	14 pkg	Afrin nasal spray
	4 pkg	Wycillin suspension
01-12-82	80 L 24 lb ea.	Iron (II) nitrate liquid
	272 lb	Ferric nitrate
	1 pkg	APC compound
01-25-82	6 g	Bisdihydroxy phosphinyl
	10 g	Glyoxal-bis-(2-hydroxyanil)
	6 g	Erio Chrome* blue black R
	5 g	Acid alizarin black
	15 g	Eriochromschwarz T
02-03-82	4 gal (36 lb)	CALCl-Solve
	5 gal (35 lb)	Perchloroethylene
	1 gal (9 lb)	H_2SO_4 liq
	1 gal (8 lb)	Unknown liquid
	0.66 gal (5 lb)	Ferric chloride etch solution
	0.5 gal (3.5 lb)	Nitric acid
	55 gal	50/50 35% hydrazine in sorbed absorbent
02-12-82	400 lb	Kodak* rapid fixer and hardner (contains sulfuric acid) and liquid developer (potassium hydroxide solution) that has been absorbed.

Date	Quantity	Chemical
02-12-82 (cont)	0.5 gal (3.5 lb)	Nitric acid
03-09-82	225 g	Ferrous sulfide
	0.75 lb	Lead nitrate
	1 lb	Ferrous sulfate
	0.5 lb	Magnesium sulfate
	1 lb	Mercuric oxide
	2 oz	Mercuric chloride
	0.75 lb	Magnesium chloride
	1 lb	Mercurous chloride
	1 lb	Lead oxide (low silver)
	3 oz	Tin metal
	75 g	T-O-Folylazo-o-toliudine
	5 g	L-trypotophane
	1 lb	Trypticase soy agar
	0.75 lb	Lead acetate
	0.25 lb	Zinc oxide
	100 g	Special vanadium oxytrichbride corrosive material
	8 lb & 1 pt	Sodium sulfite
	0.5 lb	Charcoal bone
	1 lb	Diphenylamine
		Desoxycholic acid
	0.7 lb	Ethylenediamine, tetraacetic acid
	0.7 lb	Salicylic acid
	0.13 lb	Magnesium carbonate
	0.6 lb	Sodium dichromate
	0.6 lb	Sodium dichromate
		Iodine
	200 g	Triethanolamine
	0.5 lb	Sodium salicylate
	0.5 lb	Sodium dichromate
	0.7 lb	Resorcinol
	0.75 lb	Sodium bisulfite, meta dry
	0.25 lb	Sodium bisulfite, meta dry
	1 lb	Sodium fluoride
	1 lb	Sodium bromate crystal
	0.5 lb	Sodium sulfite, meta
	2 oz	Sodium iodide
	0.25 lb	Sodium oxalate
	1 lb	Sodium fluoride

Date	Quantity	Chemical
03-09-82 (cont)	0.75 lb	Sodium bisulfite, meta dry
	0.75 lb	Sodium sulfite
	10 g	Sodium sulfite
	30 g	Potassium oxalate
	12 oz	Potassium permanganate
	12 oz	Potassium iodide
	12 oz	Potassium iodide
	12 oz	Potassium permanganate
	14 oz	Potassium bromide
	2 oz	Sand sea
	0.14 lb	Potassium citrate
	0.2 lb	Potassium
	2 lb	Potassium permanganate
	12 oz	Potassium chromate
	1 lb	Potassium pyrosulfate
	2 oz	Potassium periodate
	12 oz	Potassium iodate
	1 lb	Attasol
	25 g	Anion exch. FLOC DE 50
	25 g	Anion exch. FLOC AE 50
	15 g	Cation exch. CM 70, powder
	250 g	Maleic acid (pellet)
	475 g	Isopentylacetate
	0.25 lb	Hexadecyltrimethylammonium bromide
	75 g	Isoelectric casein
	500 g	Maleic anhydride
	60 g	Isoelectric casein
	100 g	n-Methylglucamine
	90 g	Glycerophosphate sodium 5-1/2 water
	100 g	Iodacetamide
	8 g	l-Inositoc
	3.5 oz	Methyl-salicylaete
	70 g	Hood mercaptoacetic acid
	100 g	2-Mercaptoethane
	25 g	n-n-Methylenebisacrylamide
	108 g	Ethyl chloride
	15 g	n-n-Methylenebisacryilamide
	25 g	Hexamethyldisilane reagent
	15 g	DL-Disodium glycerophosphate
	4 g	Sodium glycerophosphate
	95 g	Hydrazine sulfate
	2.5 g	Glycogen

Date	Quantity	Chemical
03-09-82 (cont)	50 g	Glucuronolacetone
	450 g	Diphenylamine hydrobromide
	90 g	Disodium salt
	90 g	Butylated hydroxytoluene
	0.8 k	Chloramine-T
	0.25 lb	Ascarite
	0.4 g	1-(-1-cystin)
	40 g	Bromphenylhydrazine hydrochloride
	6 g	Anthydrol
	90 g	Cholinchloride
	75 g	p-Dimethamino-benzaldehyde
	100 g	p-Nitroaniline
	12 oz	Nordihydroguaiaretic acid
	12 oz	Oxyethylated-tert-octyl-phenol formaldehyde polymer
	100 g	Phosphatidylethanotamine
	113 g	(Hood) picric acid
	44 g	(Hood) potassium cyanide
	18 g	Orcinol
	50 g	(Hood) picric acid
	25 g	4-Nitroquinolin N-oxide
	0.25 lb	Pyridine
	430 g	Oxalic acid
	450 g	Propionic acid
	15 gm	Picryl sulfonic
	0.66 lb	Phosphorus tungsten acid
	0.33 g	DL-norcuecine
	0.5 g	1-Proline
	5 g	Propylthiouracil
	4 g	DL-alanin-methyester-dihydro-chloride
	4 g	Alloxan
	g	Ammopyrine
	g	1-Amino-2-naphthol-4-sulfur
	1 lb	Ammonium persulfate
	1 L	Ammonium thiocyanate
	0.75 lb	Arsenic trioxide
	0.13 lb	Barium acetate
	1 lb	Barium hydroxide
	0.75 lb	Barium hydroxide
	0.5 lb	Barium hydroxide
	1 lb	Barium chloride
	10 g	Benzidine clare

Date	Quantity	Chemical
03-09-82 (cont)	14 oz	Chromium trioxide
	8 oz	Calcium carbonate
	8 oz	Calcium hydroxide
	12 oz	Chromium trioxide
	10 oz	Chromium trioxide
	0.13 lb	Cadmium chloride anhydrous
	2 oz	Cupric oxide
	0.13 lb	Calcium chloride
	2.5 oz	Cupric carbonate
	12 oz	Calcium chloride
	2 oz	Calcium chloride
	2 oz	Calcium chloride
	10 oz	Calcium sulfate
	1 L	1N sulfuric acid
	0.1 L	1/10N NA4SCN
	1 pt	2-Nessler's solution
	500 mL	2 folin and ciocalteus phenal reagent
	100 mL	Polyoxerelene sorbitan mono-oleate
	100 mL	Solvene-350
	500 mL	2 protosol
	50 mL each	Trizmal buffer 10 (bottles)
	100 g	Acetaldehyde
	1 qt	Ethylene glycol monomethyl ether
	1 L	Kodak rapid fix solution
	0.75 lb	Phosphorous trichloride
	0.5 lb	Glycerine
	0.75 lb	Ethyl acetate
	100 mL	X-100
	50 mL	5% polystyrene in benzene
	0.75 lb	Hydriodic acid
	1 mL	Beckman filter solvent
	90 g	Sebacyl chloride
	3.5 oz	Contrad 70
	1 pt	Aerosol OT cleaner
	.75 pt	Collodion
	10 vials, 1 mL each	Di-sil-prep
	2 lb	Triphenyltetrazolium chloride 2 ferrous sulfate solution
	3 oz	Methyl salicylate
	27 mL	U-DTPA 32 mg/mL

Date	Quantity	Chemical
03-09-82 (cont)	2 bottles, 420 mL each	Electrolyte
	175 gm	10% DTPA
	20 mL	Tris-tetra methylene-phosphoric-triamide
	0.1 mmol	manganese sodium DTPA
	25 mL	Foto-flo* Fluoro surfactant
	2 vials, 15 mL each	Latex particles - polystyrene
	4 vials, 10 mL each	Grobax* - sodium polyanethol sulfonate 5%
	10 mL	Hydrogen-gold DTPA
	10 cc ampule	Calcium gluconate - glucoheptonate
	9 ampules, 10 mL each	Calcium gluconate - gluceptate
	50 g	d-Limonene
	6 vials, 5 cc each	Madribon 10% (sulfur)*
	0.5 lb	Phosphorus trichloride
	8 oz	Acrylamide
	0.25 lb	Aluminum oxide powder
	0.5 lb	Aluminum potassium sulfate crystal
	75 gm	Agarose
	0.75 lb	Ammonium sulfate granular
	0.5 lb	Amberlite IRC-50
	0.25 lb	2-bromoethylamineltycrobromide
	8 oz	Boiling chips micro-porous
	0.25 lb	Ferric ammonium sulfate crystal
	0.25 lb	Fluorescein sodium salt
	0.13 lb	Hydrazine sulfate
	1 lb	Hydrazine sulfate
	0.25 lb	Lead nitrate crystal
	0.25 lb	Trichloroacetic acid crystals
	0.25 lb	Potassium citrate crystal
	2 oz	Merculic chloride crystal
	0.13 lb	Potassium bromate
	4 oz	Potassium biphthalate
	4 oz	Sequlene
	0.75 lb	Resorcinol crystals
	1 lb	Trishydroxymethylamine (TRIs) methane
	1 lb	Zeokarb H*
	100 gm	An O

Date	Quantity	Chemical
03-09-82 (cont)	1 lb	Z10 Cl
	3 oz	Acid tungsten powder
	0.25 lb	Sodium pyrophosphate
	0.25 lb	Sodium phosphate dibasic crystal
	0.5 lb	Sodium acetate
	0.5 lb	Citric acid granular
	0.5 lb	Hydroxylamine hydrochloride crystals
	2 oz	Iodine crystals (resublimed)
	1 lb	Sodium diethyldithiocarbonate
	10 gm	l-Lysine ethyl ester dihydro-chloride
	10 gm	S-carboxyethyl-l-cysteine
	10 gm	S-carboxyethyl-l-cysteine
	10 g	S-carboxyethyl-l-cysteine
	10 g	S-carboxyethyl-l-cysteine
	0.25 lb	Cesium chloride
	5 vials	Methyl bis/b-chlorethyl
	1 jar	Calcium sodium
	1 jar	Calcium DTPA
	0.25 lb	Methyl metharylale
	0.13 lb	Sodium hydrogen ethylenediaminetetra-acetic acid
	90 g	Chelidamic acid monohydrate
	45 g	Sodium taurochelate
	90 g	Sodium DTDA
	90 g	l-Ethylenedinitriloldi-o-cred
	45 g	n,n-Dicyclohexylcarbodiimide
	1 g	2,4,6-Triethyleneamino triazin
	25 g	Salicylhydroxyamic acid
	25 g	Aces
	125 g	DTPA
	90 g	Triethylene tetraamine tetrachloride
	50 g	Thielated gelatin
	10 oz	Isocinchomeronic acid
	8 oz	Microporous boiling chips
	25 g	2 Thiophenecarboxylic acid
	oz	Cit-A 1 water
	oz	DTPA acid
	20 g	2-3 dimethoxybenzoic
	g	Zirconium DTPA
	g	Zinc hydrogen DTPA
	0.25 lb	Sulfur compound
	45 g	Palmitic acid

Date	Quantity	Chemical
03-09-82 (cont)	5 g	PDT disulfonate
	2 g	Phthaleincomplexore
	10 g	Phloridzin
	oz	5-amino-3-sulphosalicylic-acid
	5 g	Thymine-5-methyluracil
	g	Sodium polystyrenesulfonate
	100 g	Sodium chelate MA
	50 g	Eriochromschwarz +
	60 g	Brenzkatechin
	50 g	Ethyl glycine
		623 dimethyloxybenzoil
	430 g	Procaine hydrochloride
	90 g	Proplygaliate
	100 g	Polyvinyl pyrrolidone aiceut
	14 oz	Pyromellitic acid
	75 g	2,5 Diphenyloxazole
	90 g	MPTT K+
	50 g	Polyvinyl pyrrolidone
	90 g	Sodium desoxycholate
	1 kg	Poly-oxyethejiene-23-lavrylether
	14 oz	Hydroquinone
	12 oz	Sorbitan monolavrate
	1 lb	Dextrose
	50 g	Fat black (microscope)
	450 g	Hexamethyenetetramine
	100 g	Dimethydithiacarbamic acid sodium salt dihydrate
	100 g	Dextran
	14 lb	Calcium phytate
	90 g	5 Sulfosalicylic acid
	25 g	n-Acytyl-di-penicillamine
	4 g	Neutral red
	8 oz	Gelatin powder
	100 g	5B Cholanic acid 3, 7, 12 tricue
	75 g	Acridine orange
	20 g	POPOP
	90 g	Ethylenedinitrilo tetraacetic acid epsom salt
	100 g	P1 Dimethylamino
	75 g	4,4-diamino-2,2-biphenyl-disulfate acid
	100 g	Sodium glocuranate
	100 g	N,N-Ethylennis (forraini de)
		Acridine orange

Date	Quantity	Chemical
03-09-82 (cont)	4 g	Gramine
	10 g	Aurnic acid natural
	25 g	2,6 dicarbonypyridine-n-oside
	5 g	Butyl alcohol
	oz	Chel. 300 acid
	oz	Cyclohexamine-N,N,N,N,L-tetraficetic acid
	48 g	8 ace + oxyquinoline
	9 g	Dithizone
	20 g	Alizarin reds
	10 g	Ammonium rhodanilate
	90 g	25 Dimercapto-1,3,4-thiadiazole
	1 lb	Fleischmann's* pure dry yeast
	0.25 oz	Calcium chloride crystal
	5 g	Ammonium perrhenate
	2 oz	Bismuth trioxide
	1 g	Calcium fluoride
	1 lb	Ammonium tetrasulfate cerate
	1 g	Calcium fluoride
	1 lb	Ammonium tetrasulfate cerate
	1 g	Calcium fluoride
	1 lb	Ammonium tetrasulfate cerate
	1 g	Fluorescein isothiocyanate
	1 g	Benzenesulfohydroxamic acid
	0.25 lb	Barium permanganate
	8 mL	Ferrous surfactant
	5 g	Murexide
	10 g	8-Mercaptopurine
	4 gm	3-Hydroxyflacene
	5 g	1-(2-pyridylaze) 2-naphthol indicator grade
	10 g	f-Mercaytopurine
	0.25 lb	Nickle oxide powder
	200 g	Calcium sulfamate
	5 g	Periodic acid H5IO
	1 g	Acetyl-D-phenylalanine
	1 gm	1-Thyrexine sodium salt
	0.75 oz	Titanium oxide anhydrous
	0.75 lb	Copper-iron
	20 g	Silicon-carbon
	0.2 lb	Potassium acid phthalate crystals
	1 lb	Manganese dioxide powder
	50 mg	Calcium chloride

Date	Quantity	Chemical
03-09-82 (cont)	1 oz	C-chloromercuriphenol
	0.25 lb	Potassium iodate granular
	0.25 lb	Potassium persulfate
	0.25 lb	Sodium cobalt nitrate powder
	2 oz	Lead sulfide powder
	1 lb	Zinc metal granular
	4 oz	Sodium cyanide granular
	20 g	Stannic oxide
	1 lb	Silica pow (200 mesh)
	0.25 lb	Sodium permanganate
	0.25 lb	Cesium chloride
	5 g	1-Threchin-methylester
	0.25 lb	Acid tungsten
	10 g	Dextran
	10 g	Vitastain
	1 g	DL-O-tyucsinc
	1 g	DL-C-phosphosenine
	1 g	Hydrocortisone alcohol
	1 g	Palmitic acid
	5 g	Phenol red
	5 g	Alizanin complexane
	5 g	Phenol red
	10 g	Easin Y
	10 g	Calcein W
	5 g	Phenol red
	2 vials, 15 mL ea.	Polystyrene - latex particles
	1 g	Fuchsin basic
	4 vials, 10 mL ea.	Grobax (sodium polyanethol sulfonate 5%)
	90 g	Butylated hydroxyanisole pellets
	2 g	Aluminum CP
	21 g	Girard's P
	100 g	Arsanalic acid
	2 g	Isatin-3-oxime
	25 g	N-acetyl-DL-penicillamine
	5 g	Diphenic acid
	100 g	1-Thiazolidine-4-carboxylic acid
	50 g	2-Guanidino-4-ammonium bromide
	60 g	Buffalo black NBR
	0.25 lb	Beef blood serum
	mL	1-Dyenkolic acid

Date	Quantity	Chemical
03-09-82 (cont)	mL	Glucoronolaetone
	25 g	D-(-)-penicillamine
	25 g	Dimethyl big vanide hydrochloric acid
	20 g	Erio glaucine
	12 g	Glycocyamine
	20 g	EMPC
	5 g	Dihydro-ketoquinoxaline carboxylic acid
	10 g	Synthetic arbotin
	Almost empty	Osmium tetoxide
	5 g	2,6-Dihydroxy-isonicotinic acid
	5 g	4,4-Bis-Dimethylamino-diphenylcarbinol
	500 mg	Deferal
	4 g	3,4-DL-Dihydroxyphenylalanine
	25 g	Diothylstibesterol
	5 g	Ethoxzolamide
	5 g	Dibenzoyl-diamino ethylene
	2 g	29-Dimethyl-1, 10-pherantnrolire
	2 g	4,7-Diphenyl-1,10-phenanthraline
	5 g	Dihydronaphtlool naphthofurofuran
	1 g	Neocuproine
	10 g	2-Nitrosolnaphtlool-4-sulfuric acid
	5 g	Beta-alanine
	9 g	Calciferol
	5 g	Chondroitin sulfate
	oz	N-(4-amino 3-carboxyphenyl sulfonyl)
	oz	Calmagite
	15 g	Calcein
	1 oz	Benzotriazol purified
	5 g	Diazine green
	2 g	Pan indicator
	25 g	Imidazole-4,5-dicarboxylic acid
	25 g	Isatin
	2 g	Dipotassium pentacalcium dicalcein
	8 g	Sulfaethidole
	oz	Thio-Michler's ketone
	1 oz	Pepsin
	5 g	N-acetyl-DC-penicillamine
	25 g	2-mercaptocihydrouracil propionic acid
	10 g	Nile blue A
	0.5 g	DL-proline
	10 g	2-Nitrosolnaphth-4-sulfonic acid
	5 g	2,4,6-Tripyridyl-S-triazine

Date	Quantity	Chemical
03-09-82 (cont)	5 g	DL-penicillamine
	5 g	D-penicillamine disulfide
	5 b	2-(DL-penicillamine acetone adduct hydrachloride)
	8 g, 10 g	2-(a,a-dicarboxy-n,n-diformyl-4-piperazinediaianine-tetreathylester)
	0.25 lb	Thiazolilidine-4-carboxylic acid
	0.2 g	Polyaspartic acid
	5 g	Hodizonic acid, potassium salt
	0.2	dl-homocystine
	5 g	D-penicillamin puriss
	0.1 g	4,7-diphenyl-1, 10-phenanthroline
	5 g	7-aminocephalosporanic acid
	5 g	Potassium chromium sulfate
	5 g	1,2,3-Triketohydrinolene
	4 g	2,4,6,8-Tetrahydroxypyrimido pyrimidine (54)
	1 g	Zincon*
	10 g	Eri Chrome blue black
	8 g	p-Nitrobenzeneazocrornal
	1 g	Acetazolamide
	1 g	D-serine
	2 g	Enemethyl blue
	1.75 g	Poly-L-glutamic acid sodium salt
	0.5 lb	Sodium anthraquinone sulfenate
	8 g	Uric acid
	85 g	4-N-maleysulfanilamide
	100 g	2-Meraptobenzothiazolylbutyric acid
	50 g	5-Salicylsulfonic acid
	4 g	Naphthol-beta
	75 g	1-(p-sulfophhenyl)-5-pyrazdene-3 carboxylicaad
	g	4-dimethylamino-azobarizene
	0.33 lb	Hydroxylamine hydrochloride
	0.5 lb	De-acutite anich exchanger
	0.5 lb	Ferric nitrate crystals
	0.5 lb	Acid citric monohydrate crystal
	1 lb	Jaguar A-20-A
	0.25 lb	Hydroxylamine hydrochloride
	1 lb	Cupric sulfate
	0.75 lb	Ferric ammonium sulfate
	0.25 lb	Pyrogallol
	4 oz	Phenylhydrazine hydrochloride
	1 lb	Potassium phosphate monobasic

Date	Quantity	Chemical
03-09-82 (cont)	10 g	Siractan AF #2 (arabinogalactin)
	0.75 lb	Potassium iodide
	0.75 lb	beta-Methylumbelliferone
	1 lb	Paraformaldehyde
	1 lb	Potassium permanganate crystals
	1 lb	Ferrous ammonium sulfate crystals
	200 g	Monogram ink (black)
	5 g	Guantec E-2
	5 g	2-Mercaptoacetanilide
	5 g	2-Mercaptoacetanilide
	5 g	2-Mercaptoacetanilide
	5 g	2-Mercaptoacetanilide
	5 g	2-Mercaptoacetanilide
	0.5 lb	Ferrous ammonium sulfate crystals
	20 g	Fluroescent zinc sulfide
	1 lb	Sodium fluoride powder
	0.25 lb	Schooghan
	100 g	2-Mercaptoacetanilide carbonate
	1 lb	Potassium chloride crystals
	200 g	Rexyn RG 50* (H)
	0.5 lb	Magnesium perchlorate
	1 lb	Purulic chloride
	0.75 lb	Lead carbonate
	0.5 lb	Sodium titanate
	1 lb	Seelex-C
	1 lb	Seelex-A-100
	1 lb	Morclire white petroleum jelly
	0.5 lb	Potassium hydroxide
	1 lg	Phenol
	40 g	Zinc oxide
	0.25 lb	Hood potassium cyanide
	1 lb	Sulfur powder
	0.5 lb	Potassium thiocyanate
	1 lb	Ammonium carbonate
	0.25 lb	Calcium gluconate
	0.75 lb	Potassium thiocyanate
	15 g	2-Aminoethan-1-hydrochloride
	0.25 lb	Sodium malonate water
	0.13 lb	Sulfamic acid
	0.25 lb	Nitroso R salt
	15 g	Phloriazin
	45 g	2-Mercaptoorotic acid

Date	Quantity	Chemical
03-09-82 (cont)	3.5 oz	Sarkosyl* N1-100
	20 g	Sudan black B
	6 g	Crio glaocine
	5 g	Violursavre
	oz	Calco* oil red N-1700
	3 g	Sialic acid concentrate assay
	8 oz	Calco alizarine cyanine green base
	22 g	Quinacrine dihydrochloride
	8 oz	Alcofast spirit yellow zirconium
	40 g	Thioacetamide
	8 g	Persantin active ingredient
	0.2 g	Piperic acid
	50 g	Insulin
	10 g	4-Methylumbelliferone
	10 g	Phenoxymethyl-Pencilloic acid
	50 g	Luxol hydrate
	1 g	2,4,6-Triamino-pyrimidine
	4 g	Taurine
	2 g	2-Mercaptothiazoline
	10 g	Pheroxymethyl-penicilloic acid hydrate
	1 oz	Thymol USP
	20 g	Alloxan
	15 g	Brilliant ponceau
	0.5 lb	Zinc chloride
	0.5 lb	Magnesium chloride
	1 lb	Sodium hydroxide
	0.5 lb	Sodium bicarbonate
	1 lb	Potassium chloride
	0.5 lb	Sodium bisulfate meta
	0.75 lb	Potassium iodide
	1 lb	Sodium hydroxide
	1 lb	Surfylnol 104
	30 mL	Chromerce
	1 lb	Calcium gluconate
	0.25 lb	Potassium cyanide
	1 lb	Sodium thiosulfate
	1 lb	Calcium chloridecihydrate
	1 lb	Sodium bicarbonate
	0.5 lb	Sodium phosphate
	1 lb	Potassium carbonate
	0.25 lb	Cupric sulfate
	0.13 lb	Potassium cyanide

Date	Quantity	Chemical
03-09-82 (cont)	0.75 lb	Boric acid
	0.5 lb	Ammonium acetate
	1 oz	Titanium oxide anhydrous
	0.75 lb	3 Zinc carbonate
	0.75 lb	Ammonium thiocyanate
	0.33 lb	Anhydrone
	0.5 lb	Calcium powder
	0.75 lb	Potassium sodium tartrate
	0.5 lb	Zinc oxide
	1 lb	Kojic acid
	25 g	Used drierite
	44 lb	Car bopol 941
	4.5 lb	Drierite*
		Cesium hydrogen sulfate
	125 mL	Hydrazine
	1-100 mL boxes	Procaine penicillin G
	3	Batteries AA
	10 g	Spermidin
	2	Service batteries
	1	Duracell* battery
	500 mg	Lecithin
	100 mg	Deferrichrome
	1 g	Rhodotorulic acid
	50 mL	Barentrifluoride-methanol
	10 g	Cyclopentadienylthallium
		Chloroacetontrile
	50 g	Glutanaldehyde
	50 cc	Iron-dextran injectible
	100 g	t-Pyriclidinecarbodithicic acid ammonium salt
	2.1 oz	Acufine developer
	4 oz	Soluble powder-terramycin
	0.33 lb	Scotchcast* electrical resin
	0.67 lb	Scotchcast electrical resin
	0.75 lb	Nitric acid
	200 g	CH-USP cholesterol
	1 lb	Bromine
	500 g	Ethylchloroformate
	1 pt	Ammonium sulfide solution
	1 g	B(2FVRYL)-acrylic acid
	1 g	Colchicine

Date	Quantity	Chemical
03-09-82 (cont)	1 g	Ethyl-3-indole acetate
	1 g	Maleic acid hydrazide
	1 g	D-Napthalen-acetamide
	0.1 g	Traumatic acid
	10 g	Lysozyme 3X
	1 g	Carbonyl bis (L-methionine) -nutraphenyl este
	1 g	Carbonyl bis (L-methionine) -nutraphenyl este
	5 g each 2 bottles	Cleland's reagent (dithiothreitol)
	1 g	Keflin*
	1 g	DL-tallo-crystathionine
	10 g	Histamine-dihydrochloride
	1 g	Lysozyme
	5 g	B-aminoproplanitrile, B
	50 g	Desferriaxamine B-metharesulfonate
	5 g	Thiagel
	5 g	Thiagel
	0.25 lb	Trypticase soy agar
	125 cc	LC 124 liquid crystals in petroleum ether solution
	125 cc	LC 124 liquid crystals in petroleum ether solution
	3 g	Desferrioxamine-B-methanesulfonate
	1 g	Pourlese ecatalase 30 1 g standard 750 mg
	50 g	L-a-phosphatidyl choline [L-a-lecithin]
	25 g	Lecithin egg (highly purified)
	25 g	Lecithin egg (highly purified)
	250 mL	Toluene spent
	100 g	Dizalmitin (1,2,41,3 mixture of isomers) (Sigma)
	2 vials ea. 0.1 g solid	Rebonuclease-A from bovinepancreas
	0.25 mg	Phosphatidyl ethanolamine
	500 mg	BIS-DHB-1, 3-propane diamine
	500 mg	DIS-DHB-ethyenediamine
	25 mg	TS-6
	500 mg	DIS-DHB putrescline
	500 mg	BIS-DHB octanedamive
	4 vials 100 mg ea.	Cytochrome-C from horse heart

Date	Quantity	Chemical
03-09-82 (cont)	4 vials 100 mg ea.	Cytochrome-C from horse heart
	500 mg	Cytochrome-C from horse heart
	100 mg	Cytochrome-C, type 11-A, horse H
	100 mg	Cytochrome-C, type 11-A, horse H
	0.1 g	Methyl palmitoleate
	3 vials, 1 g ea.	DL-isocitric lactone
	25 g	Tributyrin
	5 mL	Transaminase chem. control sch.
	3 vials, 1 g ea.	N,N-Bis-(2-carboximidoethyl) tantarmide dimethyl estea dihydlicchloride
	10 mg	Hemoglobin standard
	2 vials, 1 g ea.	Pepsin 3X cyst (parcine stomach mucous)
	1 g	Pepsin
	2 vials 25 mg ea.	Gangliosides
	25 mg	N-acetyl neuraminic acid
	2.5 mL	Lactic dehydrogenase enzyme
	2 vials, 5 mL (3 ug/mL)	N-4-nitrobenzo-Z-iva 1,3 diazide phosphetidyl ethanolamine
	1 g	Pepsin crystallizer
	100 mg	Cholesteryl oleate
	1 g	4-fluoro-3-nitro-phenylazide
	1 g	O-phenyl
	500 mg	Peroxidase
	mg	Cyto-C
	2 vials 0.1 g ea.	Cytidine-5-diphospho choline
	500 mg	Cytochrome-C, type III
	<1 kg	NEC-084H sodium acetuate-1-C (1 mCi C^{14})
	10 caps 25 mg ea.	Fast blue RR salt
	5 g	2-acetamido-2-deoxy-1,2,3,4-tetra--acetyl-b-diglueopyrabose
	0.1 g	Methyl palmitoleate
	3 vials, 1 g ea.	DL-isocitric lactone
	25 g	Tributyrin
	5 mL	Transaminase chem control sch.
	3 vials, 1 g ea.	N,N-Bis-(2-carboximidoethyl) tantarmide dimethyl estea dihydlicchloride

Date	Quantity	Chemical
03-09-82 (cont)	10 mg	Hemoglobin standard
	6 g	Bisdihydroxy phosphinyl
	10 g	Glyoxal bis(2 hydroxyanil)
	6 g	Eriochrome blue black
	15 gs	Spermidine
03-11-82	185 g powder	Nalco 66-B-619-5
	5 gal liquid	H-230 calgon biocide
	1 gal	Pozzalon 300
	25 lb dry	Bromocide
	250 g	Sterotex-K*
	70 lb	TURCO 4502
	110 lb	TURCO 4521
	300 lb	Nalclean-68* scale remover
	45 gal	Amerzine-TM-35* catalyzed hydrazine
	28 gal	Hydrazine 35% sonbed
	5 lb	Sample #3, Project #1086
	15 lb	Sample #1, Project #1086
	100 lb	Nalclean 68
	30 lb	Bromicide
	55 gal	Calgon CL-77
	4 gal	Rodine* 82A acid inhibitor
	44 lb	Calgon D-26 deposit inhibitor
	38 lb	Calgon H230 water microbiocide
	1 gal	Betz 403
	2 gal	Betz 403
	0.5 gal	35% hydrazine
	1 gal	Amerzine
	1 qt	Malco 310(B-6126)*
	3 qt	Calgon CL-162
	1 qt	Calgon CL-246
	1 pt	10% methylene Bis thiocyanate
	0.66 pt	Nalco 7323 (B-8118)
	0.66 pt	Nalco 7326 (B-8251)
	0.66 pt	Nalco 7326 (B-8264)
	0.13 pt	15% Amerzine
	0.25 pt	Nional
	3 15	CL-246
	1 pt	Biosperse-201*
	3 qt	CL-162
	1 qt	310-B-6126

Date	Quantity	Chemical
03-11-82 (cont)	1 qt	7328 B-8251
	1 qt	7326 B-8264
	1 pt	7323 B-8118
	1 pt	Methylene Bis thiocyanate 10%
	0.5 pt	Nional
	10 oz	Nalco 7324
	20 mL	Cat-Floc T*
	0.75 gal	Bentonite
	2 gal	Rodine 82-A
	25 mL	Amerzine
	1 gal	Pozzalon 300
	5 gal	D-26 inhibitor
	5 gal	H-230 biocide
	4 L	Betz 403
	2 gal	Rodine 82-A
	40 lb	TURCO 4502
	6 L	Betz 403
	80 lb (est.)	TURCO 4521
	30 lb (est.)	Oxalic acid
	250 g	Sterotex - K
	185 g	Nalco 66 B-169-5
04-15-82	1 gal	Jenny Coil Cond. Compound #80 (has hydrochloric acid)
	11 pt	Lactated Ringer's solution
	57 pt	Donnagel suspension
	67 tbe	Neosporin*-antibiotic
	12 box	Band-Aid*, butterfly
	16 tbe	Cordran .05%*
	7 box	Coricidin* tablets
	1 btl	Gantrisin* tablet
	3 btl	Medrol* tablets 4 mg
	16 tbe	Neo-Cortef* ointment 5%
	4 tbe	Neo-Cortef ointment 1%
	8 btl	Novahistine* L.P.
	1 btl	Apc Compound, tablets
	6 tbe	Polysporin* ointment
	5 ea	Ger-o-foam
04-29-82	1.5 lb	Ferric chloride
	2 lb	Carbon powder
	4 lb	Cesium chloride

Date	Quantity	Chemical
04-29-82 (cont)	1.5 lb	Cuprous chloride
	5 lb	Sodium dithionate
	4.25 lb	Calcium carbonate
	4.25 lb	Barium hydroxide
	1 lb	Aluminum nitrate
	2 lb	Barium nitrate
	2 lb	Stannous chloride
	1 lb	Lead acetate
	2 lb	Magnesium sulfate
	1 lb	Aluminum silicate
	1 lb	Sodium oxalate
	1 lb	Magnesium sulfate
	4 oz	Cobalt nitrate
	8 oz	Ammonium thiocyanate
	3 lb	Hydroxylamine hydrochloride
	1.25 lb	Sodium acetate
	0.5 g	Potassium chromate
	2 lb	Lithium hydrochloride
	1.5 oz	Mercuric nitrate
	1 lb	Potassium iodate
	1 lb	Potassium phosphate
	2 lb	Potassium chloride
	3 lb	Ammonium acetate
	10 oz	Cobalt nitrate
	2 lb	Calcium chloride
	4 oz	Barium chloride
	8 oz	Sodium bisulfite, meta
	1 pt	Carmine
	3 oz	Magnifloc
	4 oz	Aurintricarboxylic acid
	2 lb	8-Hydroxyquinoline
	5 lb	Potassium thiocyanate
	5 lb	Pyrogallic acid
	0.5 lb	Potassium acid phthalate
	8 oz	Boric acid
	1 lb	Salicylic acid
	8 oz	Anti foam 60
	3/8 lb	Dimethylgloxime
	1 lb	Hydrin-K*
	2 oz	Sodium cyanide
	2 lb	8-Hydroxyquinoline
	2.75 lb	Phenol

Date	Quantity	Chemical
04-29-82 (cont)	10 g	$C_5H_4NN:NC10H_6OH$ pan powder
	2 oz	Potassium ferrocyanide
	4 oz	Ammonium citrate dibasic
	12 oz	Aluminum
	1 kg	Sodium gluconate
	12 oz	Separan*
	4.5 lb	Sodium sulfate
	4.5 lb	Sodium phosphate
	5 lb	Sodium sulfite
	7 lb	Ammonium sulfate
	0.4 lb	Cuprous chloride
	8 pt	Perchloric acid
	4 pt	Formic acid
	1 pt	Zinc chloride
	2 pt	Carbon tetrachloride
	1 pt	Chloroform
	500 mL	Phenol carbolic acid
	0.75 kg	50% gluconic acid
	1 pt	Formaldehyde
	2 gal	Acid
	1 L	ORSAT solution
05-04-82	55 gal	Spent trichloroethyline absorbed in vermiculite
05-05-82	3 L (12 lb)	Perchloric acid
05-23-82	10 gal	Corrosive mixture
	500 gm	Kepone
	1 gal	Heaxane
05-27-82	1 pt	Dry 1,4-dioxane-diethylene oxide tec. grape
06-25-82	550 gal	Ferrous hydroxide (solid)
	30 gal	Chromic nitrate
	10 gal	Corrosive mixtures
	500 g	Kepone
	15 lb	Phosphoric acid
	1 gal	Hexane
	1 lb	Potassium cyanide
	1 lb	Sodium cyanide

Date	Quantity	Chemical
08-17-82	1 gal	Nitric acid
	1 gal	Glacial acetic acid
	1 gal	Hydrochloric acid
	1 gal	Chloroform
	4 lb	Ether
	1 L	Dimethyl formamide
	9 gal	Mixed solvents (Tetrahydrofuran, acetone, methylene chloride)
	50 lb	Mercury-concreted
	13 gal	Benzene-concreted
	3 gal	Mixed carcinogens-concreted

Table B-7. Trench 34

Date	Quantity	Chemical
11-08-75	48,875 lb	DECON-4306c (TURCO)
11-13-75	3-55 gal overpacks	Lab pack of misc. small quantity laboratory chemicals
12-11-75	2 yds	Battery acid contaminated soil
	50 lbs in a 55 gal overpack	Lab pack of misc. small quantity laboratory chemicals
	(8) jars	unknown liquids
	100 ml	phenyl isocyanate
	1 jar	2,7,Dichlorofloresceine spray reagent
	1 plastic	NHy MB
	21,600 ml	Solvent extracts
	10 L	Scintilation vials
	12 chunks	Sediment
	100 vials	Unknown
	1 L	Formamide liquid
	1 L	Hydrochloric acid in metal container
	15 lb	Phosphorous pentoxide (granular)
	13.0 lb	Aluminum (powder)
	1.0 lb	Calcium chloride
	1.0 lb	Soda lime
	19.0 lb	Phosphoric acid (granular)
	11.0 lb	Sodium oxalate
	0.8 lb	Pentasodium diethylenetriamine pentaacetate
	0.5 lb	Ethylenediaminetetraacetic acid
	2.5 lb	Oxalic acid (granular)
	1.0 lb	Manganous sulfate
	0.75 lb	Magnesium sulfate (anhydrous)
	25.0 lb	Silica gel
	4.0 lb	Sodium carbonate
	1.0 lb	Acridine
	1.0 lb	8-Quinolinol
	0.1 lb	8-Hydroxy-7-iodo-5-quinoline sulfonic acid
	0.5 lb	Sulfamic acid
	0.75 lb	Magnesium oxide
	0.75 lb	Potassium dichromate
	1.0 lb	Potassium iodide
	3.0 lb	Potassium permanganate
	0.5 lb	Thenoxitrifluoracetone
	1.0 lb	Calcium carbonate
	0.25 lb	Phosphorous acid (granular)

Date	Quantity	Chemical
12-11-75 (cont)	10.0 lb	Unknown liquid
	0.1 lb	Unknown liquid
	1 gal	Electrolyte
	2 gal	Crude sludge
	4 bottles	Crude oil
12-22-75	55 gal	Trichloroethylene
01-05-76	1,400 gal	Septic tank sludge
04-76	3 lb	Bromo-napthalene
	5 gal	Carbon tetrachloride
04-21-76	25-55 gal drums	Sodium oxide film on scrap metal
05-76	6 lbs	Hydrochloric acid 37%
	7 lbs	Nitric acid 70%
05-01-76	3 lbs	Bromo-naphthalene
	5 gal	Carbon tetrachloride
05-19-76	250 g	Acid aminonaphinol-sulfonic
	0.5 lb	Aluminum sulfate
	50 g	1-Amino-2-napthol-4-sulfonic acid
	50 g	Ammonium acetate
	200 g	Ammonium formate
	0.5 lb	Ammonium phosphate-dibasic
	500 g	Amonium sulfamate
	100 g	Aniline hydrochloride
	100 g	p-Bromaniline
	70 g	Brucine sulfate
	0.5 lb	Calcium nitrate
	50 g	Chloroanilic acid
	25 g	DL-Citrulline
		p-Dimethylamino benzaldehyde
	500 g	Ethylenediamine dihydrochloride
	50 g	1-Hydroxy-2-acetonapthone
	400 g	1-Hydroxy-2-napthoic acid
	0.5 lb	Lithium nitrate crystal
	0.5 lb	Lloyd reagent alkaloid
	1 lb	Magnesium nitrate
	0.5 lb	Manganous sulfate

Date	Quantity	Chemical
05-19-76 (cont)	100 g	Napthol
	100 g	p-Nitroaniline
	0.25 lb	Phenyl mercury chloride
	0.25 lb	Potassium citrate
	1 oz	Quinidine sulfate
	0.5 lb	Rosin
	0.5 lb	Sodium bromide
	0.25 lb	Sodium formate
	2 0.5 lb	Sodium molybdate
	200 g	Succinic acid disodium salt
	g	Sulfosalicylic acid
	5 g	Triketohydrindene hydrate
	2 g	Tripyridine
	100 g	2,4-D
	0.25 lb	Ferric chloride
	100 g	1-10-(ortho) phenanthralin monohydrate
	250 g	p-Toluene sulfonic acid
06-24-76	100 lbs	Paraffin
07-76	500 g	Cyclopentane
07-12-76	100 lbs	Cadmium nitrate solution 50% contaminate cleanup items
08-20-76	10 gal	Foam concentrate
	120 lb	Butvar BR 50%
	10 gal	Pluconic acid
	55 gal	Versenex 80
	100 lb	Sodium cluconate
	10 gal	Rodine #214
	2 L	Rodine #92-A
	10 lb	Methyl violet
	15 lb	Oil blue A (dye)
	1.5 gal	Zef-pure
	5 lb	Fire-sord
	7 gal	Petrogon
09-76	500 lbs	Sodium oxide contaminated shipping containers
	10 g	Mercury
	110 gal	TURCO 4521

Date	Quantity	Chemical
09-76 (cont)	2,500 lb	TURCO 4521
	430 lb	Sodium carbonate
	10 gal	Rodine #214
	55 gal	Hi-EX foam
10-28-76	300 lbs	Sodium hudroxide
	55 gal	TURCO fabrifilm
	55 gal	TURCO 430GC
	100 lbs	TURCO 430GB
	1,700 lbs	TURCO 430GD
	1,300 lbs	Sodium sulfate, borax sweepings
	800 lbs	Sodium persulfate sweepings
	600 lbs	Sodium sulfite sweepings
10-29-76	173 gal	Misc. paint
	1 pt	Epoxy hardener
12-76	10 L	Hydrazine solution depleted
	630 lbs	Poly-vinyl sulfonated Benzene cation exchange Resion
12-15-76	55 gal	Dibutyl carbitol
01-03-77	25 g	1,3,5-Trinitrobenzene mixed with 100 parts sand
02-07-77	0.75 gal	2,4-D dilute
	50 L	Coal tar/water
02-10-77	990 gals	Toluene/Isopropyl 50/50
02-11-77	30 lb	Sodium oxide waste
03-77	30 L	Unknown organics
	55 gal	Tetrachloroethylene 90% ethylene glycol 10%
03-29-77	3 lbs	Potassium permanganaate
	10 lbs	Sodium hydroxide
	5 lbs	Nickel chloride
	5 lbs	Nickel sulfate
	1 lb	Collodion flexible

Date	Quantity	Chemical
03-29-77 (cont)	1 lb	Sodium phosphate
	1 lb	Sodium borate
	1 lb	Boric acid
	1 lb	Cuprous cyanide
	6 lbs	Cupric sulfate
	1 lb	Lithium fluoride
	1 lb	Aluminum chloride
	1 lb	Lithium carbonate
	1 lb	Sodium fluoride
	13 cans	Spray paint (pressurized)
	1 pt	Dow Corning* fluid 200
	1/3 gal	Paper cement
	1 qt	Dowanol*
	3.05 gal	2-propanol
	6 lbs	Calcium carbonate
	0.25 pt	Unknown
	1 lb	Sodium cyanide
	1 pt	Dimethyl formamide
	1 qt	Cyclohexane
	4 pt	Ethylene dichloride
	1 gal	Carboline thinner 2J
	2 oz	Fine sulphide
	1 qt	Mineral oil
	1 pt	Chloroform
	1 pt	Collodion
	1 pt	Ethylene glycol
	1 pt	Diethylene glycol
	6 pt	Butyl alcohol
	14 pt	Benzene
04-77	165 gal	Paint/solvent
	0.2 kg	Hydrochloric acid gas
	1.4 kg	Hydrobromic acid gas
04-19-77	NA	Sodium oxide contaminated equipment including two 2-inch valves and one 6-inch-diameter and 18-inch-long tank
04-24-77	26 gal	Liquid penetrants
05-77	40 lb	Ion-exchange cleaner
	100 lb	Sodium phosphate tribasic

Date	Quantity	Chemical
05-77 (cont)	100 lb	Scale cleaner
	10 lb	Caustic
	50 lb	Nitrogen fertilizer
	4 gal	Alfa bromonaphthalene
05-04-77	40 lb	Amberlyst A-26* anion strong base resin
06-77	5 gal	Unknown liquid
06-06-77	48 ft^3	Sodium oxide contaminated pipe
06-15-77	5 gal	Phenoline 300 catalyst
06-22-77	5 gal	Phenoline 300 catalyst
	3 lb	Bird-X
08-77	7.2 kg	Cupric oxide
	4.5 kg	Ferric oxide
	36.3 kg	Ferric oxide
09-30-77	30 lb	Dimethylsalf oxide (DMSO)
10-12-77	Small quantity less than 1 lb	Litharige lead monoxide
		Cobaltous nitrate
		Potassium nitrate
		Sodium nitrate
		Sodium cobaltous nitrate
		Nickelous nitrate
		Zirconium nitrate
		Zinc oxide
		Sodium molybdate
		Trisodium phosphate
		Black ferric oxide
		Red ferric oxide
		Ferric chloride
		Ferric oxide
		Cupric oxide
		Sodium phosphate
		Tin metal
		Lead
		Strontium chloride
		Sodium peroxide

Date	Quantity	Chemical
10-12-77 (cont)		Potassium chloride Magnesium metal
10-19-77	110 gal 20 gal	Solvent refined coal and solvent Waste oil/solvents
10-31-77	10 ft^3	Oil shale (rock)
11-11-77	8 oz 500 lbs 12 kg	Beryllium metal Concreted carcinogen (benzene, pyrene) Mercury in solution with hydrochloric acid, sodium chloride and organics
12-01-77	3 gal	Organic solvents--methyl isobutyl ketone, benzene, pyridine, carbondisulfide, pesticides and beryllium
12-12-77	540 lbs	Sodium oxide contaminated equipment
01-78	30 gal 15 gal 2.5 gal	Boiler treatment solution NINALK B acid Produce #135 (contains chromate)
02-15-78	55 gal 55 gal 100 lb 100 lb 5 gal 5 gal 100 gal 18 L 1 L 4 L 3 L 2 L 1 500 ml 1 L 1 L 250 ml 250 ml	Aluminum nitrate DTPA Sodium nitrate Sairset bonding mortar Manganese nitrate Sodium silicate Ferric nitrate DTPA Unknown solution HEDTA-hydroxyethylethylenediametriacetic acid 100% TBA NPH 15% Aliquot 336/xylene 5% Aliquot 336/chloroform 30% Aliquot 336/xylene DI (secondary-butyl) phenol phosphonate 5% TOPO/cyclohexane 1.3 m HDEHP/cyclohexane

Date	Quantity	Chemical
02-15-78 (cont)	200 ml	30% DI (secondary butyl) phenol phosphonate/xylene
	150 ml	100% Di butyl N,N-diethylcarbamoyl-phosphonate
	500 ml	Chloroform
	250 ml	5% TOPO/cyclohexane
	130 ml	D_2 EHPA
	150 ml	Hexone
	400 ml	.1m TOPO/cyclohexane
	400 ml	15% Aliquot 336/xylene
	200 ml	30% Aliquot 336/xylene
	500 ml	Soap i isopropano
	500 ml	Cyclohexane
	500 ml	Hexone
	700 ml	Nitroethane
	300 ml	Chevron dispersant NI-W*
	100 ml	.05 M Br-PADAP/hexanol
	100 mt	.05 M BR-PADAP/cyclohexane
	3 L	HOPPES #9 solvent
	1 lb	Barium perchlorate
	2 oz	Zirconyl nitrate
	36 oz	Mercuric nitrate
	0.75 lb	Silver nitrate
	1 lb	Lead nitrate
	2 lb	Lead dioxide
	2 lb	Larnthanium nitrate
	2.5 lb	Mercuric nitrate
	1 lb	Magnesium perchlorate
	5 lb	Sodium perchlorate
	5 lb	Phosphorous pentoxide
	1 lb	Potassium oxalate
	2 lb	Larthanum nitrate crystals
	1 lb	Sodium bisulfate
	1 lb	Graphite powder
	0.25 lb	Lithium fluoride
	5 g	Ferric sulfate
	1 lb	Potassium bromide
	100 g	Reinecke salt $NH_4(Cr(NH_3)_2(SCH))\cdot H_2O$
	4 oz	Sodium stearate
	6 lb	Sodium sulfate, anhydrous
	0.25 lb	Turgatic anhydride
	1 lb	Sodium silicate
	1 lb	Potassium carbonate

Date	Quantity	Chemical
02-15-78 (cont)	5 g	Hexachloric dihydrager platinum IV
	1 gal	Ferric sulfate
	10 lb	Cresco sulphur
	1 lb	Iron chip accelerator
	1 lb	Potassium ferrocyanide
	1 lb	Lithium hydroxide, anhydrous
	1 lb	Sodium hydrochlorite
	1 lb	Potassium fluoride
	10 g	Zinc sulfate
	25 g	Zinc sulfide
	4 oz	Mercuric chloride
	10 g	Meta sodium bisulfate
	1 lb	Sulfamic acid
	10 g	Sodium tetra borate
	10 g	Magnesium chloride
	10 g	Nickel sulfate
	25 g	Sodium perchlorate
	50 g	Black K salt (Nation Anvine Divison)
	25 g	Potassium ferricyanide
	0.25 lb	Lithium chloride
	100 g	Sodium azide
	100 g	Nitroso R salt
	250 ml	Hydroxylamine hydrochloride
	0.5 lb	Manganous chloride
	2 lb	Manganous chloride
	6 pt	Ceric ammonium, sulfate (0.04N)
	1 pt	Titanium trichloride
	10 g	Phenol red
	0.5 lb	TTA
	1 lb	Hydroquinone
	100 g	2,5-Diphenyl oxazole
	25 g	1,5-Diphenyl carbohydrazide
	10 g	Cholesteryl escuate
	5 g	Glyoxol-bis (2-hydroxyanil)
	15 ml	Benzalkorium CL(zephiron), 2.8% (rexall phum.)
	100 g	Dodecyl alcohol
	100 g	4,5-Dihydroxyl-3-(p-sulfophenylazo)-3,7-napthalene disulfonic acid in sodium salt
	5 g	Bis (1-phenyl-1,3-butaine dicro)copper
	10 g	N-phenrylberzo hydroxamis acid
	160 oz	1,10-pherathrolie ferrous sulfate, solution (ferrous)

Date	Quantity	Chemical
02-15-78 (cont)	5 g	Aluminum (2-ethylhexaroate)
	100 g	1-Nitroso-1-naphthol
	10 g	6-Methyl-2,4-heptanedione
	1 lb	Ammonium sulfide
	1 lb	Aerosol OT solution, 25% (Verwalters & Rogers)
	5 g	Nickel cyclohexane butyrate
	10 lb	Trilauryl testing amine (alamine 304)
	250 ml	2-Ethylhexylamine
	500 g	o-Aminophenol
	1 kg	Di-N-butyl phosphate
	5 g	Tris (-phenyl-1,3-butanedione) iron
	2 g	Bathopherzathroline, sulfonated, sodium salt
	2 g	Thymol blue indicator
	10 g	Hematoxylin.
	5 g	2-Napthylamine
	40 g	Bromothymol blue
	20 g	Methyl violet 2B
	10 g	Diphenylthiocasbazone
	25 g	2,4-Dimethyl pharol
	10 g	Cargo red
	1 pt	Kad fisdur reagent
	25 g	1-Nitroso-2-napthol-3,6-disulfours acid disodium salt
	25 g	1-Pyfolidine carbonithior acid, ammonium salt
	5 g	POPOP 1,4-bis (2-(5-phenyloxazolyl))-benzene
	25 g	Premix 'P' 2% POPOP; 98% PPO(PPO-aphenoazide)
	20 g	Methyl red
	100 g	Trioctylphosphine oxide
	10 g	Oxime
	100 g	Sulfosalicylic acid
	4 oz	Potassium biphthalate
	21 g	CDTA (1,2-cyolohexylene-dinitirile)-tetraacetric acid
	10 g	Potassium fluoride
	200 g	Amadac-F (Besdiet/Jackson Laboratories)
	1 pt	'Aerosol' OT clear, 25% (American Cyanimid Co.)
	1 oz	Methyl red
	1 lb	Anion exchange resin (chloride form)
	20 g	Dithizone
	50 g	Petrol black 'A'
	12 pt	Ehrlich reagent solution (p-dimethylamino benaldehyde)

Date	Quantity	Chemical
02-15-78 (cont)	1 lb	Silica powder
	250 ml	Collodion in ethylether
	14 pt	Formaldehyde
	1 pt	Benzene
	1 gal	Special thinner #92 (alcohol derivative)
	1 L	Chclohexane
	1 gal	N-butyl acetate
	1 gal	Ketone
	250 ml	24.7% Aromatic solvent
		30.0% M-purol
		25.0% O-dichlorobenzene
		12.5 % Crysylic acid
		5.0% Monoethandamine
		2.8% Igepal* CO 210% by volume
	1 kg	Butylacetate
	5 pt	Carbon tetrachloride
	600 ml	Organic gelatin & dye
	1 gal	Flammable organic
	4 gal	Ammonia
02-24-78	4 gal	Ammonia
03-78	30 gal	TURCO DESEN IT II
	40 lb	Microdoiocide
06-01-78	110 gal	Sulfamic acid
03-09-79	30 lb (6 gal)	Hydrofluoric acid
	30 lb (15 L)	Hydriodic acid
03-27-79	5 gal	Sodium hydroxide
	4 gal	Ammonium hydroxide
	10 gal	Chloroform, hexane, tetrahydrofuran acetone
	6 gal	Carbon tetrachloride, hexane, tetrahydrofuran
	1 L	Phosphorous pentoxide
04-23-79	55 gal drum	Methyl ethyl ketone, mineral spirits and absorbent
06-08-79	600 ml	Benzene

Date	Quantity	Chemical
07-19-79	55 gal drum with absorbent & individual containers	Flammable organic solvents
		Corrosive liquid
		Ammonia
		Phosphoric acid (1.5 gal)
		Epoxy resin (1 gal)
		Catalyst (1 qt)
		Xylene (2 qt)
		Fixing agent (2.25 gal)
		'Photo resist' (2 qt)
07-24-79	4 L	Dibromobutane
	3 qt	Dibutyl phthalate
	1 kg	Dichloromethane
	75 g	2-Methylamino ethanol
	1 L	.1M TTA, 0.01M tributyl phosphate in hexane
	1 lb	Aquafluor
	1 qt	White oil (mineral oil)
	2 lb	Glycerine
	1 gal	Glycerine
	500 g	2,4-Pentane.
	4 kg	2,6-Dimethyl-4-heptanol
	5 pt	Triethanolamine
	2 L	Isooctane
	12 kg	2,2,4-Trimethyl pentane
	11 pt	Amyl acetate
	4 qt	Isoamyl acetate
	19 pt	Cylohexanone
	30 pt	Carbon tetrachloride
	24 pt	Carbon tetrachloride
	5 gal	Ethylene glycol monoethyl ether
	45 pt	Xylene
	15 pt	Isoamyl alcohol
	500 g	Bis(2-ethoxyethyl) ether
	645 g	Bis(2-ethylhexyl) hydrogen phosphate
	10 pt	Ethyl acetate
	9 pt	Bromobenzene
	12 pt	Butyl alcohol
	5 pt	Pyridine
	4 kg	Nitrobenzene
	5 pt	Chloroform
	24 pt	Chloroform
	3 pt	Petroleum ether

Date	Quantity	Chemical
07-24-79 (cont)	10 pt	Isopropyl ether
	5 gal	Heptane
	1 gal	Butyl cellosolve
	16 pt	Hexanol
	1 gal	Salicylaldehyde
	5 gal	Transformer oil
	1 gal	Flammable liquid NOS
	18 lb	Hydrofluoric acid
	1 gal	Freon*
08-28-79	25 lb	Ammonium hydroxide
	8 lb	Hydrogen peroxide
	0.75 gal	Dimethyl formamide
	0.66 gal	Heptane
	1 gal	Formaldehyde
	1 gal	Acetonitrile
	0.75 gal	Dichloroethane
	1 gal	Butyl ethyl acetate
	5 pt	Carbon tetrachloride
	0.5 gal	Methanol
	0.75 gal	Propanol
	4 lb	Glacial acetic acid
	13 lb	Sulfuric acid
	6 lb	Hydrochloric acid
	20 lb	Oxalic acid
	30 lb	Potassium hydroxide
09-11-79	4 gal	Petroleum ether, hexane, benzene, pyridine, pesticide, beryllium
10-25-79	5 gal	Cine 2 reversal bleach solution developer reprenisher
11-28-79	2-5 gal cans	Mixed liquid carcinogens (benzene, benzyl-para-aminophenol, etc.) absorbed into Discasorb, placed into 5-gallon cans and concreted into 55-gallon drums
	125 lb	Mercury with 'discasorb'
03-05-80	6 pt	Isoamyl alcohol
	500 ml	50% Isoamyl alcohol

Date	Quantity	Chemical
03-05-80 (cont)	2 L	Isooctane
	2 kg	Mesityl oxide
	4 kg	Triethanolamine
	2 kg	Nitrobenzene
	4 pt	Nitrobenzene
	16 oz	Phenol reagent
	500 g	Propylene carbonate
	9 pt	Pyridine
	1 L	1 g/L Rhodium
	5 kg	1,1,2,2-tetra-bromo-ethane
	1 kg	Tetrahydrofuran
	16 pt	Trichloro-ethylene
	2 bottles	Triisooctylamine
	4 L	2,2,4-Trimethyl pentane
	8 pt	Tri-n-octylamine
	2 pt	Octyl alcohol
	3 lb	Cadmium
	3 oz	Cadmium nitrate
	1 lb	Cadmium chloride
	5 lb	Cryolite
	5 lb	Calcium hydroxide
	500 g	2-(2-hydroxyl-1-naphtylazo)-2-naphthol-4-sulfonic acid zinc salt
	9 oz	Iodine
	750 g	Hydroxylamine sulfate
	500 g	Hydrazine sulfate
	2 lb	Lead nitrate
	4 lb	Iron metal wire
	1 lb	Magnesium acetate
	0.25 lb	Lead iodide
	1 lb	lead chloride
	0.5 lb	Lithium aluminum oxide
	1 lb	Magnesium chloride
	0.25 lb	Manganous chloride
	25 g	2-Mercaptobenzathiazole
	10 g	2-Mercapto-N-2-naphthylacetamide
	0.25 lb	Mercuric oxide red
	10 g	3-Methylindole
	100 g	3-Methyl-1-phenyl-2-pyrazoline-5-one
	200 g	1-Naphthylamine hydrochloride

Date	Quantity	Chemical
03-05-80 (cont)	100 g	1-Naphthalamine
	5 g	di-β-naphthylthiocarbazone
	4 oz	Nickelous sulfate
	0.25 lb	Nickelous nitrate
	4 oz	Nickel metal powder
	4 oz	Oxalic acid
	200 g	Pararosaniline hydrochloride
	25 g	3.3'-dimethyl-1,1'-diphenyl [4,4'-bi-2-pyrazoline]-5,5'-dione]
	25 g	Phenylazoaniline
	3 lb	Potassium carbonate
	0.25 lb	Potassium bromate
	1 lb	Potassium chlorate
	25 g	Potassium dithio-oxalate
	100 g	Potassium ferrocyanide
	0.25 lb	Potassium chloride
	1 lb	Potassium biohydrate
	1 lb	Potassium ferricyanide
	1 lb	Potassium nitrate
	0.25 lb	Potassium periodate
	1 lb	Potassium phosphate dibasic
	2 lb	Potassium phosphate monobasic
	2.25 lb	Potassium sodium tartrate
	1 oz	Quinine sulfate
	10 g	Quinalizarin
	1 lb	Pumice
	100 g	8-Quinolinol
	1 lb	Potassium sulfate
	1 lb	Potassium thiocyanate
	4 oz	Pyrogallic acid
	0.25 lb	Silver nitrate
	0.25 lb	Saponin
	0.25 lb	Sequestrene NA2*
	1 lb	Sodium arsenate
	2.25 lb	Potassium sodium tartrate
	1 oz	Quinine sulfate
	10 g	Quinalizarin
	1 lb	Pumice
	100 g	8-Quinolinol
	1 lb	Potassium sulfate
	1 lb	Potassium thiocyanate
	4 oz	Pyrogallic acid

Date	Quantity	Chemical
03-05-80 (cont)	0.25 lb	Silver nitrate
	0.25 lb	Saponin
	0.25 lb	Sequestrene NA2
	1 lb	Sodium arsenate
	0.25 lb	Sodium bismuthate
	0.25 lb	Sodium cyanide
	3 lb	Sodium dichromate
	100 g	Sodium diethyldithiocarbamate
	2 lb	Sodium dithionate
	1 kg	Sodium formaldehyde bisulfite
	2 lb	Sodium formate
	1 lb	Soda lime
	4 oz	Sodium oxalate
	1 lb	Sodium nitrite
	1 lb	Sodium phosphate tribasic
	1 lb	Sodium phosphate tera
	1 lb	Sodium sulfide
	4 oz	Strontium bromide
	4 oz	Strontium carbonate
	4 oz	Strontium hydroxide
	2 lb	Stannous sulfate
	2 lb	Sulfur
	10 lb	Sulfanilic acid
	700 g	N-1-naphthylethylenediamine dihydrochloride
	5 lb	Sodium sulfite
	0.25 lb	Strontium nitrate
	1 g	Thymolsulfonephthalein
	1 g	Tartaric acid
	1 g	Tetrahydroxyquinone
	1 lb	Thymol
	1 lb	o-Toluidine
	4 oz	Zinc
	3 oz	Calcium nitrate
	3 lb	Calcium chloride
	1.25 lb	Chromium potassium sulfate
	2 lb	Chromium trioxide
	1 lb	Copper turnings
	1 lb	Cobalt chloride
	0.25 lb	Cobalt nitrate
	1 lb	Cobalt sulfate
	4 oz	Cupric nitrate

Date	Quantity	Chemical
03-05-80 (cont)	4 oz	Cupferron
	5 lb	Ceric sulfate
	1 lb	Talc
	1 lb	Magnesium turnings
	6 lb	Potassium dichromate
	2 lb	Dextrose
	100 g	Diazole
	25 g	1,8-dihydrosynaphthalene-, 6-disulfonic acid
	200 g	M-dinitrobenzene
	45 g	Diphenylthiocarbazone
	1 lb	Ethylenediamine tetraacetic acid
	1 lb	Ferric nitrate
	1 lb	Ferrous sulfide
	100 g	Fluorescein disodium salt
	2 lb	Gelatin
	500 g	L-(t)-Glutamic acid
	1 lb	Zinc sulfate
	1 lb	Zinc oxide
	2 lb	Zinc acetate
	1 lb	Zinc chloride
	1 lb	zinc nitrate
	1 oz	Zirconium chloride
	500 g	Zirconyl chloride
	1 oz	Zirconyl nitrate
	100 g	Acetyl choline chloride
	1 lb	Aluminum chloride
	1.5 lb	Aluminum sulfate
	6 oz	Asbestos
	0.5 lb	Agar agar
	2 oz	Ammonium chromate
	4 oz	Ammonium iodide
	0.25 lb	Ammonium oxalate
	4 oz	Ammonium phosphate
	2 lb	Ammonium thiocyanate
	4 oz	Arsenic trioxide
	4 oz	Arsenic acid
	5 lb	Ammonium persufate
	0.25 lb	Barium hydroxide
	1 lb	Barium nitrate
	0.5 lb	Beryllium sulfate
03-15-80	500 g	Acetonitrile

Date	Quantity	Chemical
03-15-80 (cont)	3 pt	Aniline
	1 pt	Ammonium sulfide
	1 kg	2-Butoxyethyl acetate
	1 kg	Butyl acetate
	500 ml	N-butyl acetate
	500 g	Butylamine
	1 kg	o-Dichlorobenzene
	250 g	2-Dimethylamino ethanol
	100 g	n,n-Dimethyl-1-naphthylame
	2 pt	Dimethylsulfoxide
	1 pt	1,4 Dioxane
	2 pt	Ethylene glycol
	500 g	Formamide
	2 pt	1 Hexanol
04-10-80	0.4 lb	Benzene reagent
04-15-80	5 lb	Glycerol
	10 lb	Hydrogen peroxide
	20 lb	Mercury - double contained + concrete
	2 oz	Methanol
	6 oz	D-tartaric acid
	10 g	Dimethyl amino ethanol
	3 qt	Ethylene glycol
	4 lb	Easy Off* oven cleaner
	1.5 gal	OSPHO acid metal prepcint conditioner
	1 pt	68% Ammonium nitrate monohydrate
	1 gal	potassium-permanganate
	1 pt	25% Oxalic acid
	0.5 pt	Sodium hydroxide
	1 gal	Glycerol
	0.5 pt	Murokami etchart
	0.13 pt	Nitric acid, hydrofluoric acid, water
	0.5 pt	20% Acetic acid, water
	0.25 pt	Kellign's reagent
	0.25 pt	Nitric acid, hydrofluoric acid, water
	1 pt	Liquid paraffin
	1 gal	Diethylene glycol monoethyl ether
	1 qt	Norcune 3416
	2 gal	Hypersol lubricant
	3 cans	OS lubricant
	2 qt	Hypalube 'Hyprez'*

Date	Quantity	Chemical
04-15-80 (cont)	1 pt	1% Chromium trioxide
	1 qt	2% Chromium trioxide
	0.5 pt	25% Sodium hydroxide
	0.5 pt	10% Oxalic
	2 glass containers	Ballards triple-distilled mercury
	1 lb	Magnesium oxide
	14 lb	Fluorochemical inert
	2 lb	Cupric sulfate
	1 gal	Dimethyl phosphate
	1 lb	Dimethylformamide
	4 gal	Zinc bromide
	2 lb	Ammonium citrate dibasic
	4 lb	Aluminum oxide
	1 lb	Aluminum metal
	6 lb	Aluminum nitrate
	5 lb	Ammonium persulfate
	3 lb	Acid citric
	1 lb	Ammonium fluoride
	1 lb	Cesium nitrate
	1 lb	Copper metal
	1 lb	Cupric chloride
	2 lb	Chromium oxide
	9 lb	Chromium trioxide
	8 lb	Cupric sulfate
	4 lb	Disodium dihydrogen ethylene diaminetetracetate dihydrate
	2 lb	Ferric chloride
	4 oz	$Fe(NO_3)_3$
	1 oz	Fluorescein sodium
	2 lb	Iron metal
	6 lb	Lead metal
	4 lb	Mercuric nitrate
	10 lb	Oxalic acid dihydrate
	4 lb	Magnesium permanganate
	4 lb	Potassium permanganate
	4 lb	Potassium ferricyanide
	1 lb	Potassium thiocyanate
	5 lb	Sodium sulfite anhydrous
	0.25 lb	Sodium iodide
	1.25 lb	Sodium metabisulfite
	4 oz	Sodium cyanide

Date	Quantity	Chemical
04-15-80 (cont)	3 lb	Sodium dichromate
	44 lb	Sodium nitrite
	5 lb	Calcium sulfate
	100 gms	Diclycidl ether of polypropylene glycol
	1 lb	Magnesium oxide
04-25-80	3 plastic jars in 5 gal metal drums	Paraquat
	2 glass containers	Ballard's mercury triple distilled
05-07-80	1,500-1,700 gal	Dilute 2,4-D amine
05-14-80	15 gal (90 lb)	Dow Corning 710 silicone fluid mixed with 'Dry Floor': stiff paste
06-04-80	2 L	Hydrochloric acid
	1 gal	Carbon tetrachloride
	1 gal	Unknown resin
	3 L	Formamide
	5 oz	Methylene iodide
	200 ml	Mercury
	10 gal	Liquid heat mixture: 52.5% $BaCl_2$, 14.2% NaCl, 33.3% KCl
	9 L	Rhodium
	2 gal	Chromium compounds
	1 qt	Potassium gold cyanide
06-17-80	72 pkg (100 lb)	Neomycin sulfate antibiotic
	16 plastic containers 1 in. x 3 in.	Lactated ringer solution
	15 gal (130 lb)	Calcium hypochlorite liquid
	60 gal (500 lb)	Yellow dye

Date	Quantity	Chemical
06-17-80 (cont)	132 jars 11 lbs each	Sodium dithionite
	100 lbs	Oxalic acid
07-30-80	1 L (4 lb)	Lead perchlorate perchloric acid

Table B-8. Trademark Information

*The following are registered trademarks or trade names.
Altrex is a trademark of Diversey Wyandotte Corporation
Amberlyst is a trademark of Rohm & Hass
Amerzine is a trademark of Ashland Chemical Co.
Aropol is a trademark of Archer Daniels Midland Company
Band-Aid is a trademark of Johnson & Johnson
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Madribon is a trademark of Roche Laboratories
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Trademarks (cont)
Medrol is a trademark of the Upjohn Company
Monoplex is a trademark of C.P. Hall Company
Nalclean is a trademark of Nalco Chemical Company
Nalco is a trademark of Nalco Chemical Co.
Neo-Cortef is a trademark of the Upjohn Company
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Separan is a trademark of Dow Chemical Company
Sequestrene is a trademark of Ciba-Geigy Corporation
Sterotex is a trademark of Capital City Products Company
Teflon is a trademark of E.I. DuPont de Nemours
Tordon is a trademark of Dow Chemical Company
Tri-Sil is a trademark of Pierce Chemical Company
TURCO is a trademark of Turco Products Incorporated
Versenex is a trademark of Dow Chemical Company
Versenol is a trademark of Dow Chemical Company
Zeokarb is a trademark of J.M. Huber Corporation
Zincon is a trademark of La Motte Chemical Products Company

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B4 References

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Appendix C

Reprint of 91-EAB-078, *Report on the Excavation and Inventory of Trench 19N at the Nonradioactive Dangerous Waste Landfill, Hanford Site*

Published April 1991

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Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

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91-EAB-078

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CORRESPONDENCE CONTROL

Mr. Paul T. Day
Hanford Project Manager
U.S. Environmental Protection Agency
Region 10
712 Swift Boulevard, Suite 5
MSIN: B5-01
Richland, Washington 99352

Mr. Timothy L. Nord
Hanford Project Manager
State of Washington
Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504-8711

Dear Messrs. Day and Nord:

REPORT ON THE EXCAVATION AND INVENTORY OF TRENCH 19N AT THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL, HANFORD SITE

The enclosed report and Chemical Waste Inventory are being forwarded to the U.S. Environmental Protection Agency and the State of Washington Department of Ecology, in accordance with agreements made at the February 14, 1991, Unit Managers' Meeting.

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91-EAB-078

Messrs. Day and Nord -2- APR 25 1991

If you have questions regarding these documents, please contact Ms. S. L. Trine of the U.S. Department of Energy, Richland Operations Office on (509) 376-6943, or Ms. C. J. Geier of the Westinghouse Hanford Company on (509) 376-2237.

Sincerely,

E A Bracken

E. A. Bracken, Director
Environmental Restoration Division
Richland Operations Office

ERD:SLT

R E Lerch

R. E. Lerch, Manager
Environmental Division
Westinghouse Hanford Company

Enclosure:
Excavation Report/Chemical Waste Inventory

cc w/o encl.:
D. L. Duncan, EPA
R. E. Lerch, WHC
P. Stasch, Ecology, w/encl.

REPORT ON THE EXCAVATION AND INVENTORY OF TRENCH 19N AT THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL, HANFORD SITE

INTRODUCTION

The Nonradioactive Dangerous Waste Landfill (NRDWL) is an isolated, operationally closed, land disposal unit located near the geographic center of the Hanford Site in the 600 Area. The landfill received nonradioactive dangerous chemicals regulated under WAC 173-303 in six trenches from 1975 through May 1985. On November 8, 1985, one of the six chemical trenches (Figure 1), designated 19N, was excavated to retrieve several drums containing regulated dangerous waste.

The purpose of this paper is to document the November 8, 1985 Trench 19N excavation activity in response to an action item identified during the January 15, 1991 Unit Managers Meeting for the NRDWL. Specifically, this paper describes the excavation process and conditions encountered during the retrieval process, and reconciles pre- and post-excavation inventories. Information concerning the excavation process was acquired from interviews with Hanford Site personnel that were directly involved with the activity.

DESCRIPTION OF THE TRENCH 19N EXCAVATION ACTIVITY

Background Information

A 150-foot section of Trench 19N was opened in March 1984 to dispose of oxidizer chemicals. The trench was approximately 14 feet deep and 16 feet wide at the base. An access ramp on the south end of the trench allowed transfer vehicles to access the working face. An 8- to 12-inch layer of cobble/gravel was placed over the bottom of the trench to form a temporary roadbed. A representative cross section of the trench is shown in Figure 2.

Trench 19N received its first shipment of waste in April 1984 consisting of nonregulated empty containers. The first receipt of chemical waste occurred in June 1984. A total of 4 shipments of chemical waste where placed in Trench 19N, the last of which was received in May 1985. The trench also received 7 shipments of empty containers not regulated under WAC 173-303. Each shipment of waste was catalogued using a disposal request number. All containers disposed of in Trench 19N were covered by an approximately 10-foot thick operational cover consisting of local sand.

On November 8, 1985, Trench 19N was excavated to retrieve drums containing sodium nitrite which had been mistakenly disposed of in the trench. Sodium nitrite which is designated as an extremely hazardous waste was prohibited from being disposed of in the NRDWL. In the process of retrieving the sodium nitrite drums, all other waste containers that were disposed of in Trench 19N also were removed. Approximately 120 feet of available trench space had been filled prior to the Trench 19N excavation activity.

OPEN 1-76	SANITARY TRASH	CLOSED 9-76	1N
OPEN 5-85	ASBESTOS	CLOSED 10-86	2N
OPEN 7-79	ASBESTOS	CLOSED 7-81	20
OPEN 1-84	ASBESTOS	CLOSED 5-85	21
OPEN 10-86	ASBESTOS	CLOSED 5-88	22
OPEN 7-81	ASBESTOS	CLOSED 9-82	23
	UNUSED		24
OPEN 9-82	ASBESTOS	CLOSED 3-84	25
OPEN 1-85	CORROSIVES	OPEN	26
OPEN 1-75	ASBESTOS	CLOSED 7-76	27
OPEN 2-84	CORROSIVES	CLOSED 1-85	28
OPEN 9-76	ASBESTOS	CLOSED 6-79	29
OPEN 8-76	ASBESTOS	CLOSED 9-76	30
OPEN 9-82	CHEMICAL	CLOSED 4-84	31
	UNUSED		32
OPEN 11-80	CHEMICAL	CLOSED 9-82	33
OPEN 1-75	CHEMICAL	CLOSED 11-80	34
	UNUSED		18N
OPEN 3-84	OXIDIZERS	OPEN	19N

Figure 1. Nonradioactive Dangerous Waste Landfill Trench Plan.

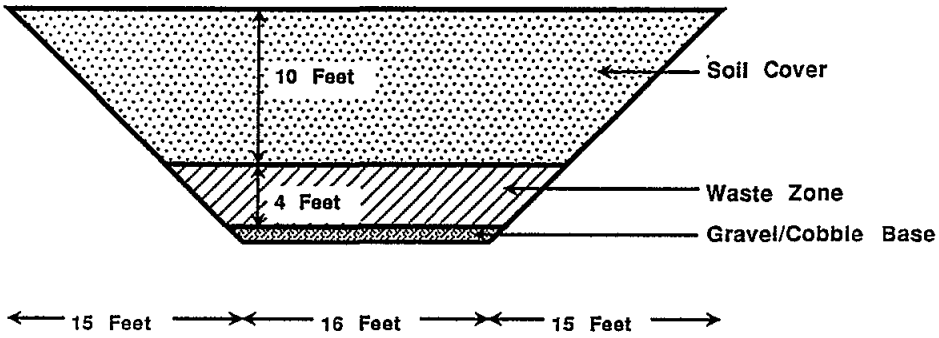

Figure 2. Representative Cross Section of a Nonradioactive Dangerous Waste Landfill Chemical Trench.

Excavation Methodology

The excavation of Trench 19N and retrieval of drums was performed by NRDWL landfill operating personnel including a work supervisor, a heavy equipment operator, and two laborers. Equipment used included a front end wheel loader and hand shovels. No written work plan was prepared.

The excavation activity began by scraping off a portion of the operational cover using a front wheel loader to decrease the amount of overburden. The depth of material removed in this manner was limited to a few feet to prevent damaging the underlying containers. Cover material that was removed was piled along the sides of the trench.

After the upper portion of the cover was removed, the front end loader was then used to locate the buried containers. Working in the bottom of the trench, the loader operator carefully exposed containers by driving the loader bucket into the base of the waste layer and then tilting or lifting the bucket. By following the coarse gravel/cobble layer (Figure 2), which defined the base of the waste layer, the operator was successful in positioning the bucket beneath the containers. Excavated soil was piled along the edges of the trench.

After a container was located with the front end loader, laborers would complete the excavation using hand shovels and place the container in the loader bucket. The container would then be transported out of the trench. Retrieved containers were segregated by shipment (i.e. disposal request number) and staged along the east side of the trench. The method of excavation was considered to be effective in finding and retrieving containers without damage.

The retrieval process started on the south side (open side) of the Trench 19N and progressed in manner opposite to the original disposal sequence. The activity took two days to complete at a cost of approximately $2,000. Thirty metal drums containing regulated waste, and numerous empty containers were retrieved. No leaking containers or evidence of soil contamination was observed. The metal drums containing regulated waste were found to be in good shape with no damage from the excavation process. Container labels; however, were often illegible, which added some uncertainty to the identification process. This was further complicated by the finding that a number of shipments, which were thought to have been placed in Trench 19N were actually not present. The matching of containers to a particular disposal request number was often based on the arrangement in which they were found in the trench.

On November 11, 1985 containers with regulated waste were either loaded onto a flat-bed for transportation to the 2727S Nonradioactive Dangerous Waste Storage Facility or returned back to Trench 19N and covered. No attempt was made to open retrieved containers at the NRDWL to verify their contents. No waste or soil sampling was performed. Empty containers which were not regulated under WAC 173-303 were transferred to the adjacent Solid Waste Landfill for disposal as sanitary waste.

WASTE DESCRIPTION AND INVENTORY

Three distinct inventory lists for Trench 19N have been provided in RCRA regulatory documents. The first inventory list was provided in Appendix D-1 of the 1985 Part B Permit Application for the Nonradioactive Dangerous Landfill and Storage Facility. In August 1990, a closure and postclosure plan was prepared for the NRDWL (DOE/RL-90-17) that contained two other lists including a revision of 1985 inventory (Appendix 4C) and a post-excavation inventory (Appendix 4A). The following discussion explains the differences between these three inventory lists.

Appendix D-1 contained in the 1985 Part B permit Application was compiled before November 1985, and did not take into account the findings and results of the November 8, 1985 excavation activity. During the excavation of Trench 19N, several shipments that were thought to have been placed in Trench 19N were not found. It was deduced that the missing containers had actually been disposed of in another NRDWL trench (28 or 26) which happened to be open at the same time as Trench 19N. Appendix D-1 was revised accordingly and issued as an appendix (4C) in the closure/postclosure plan. Several discrepancies with the original records were also corrected in Appendix 4C. The inventory for Trench 19N was then revised a second time (Appendix 4A) to reflect the containers that where removed during the excavation activity and transferred elsewhere (e.g. 2727S Facility).

Table 1 summarizes the differences in the three inventory lists, and provides specific comments governing why changes were made to the inventory. In addition, Table 1 identifies several remaining errors. These errors have been corrected in the attached inventory lists for Trench 19N and 28. Effected inventory lists in the NRDWL Closure/Postclosure Plan will also be revised accordingly in the next revision of the document.

9 1 1 2 1 0 2 5 5

TABLE 1. CHEMICAL WASTE INVENTORIES FOR NONRADIOACTIVE DANGEROUS WASTE LANDFILL TRENCH 19N

1985 Part B Permit Application Inventory (Appendix D-1)			Disposal Request #	Comments/Disposition	1990 Closure/PostClosure Plan (DOE/RL-90-17)	
Date	Quantity	Chemical			Pre-Excavation Inventory (Appendix 4C)	Post-Excavation Inventory (Appendix 4A)
04-17-84	10 gal 20 gal 55 gal 55 gal 55 gal 30 gal 5 gal 5 gal 5 gal	Ferric nitrate Lithium nitrate Ferric phosphate Neodymium nitrate Aluminum nitrate Rare earth nitrate Magnesium nitrate Kesel Manganese nitrate	5-17	•Original record indicates that all containers were empty •Empty containers were transferred to SWL	•Deleted	•Deleted
06-13-84	2 lb 20 lb	Sodium nitrate Sodium nitrate	9-33	•Original record indicates that the total quantity should read 20 lbs not 22 lbs •Returned to Trench 19N following excavation	•Included	•Included
07-05-84	100 lb 25 lb 13 gal 225 lb	Versene EDTA Thiourea Ethylene glycol Ammonium persulfate	9-41	•Not found during excavation of Trench 19N •Assumed to be disposed of in corrosive Trench 28	•Deleted	•Deleted, but not added to Trench 28 inventory
07-19-84	18 drums 10 drums	Sodium nitrite Nickel, hydrated	6-9	•18 drums sodium nitrite transferred to 2727S •1 drum nickel transferred to 2727S; 9 other drums nickel were not found during excavation of Trench 19N •Assumed that 9 drums nickel are disposed of in corrosive Trench 28	•Included; however quantity is incorrect	•Deleted and added to Trench 28 inventory, but quantity is incorrect
09-05-84	400 lb	Metal alloy - 40% Al and 60% Ca	10-9	•Not found during excavation of Trench 19N •Assumed to be disposed of in corrosive Trench 28	•Deleted	•Deleted, but not added to Trench 28 inventory
09-24-84	10 gal	Dioctyl sebacate	10-43	•Nonregulated Waste •Not found during excavation of Trench 19N	•Deleted	•Deleted
11-09-84	75 gal	Paint related material	11-39B	•Original record indicates that waste was actually placed in corrosive Trench 28	•Deleted	•Deleted, but not added to Trench 28 inventory

9 1 1 . 1 . . . 0 2 5 6

TABLE 1. CHEMICAL WASTE INVENTORIES FOR NONRADIOACTIVE DANGEROUS WASTE LANDFILL TRENCH 19N

1985 Part B Permit Application Inventory (Appendix D-1)			Disposal Request #	Comments/Disposition	1990 Closure/PostClosure Plan (DOE/RL-90-17)	
Date	Quantity	Chemical			Pre-Excavation Inventory (Appendix 4C)	Post-Excavation Inventory (Appendix 4A)
12-05-84	1 lb 1 lb 1 lb 5 lb 1 pt 1 pt 1 qt 1 gal 1 lb 1 lb 1 qt 2 qt	Potassium permanganate Sodium nitrate Sodium chromate Sodium hydroxide Ethyl acetate Methanol Isopropanol Naphtha Ammonium nitrate Ammonium chloride Ammonium hydroxide Ammonium oxalate	12-15B	•Returned to Trench 19N following excavation	•Included	•Included; however several additional chemicals were mistakenly added
12-20-84	69 mL 230 mL	Refill CQC for Fyrite Oxygen Indicator Methanol	10-23	•Original record indicates that waste was actually placed in corrosive Trench 28	•Deleted	•Deleted, but not added to Trench 28 inventory
01-11-85	13 drums	Salt cake	5-31	•Not found during excavation of Trench 19N •Assumed to be disposed of in corrosive Trench 26; however, corrosive Trench 28 may have been used, because it was also open during this period	•Included, but should have been deleted	•Deleted and added to Trench 26 inventory
05-14-85	3 drums 1 drum	Calcium nitrate Sodium nitrate	7-23	•Returned to Trench 19N following excavation	•Included	•Included

ATTACHMENT 1

REVISED INVENTORY LISTS FOR TRENCH 19N AND 28

APPENDIX 4A
CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #19N

Date	Quantity	Chemical
11-08-85	3 drums, 55 gal	Waste calcium nitrate
11-11-85	1 drum, 55 gal	Waste sodium nitrate
	~~22~~ 20 lb	Sodium nitrate
	1 pt	Ethyl acetate
	~~8 pt~~	~~Toluene~~
	~~1 pt~~	~~Xylene~~
	~~3~~ 1 pt	Methyl alcohol
	~~5 pt~~	~~Benzene~~
	~~2~~ 1 qt	Isopropanol
	1 lb	Potassium permanganate
	1 lb	Ammonium nitrate
	~~3~~ 1 lb	Sodium nitrate
	1 lb	Ammonium chloride
	1 lb	Sodium chromate
	~~1 qt~~	~~1 1 1 Trichloroethane~~
	~~2~~ 1 qt	Ammonium hydroxide
	~~1 pt~~	~~37% Formaldehyde solution~~
	5 lb	Sodium hydroxide, dry solid
	1 gal	Naphtha
	2 qt	Ammonium oxalate (TURCO 4521*)

ATT 1-1

APPENDIX 4A
CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #28

Date	Quantity	Chemical
02-03-84	6 lb	Sodium hydrogen sulfide
	1 lb	Sodium chromate
	1 lb	Sodium bichromate
	0.5 lb	Potassium chromate
	10 oz	1-Ethylquinelinium iodide
	1 lb	Sodium metabisulfite
	1 lb	Ferrous sulfate
	0.5 lb	Nickel chloride
	1 kg	Calgon*
	1 lb	Gelatine powder
	1 pt	Flexible collodion
	1 L	Polyelectrolytes
	1 lb	Ammonium sulfate
	1 lb	Aluminum oxide
	32 oz	Glycenyl triacetate
	800 g	Weldon 28 component C
	32 oz	Ammonium sulfide
	250 mL	Castor oil
	1 pt	Photo-flo 200
	100 g	Creosote
02-09-84	110 gal	Anhydrous borax
	255 gal	Sodium nitrate
	170 gal	Boric acid
	240 gal	Sodium nitrite
	145 gal	Sodium nitrite, borax, frit, sand, gravel
	22 gal	Boric acid, frit, soda ash, silica, and warehouse sweepings
	120 gal	Boric acid, anhydrous borax, brown sand
	175 gal	Boric acid, borax, potassium nitrate
	165 gal	Boric acid, sand, fine frit, borax, sodium nitrate
	220 gal	Boric acid, frit, borax, sodium nitrate
	195 gal	Borax, sand, frit, empty chemical bags
	55 gal	Low sodium nitrate sludge
	55 gal	Normal sodium nitrate sludge
	275 gal	Sodium carbonate sludge spiked
02-22-84	18 gal	Ammonium hydroxide
03-16-84	200 mL	Butyl alcohol
	1 pt	2-Propanol

ATT 1-2

APPENDIX 4A
CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #28

Date	Quantity	Chemical
03-16-84 (cont)	0.5 pt	Butyl ether
	1 L	Amyl alcohol
	0.5 kg	n-Octylalcohol
	0.5 pt	Normal paraffin hydrocarbon
	1,000 mL	Plexiglass* cement
	1 pt	Iodobenzene
	2/3 pt	Combustible liquid, n.o.s.
	0.5 L	Phosphenylchloride, dichlorophenyl phosphine
	500 mL	Indene
	1/8 pt	Diazald
	1 L	Tris (hydroxymethyl) amino-methane
	1 pt	Hypophosphorus acid
	250 g	Antimonypentachloride
	1 L	Bromine
	1 pt	Hydriodic acid
	1 pt	Dinoylnapthalenesulfonic acid
	450 g	Benzoyl peroxide
	1 L	2,2-A_2O-bis-2-Methyl propionitrile
	315 kg	Ceric oxide
	54 ft^3	Cerous oxalate
	1 pt	Butyl ether
	11 qt	Sulfurous acid
	250 lb	Magnesium nitrate
	100 lb	Bismuth nitrate
	75 lb	Sodium nitrate
	950 lb	Sodium nitrite
	75 lb	Disodium phosphate
	96 lb	Cesium carbonate
	25 lb	Soda ash
	5 gal	Kaowool* cement
	100 lb	Activated aluminum
	30 lb	Sodium fluoride
05-01-84	2 gal	Urethane component A
	1 pt	Urethane component B
	2 gal	Concentrated chemical A/B
05-23-84	20 gal	Waste corrosive liquid, n.o.s. (Picrolonic acid, formic acid, and vanadous formate all absorbed)
06-13-84	10 lb	Sodium hydroxide

ATT 1-3

APPENDIX 4A
CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #28

Date	Quantity	Chemical
06-14-84	17 gal	Ammonium hydroxide
06-20-84	0.5 kg	Zirconium hydride
06-22-84	1,140 gal	Lanthanum nitrate
	825 gal	Trichloroethane
07-05-84	100 lb	Versene EDTA
	25 lb	Thiourea
	13 gal	Ethylene glycol
	225 lb	Ammonium persulfate
07-19-84	~~90 lb~~ 9 drums, 55 gal	Nickel, hydrated
08-23-84	1 pt	Ammonium sulfide
	1 pt	Ethylacetate
	0.5 gal	Hexone
	6 pt	Butyl alcohol
	1 qt	Hexone
	1 qt	Collodion
	1 pt	Amyl acetate
	1 pt	Ethyl acetate
	3 kg	Methyl ethyl ketone
	1 pt	Hexone
	1 qt	Tetrahydrofuran
	1 pt	Perchloric acid (70%)
	1 pt	Hydrogen peroxide (30%)
	5 gal	Dichloromethane
	1 qt	Bis(2-ethylhexyl)2-hexylphosphonate
	1 qt	Mono-2-ethyl hexylacid orthophosphate
	1 pt	Glycerine
	1 kg	Octyl alcohol
	5 L	Isopentyl alcohol
	1 qt	Acetyl acetone
	1 gal	Dimethyl formamide
	1 L	Hexanol
	5 lb	Lactic acid
	1 qt	Diisopropyl ketone
	1 gal	Sulfuric acid (93%)
09-05-84	400 lb	Metal alloy - 40% Al and 60% Ca

ATT 1-4

APPENDIX 4A
CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #28

Date	Quantity	Chemical
11-09-84	75 gal	Paint related material
12-20-84	69 mL 230 mL	Refill for CQC for fyrite oxygen indicator Methanol
01-11-85	520 gal	Dry salt cake: $NaNO_3$, $NaNO_2$, NaOH

ATT 1-5

APPENDIX 4C

PRE-NOVEMBER 1985 CHEMICAL WASTE INVENTORY FOR THE NONRADIOACTIVE DANGEROUS WASTE LANDFILL

Trench #19N

Date	Quantity	Chemical
06-13-84	~~2 lb~~	~~Sodium nitrate~~
	20 lb	Sodium nitrate
07-19-84	~~990 gal~~ 18 drums, 55 gal	Sodium nitrite
	~~550 gal~~ 1 drum, 55 gal	Nickel, hydrated
12-05-84	1 lb	Potassium permanganate
	1 lb	Sodium nitrate
	1 lb	Sodium chromate
	5 lb	Sodium hydroxide
	1 pt	Ethyl acetate
	1 pt	Methanol
	1 qt	Isopropanol
	1 gal	Naphtha
	1 lb	Ammonium nitrate
	1 lb	Ammonium chloride
	1 qt	Ammonium hydroxide
	2 qt	Ammonium oxalate
~~01-11-85~~	~~13 drums, 55 gal~~	~~Salt cake~~
05-14-85	3 drums, 55 gal	Waste calcium nitrate
	1 drum, 55 gal	Waste sodium nitrate

ATT 1-6

Appendix D

Conceptual Design of the Final Cover for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill

This appendix describes the HELP modeling performed on the ET cover proposed for NRDWL/SWL. Model output files are also presented.

1

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Terms

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
HELP	*Hydrologic Evaluation of Landfill Performance*
ITRC	Interstate Technology Regulatory Council
LAI	leaf area index
LANL	Los Alamos National Laboratory
NRDWL	Nonradioactive Dangerous Waste Landfill
RCN	Runoff Curve Number
RCRA	*Resource Conservation and Recovery Act of 1976*
SCS	Soil Conservation Service
SWL	Solid Waste Landfill
WAC	*Washington Administrative Code*

1

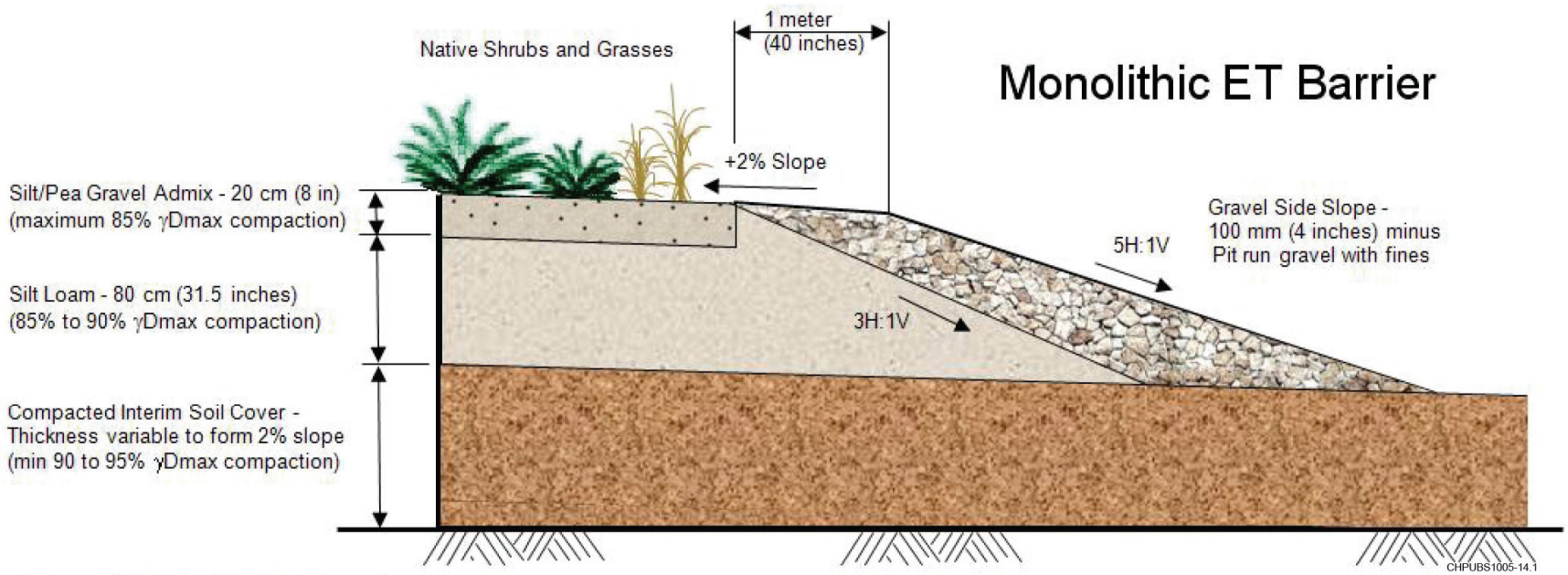
D1 Introduction

The conceptual design of the final cover for the Nonradioactive Dangerous Waste Landfill (NRDWL) and Solid Waste Landfill (SWL) is based on conformance to the requirements of WAC 173-303-610, "Closure and Post-Closure," and WAC 173-303-665(6) "Closure and Post-Closure Care." These requirements will be met by specifying a 100-cm (39.4-in.) thick evapotranspiration (ET) final cover with a general slope of approximately 2 percent but no greater than 5 percent, planted with a variety of native shrubs, grasses, and forbs. A thorough discussion of how the proposed design meets these requirements is provided in Chapter 6.

An interim soil cover is already in place at the NRDWL/SWL, but in some areas of the landfill it may require some reshaping and/or placement of additional soil fill in preparation for the installation of the ET final cover. This would be in order to achieve a general 2 to 5 percent slope such that the final cover surface drains to the perimeter of the landfill. A 100-cm (39.4-in.) thick ET cover is being proposed. The final ET cover will consist of 80 cm (31.5 in.) of a fine-grained, low-permeability soil and 20 cm (7.9 in.) of the same fine-grained soil modified with 15 percent by weight pea gravel to form an erosion-resistant top soil (Figure D-1). The slope of the final cover will be maintained at approximately 2 percent (nominal) but no greater than 5 percent because fine-grained soils (e.g., silt-loam) are more susceptible to erosional forces when the slope is greater than 2 percent (PNL-8478, *Soil Erosion Rates Caused by Wind and Saltating Sand Stresses in a Wind Tunnel*). The entire cover will be planted with a variety of native shrubs, grasses, and forbs.

In examining the topography, the existing grade will require some rework to minimize the amount of fill required to create a general 2 percent slope, while at the same time assuring the final cover will drain to runoff/run-on control ditches and basins at the outer perimeter of the landfill (i.e., outside the landfill footprint). Modeling using the HELP model (see Section D3) indicates that up to 6 percent of annual precipitation will be removed as runoff. With the evidence provided at the Hanford Barrier and other study sites, actual runoff is expected to be much less and occur only during periods of rapid snow melt on frozen ground. Even then, the addition of perimeter channels or ditches and low area collection basins is advisable due to the large surface area of the landfill. Additionally, some native material will be required to form the general shape/slope of the cover. By selectively siting adjacent local borrow areas; a sufficient runoff/run-on control system could be formed. Siting of these borrow areas should also consider the potential for constructing collection basins for runoff and interflow water. Interflow water is the subsurface water that flows laterally such as will be the case where a capillary barrier is formed at the interface between the ET cover and the interim cover.

The existing interim cover for the NRDWL is documented to be 1.2 to 3.0 m (4.0 to 10 ft) thick and the existing interim cover of the SWL is documented to be 0.6 to 1.2 m (2.0 to 4.0 ft) thick. Therefore, an assumption was made that with the expected gradual consolidation of the waste in the trenches since they ceased operation, the maximum amount of cover that could be safely removed from any particular location during regrading activities, while retaining a minimum thickness of interim cover, would be approximately 0.5 m (20 in.). On this basis, a set of conceptual integrated final cover design grading plans were generated (Figures D-2 and D-3). The amount of soil removal that can be safely allowed during any regrading activity will be established during the definitive design phase using topographical maps (historical and current), geophysical survey, and/or probes or potholes.



γDmax = Total unit weight density maximum
H:V = Horizontal to Vertical

Figure D-1. Proposed Final Cover Design for the Hanford Nonradioactive Dangerous Waste Landfill

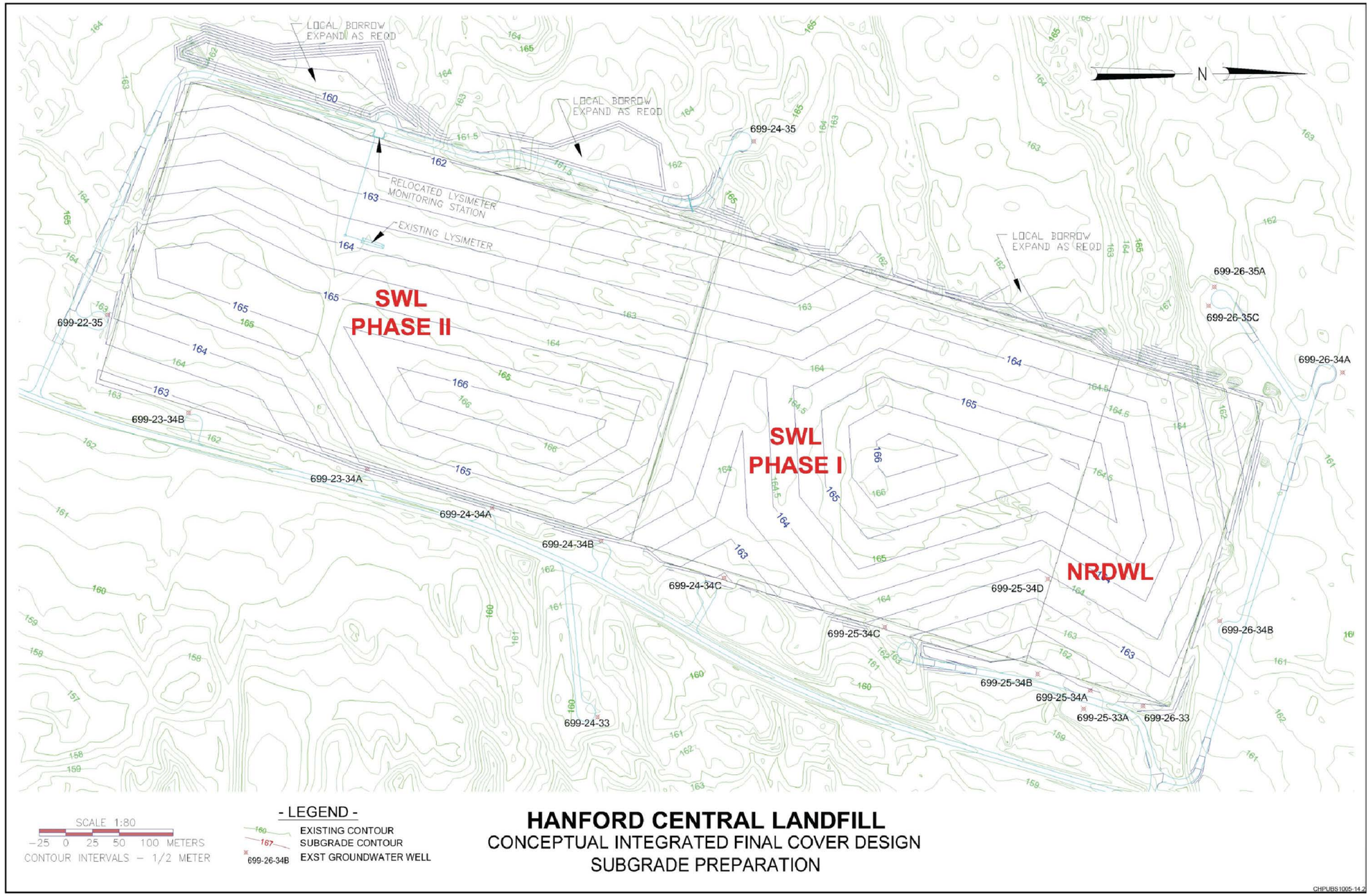


Figure D-2. Conceptual Integrated Final Cover Design Subgrade Preparation

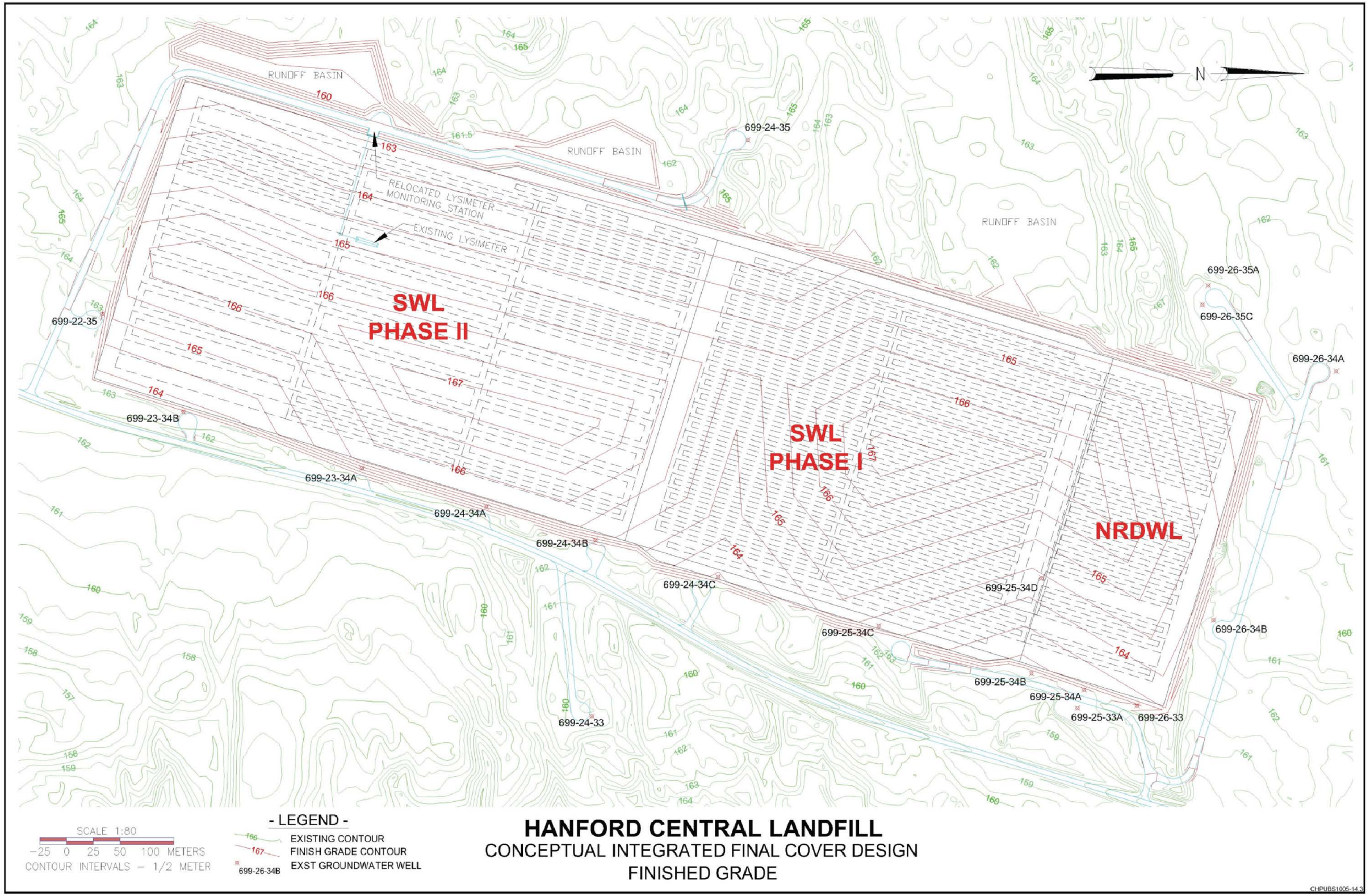


Figure D-3. Conceptual Integrated Final Cover Design Finished Grade

The design of the final cover for the NRDWL/SWL will conform to WAC 173-303, “Dangerous Waste Regulations.” Trench 1N, on the west end of the NRDWL and most of the trenches in SWL, received municipal solid waste, which is regulated under WAC 173-350, “Solid Waste Handling Standards.”

NRDWL and SWL received demolition waste containing asbestos and would normally be regulated under 40 CFR 61, “National Emission Standards for Hazardous Air Pollutants.” According to 40 CFR 61, final closure of the asbestos trenches may be achieved by planting and maintaining cover vegetation and placing a sufficient thickness of soil to provide a simple physical barrier. However, because of the contaminant release to the vadose zone and groundwater and the trenches that received asbestos and solid waste were located adjacent to each other, the entire landfill will be covered with the same 100 cm (39.4 in) cover. Suitable soil material having adequate water storage capacity and rooting thickness must be placed over the asbestos trenches to develop and retain vigorous native perennial cover vegetation at the site.

1

D2 Selection of Cover Design Concept

Over the past few decades, there have been numerous studies performed across the nation, sponsored by regulatory agencies and landfill owners, to demonstrate the performance of various cover design concepts. One of the more comprehensive studies is being performed under the Alternative Cover Assessment Program, of which the U.S. Environmental Protection Agency (EPA) is one of the principal sponsors. Under this program, large-scale test plots of a set of several cover concepts were constructed at locations throughout the U.S., and the performance at each location was compared. The Alternative Cover Assessment Program has concluded that covers that rely on the natural process of ET are well suited for application where the climate is arid or semi-arid as long as the type and thickness of the soils used in constructing the cover provide sufficient water storage capacity (DRI, 2002, *Alternative Cover Assessment Project Phase I Report*).

Another comprehensive study on cover concepts is being performed for the U.S. Department of Energy (DOE) at the Los Alamos National Laboratory (LANL), a semiarid site that receives almost three times the average annual precipitation of the Hanford Site. Several test plots were constructed at the LANL that have demonstrated that a simple ET cover will adequately protect the environment. In 2007, the LANL published a design guidance and requirements document that identifies a monolithic ET cover as the typical cover design to be used at the LANL for hazardous and radioactive mixed waste sites (LA-UR-06-4715, *Cover System Design Guidance and Requirements Document*).

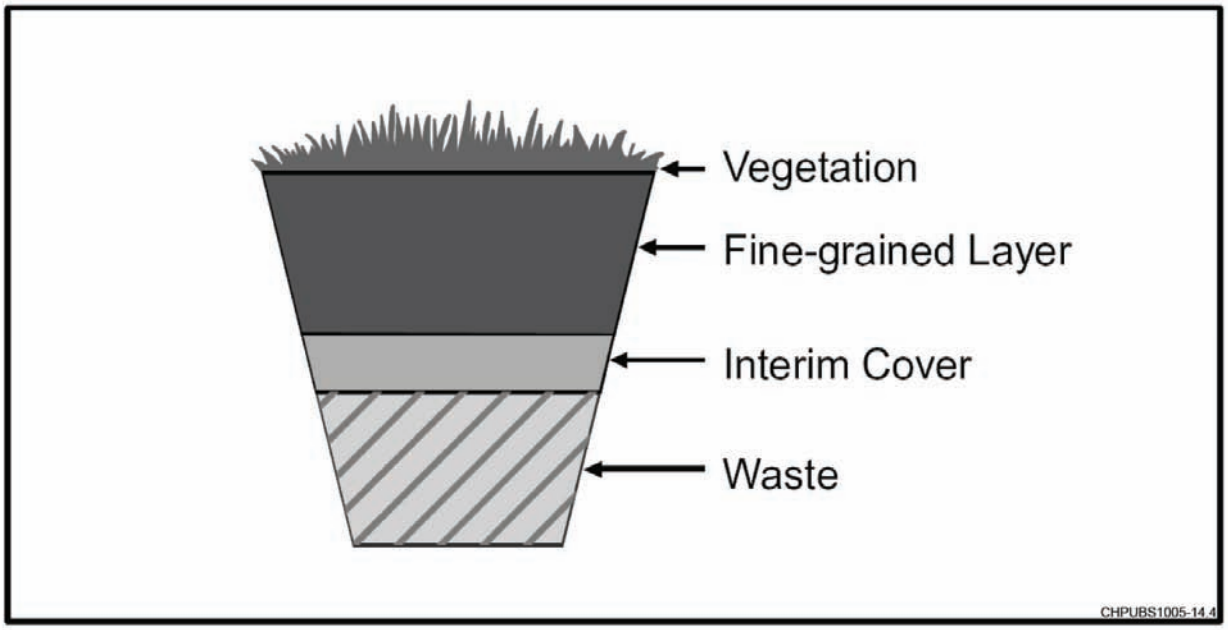
Cover design has been studied at the Hanford Site since the 1980s. Since the principal concern at the Hanford Site deals with resolving issues with radioactive waste, the Hanford Barrier Program has focused on extremely long-term performance (>1,000 years). Several natural analogue sites have been evaluated. Numerous laboratory analyses have been performed. Various test plots and weighing lysimeters were constructed and monitored, some for well over a decade. All of these tests and studies have verified that, because of the arid climate, the Hanford Site should employ covers that rely upon the natural processes of ET to control leachate generation (DOE/RL-93-33, *Focused Feasibility Study of Engineered Barriers for Waste Management Units in the 200 Areas;* DOE/RL-99-11, *200-BP-1 Prototype Barrier Treatability Test Report;* PNNL-18845, *200-BP-1 Prototype Barrier – 15 Years of Performance Monitoring;* PNL-8911, *Field Lysimeter Test Facility Status Report IV: FY 1993*.)

In 1994, a large test barrier, the "Hanford Barrier," was constructed that incorporated a layer of locally available fine-grained soils as the principal component in restricting water movement towards and through the waste. Even though a portion of the test barrier was stressed for the first 3 years with three times the annual precipitation, and experienced an additional simulated precipitation event that exceeded a 1,000-year probability of occurrence, after 8 years of monitoring, drainage through the vegetated fine-soil layer only occurred during the third year. That one year's drainage did not exceed the design goal of 0.5 mm (0.019 in.) (PNNL-14143, *The Hanford Site 1000-Year Cap Design Test*), demonstrating the ability of the cover to control leachate generation.

ET covers, or surface barriers, rely on the natural systems of the water-holding or "storage" capacity of a fine-grained soil, evaporation from the near-surface, and plant transpiration to control water movement through the cover. Precipitation is allowed to infiltrate at the surface, where it is retained in the soil until natural ET processes release the water back to the atmosphere. Such designs are particularly suitable for semiarid and arid climates with a low annual amount of precipitation and a relatively high ET potential. When precipitation exceeds ET, water is stored, and when ET exceeds precipitation, water is removed.

One of the more common types of ET cover is the monofill (or monolithic) cover (Figure D-4), which relies on a relatively thick single layer of fine-grained soil to store precipitation for later removal by direct

evaporation and plant transpiration. Figure D-4 shows a cross section showing the profile and side-slope design being proposed for the NRDWL/SWL.



Source: EPA/542/F-03/015, *Evapotranspiration Landfill Cover Systems Fact Sheet*

Figure D-4. Conceptual Monofill (Monolithic) ET Cover Design

The thickness of a monofill ET cover is based on soil characteristics (i.e., water-holding capacity) and ability to provide an adequate rooting medium for native plants. Silt-loam soils from the Hanford Site can have a total water storage or holding capacity of up to 30 percent vol/vol (PNNL-14143). Functional water storage capacity is determined by the difference in water content between the field capacity and the wilting point of a given soil, times its thickness. Field capacity (or water-holding capacity) is defined as the amount of water held in a soil after excess moisture has drained away by gravity and the soil is no longer draining (soil pore pressures of negative 1/3 bar). Wilting point is defined as the water content when a common agricultural crop can no longer draw water from the soil (pore pressures of negative 15 bars). This is conservative since it has been demonstrated by numerous studies that desert plants, physiologically adapted to arid climates, can extract water from the soil at pore pressures far below that of a common agricultural crop. Sagebrush can extract water from soils at pore pressures below negative 75 bars (PNNL-17134, *Geotechnical, Hydrogeologic, and Vegetation Data Package for 200-UW-1 Waste Site Engineered Surface Barrier Design*), while some desert plants can extract water at soil pore pressures exceeding negative 200 bars.

The long-term average annual precipitation at the Hanford Site is 173 mm (6.81 in.) (PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data*). Forty to fifty percent of the average annual precipitation at the Hanford Site typically falls during winter, when potential ET is slightly less than precipitation, making the amount of functional water storage provided by a cover an important feature. The field capacity of the fine-grained soil available at a borrow site (Area C) located 10 km (6 mi.) west of the NRDWL/SWL is 0.229 vol/vol (mean soil properties for Area C soil [PNNL-17134]). The agricultural crop wilting point for that same soil is 0.056 vol/vol. Field capacity (0.229), minus wilting point (0.056), times 100 cm (39.4 in.) thickness of soil, equals 173 mm (6.81 in.) of functional water storage capacity. Therefore, a 100-cm (39.4-in.) thick cover of Area C soil will

provide a functional water storage capacity of 200 (346 mm/yr ÷ 173 mm/yr) to 250 (432 mm/yr ÷ 173 mm/yr) percent of the precipitation that would fall during an average winter, and 125 (173 mm/yr ÷ 138 mm/yr) percent of the precipitation that fell during the wettest winter on record (138 mm [5.45 in.] fell in the winter of 1996/7 [Table 4.2, PNNL-15160]). Since the average annual potential ET (PET) is 1,270 mm/yr (50 in./yr) (PNNL-6750, *Status of FY 1988 Soil-Water Balance Studies on the Hanford Site*), during all other times of the year PET will greatly exceed precipitation, and the ability of a soil to absorb and store water becomes important to plants. Median root depths for the Hanford Site native perennial forbs and grasses are 60 cm (24 in.) and 70 cm (28 in.) (PNNL-17134, Table 5-10). Therefore, a 100 cm (39.4 in.) fine-grained soil layer will provide an adequate rooting medium (the longest roots at Hanford are 4 m (13 ft) and these type plants will be selectively removed during routine maintenance). A comparison of average PET verses average precipitation for the Hanford Site is shown in Figure D-5.

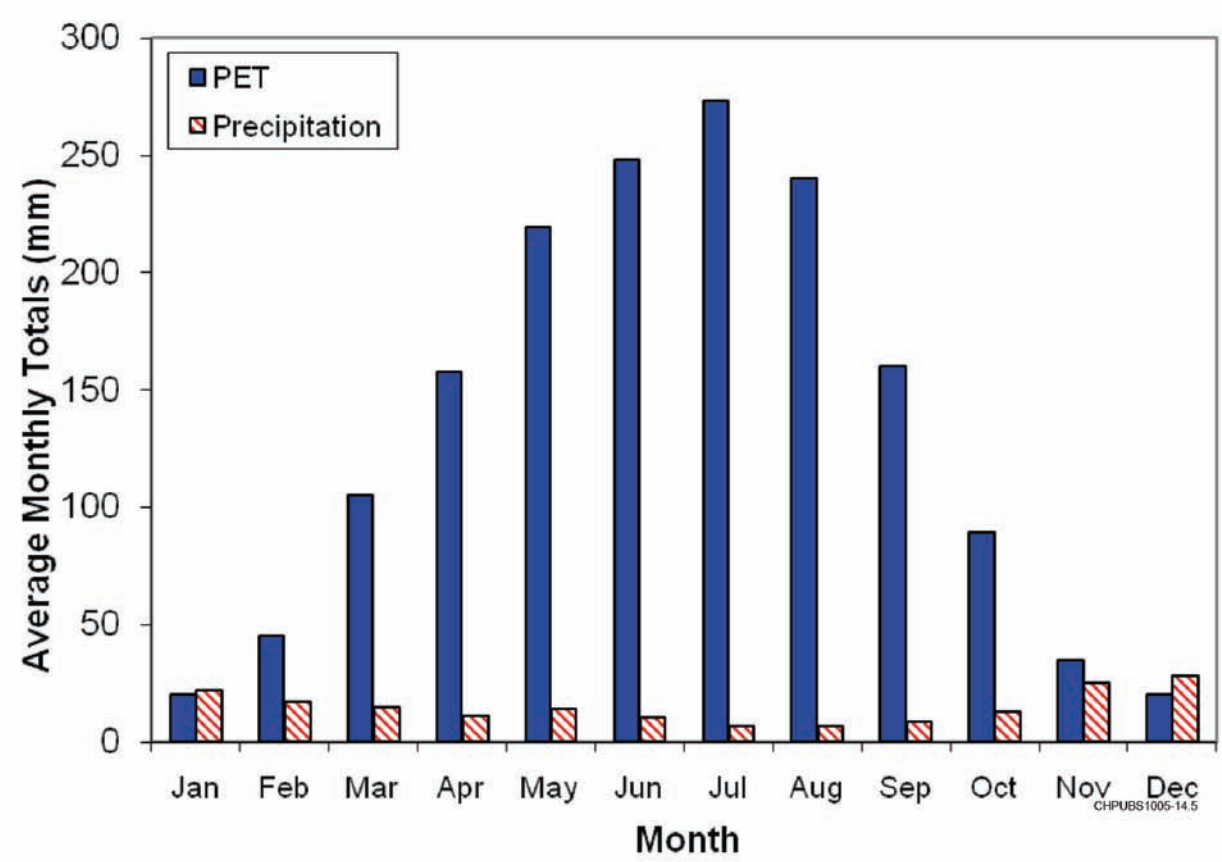


Figure D-5. Climate Water Demand (PET) Verses Water Supply (Precipitation) at the Hanford Site

1

D3 Barrier Performance Modeling

Performance modeling using EPA/600/R-94/168a, 1994, *The Hydrologic Evaluation of Landfill Performance (HELP) Model* suggests that 100 cm (39.4 in.) of Hanford silt-loam will reduce leachate generation within the NRDWL/SWL to less than 3 mm (the recommended performance standard). The HELP computer program is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. Several HELP model simulations of the NRDWL/SWL, with slight variations for a final cover, were run for comparison and to identify sensitivities to certain parameters (e.g., soil type, thickness, and plant community).

Because of the uncertainties and spatial variability in water balance model input parameters, models such as HELP generally should be viewed as a means to compare different cover thicknesses rather than to predict performance. Recent studies have compared available numerical models and found that cover design depends on site-specific factors (e.g., climate, cover type, available soils), and that no single model is adequate to predict accurately the performance of an ET cover (EPA/542/F-03/015, *Evapotranspiration Landfill Cover Systems Fact Sheet*). Even when calibrated to a specific site, some models tend to under predict, while others over predict cover performance. The HELP model has been the most widely used water balance model for landfill cover design; however, it tends to overpredict drainage at arid sites, which could lead to an overly conservative design (DRI, 2002). This limitation would lead designers to increase the thickness of the cover to compensate for the drainage predicted by the HELP model. However, in actual practice a thinner cover may have sufficed.

To minimize processor demands and computational time, the HELP model uses daily average weather, quarterly averaged humidity, annual averaged evapotranspiration depth, and other broadly averaged inputs. With these averaged inputs, the HELP model will sometimes predict cover performance in the small fractions of a percent of the precipitation that historically fell at or near the site. Cover performance predicted by the HELP model should be considered a general approximation. The HELP model was used in this report as a preliminary screening tool. Definitive design of the ET cover will be done using UNSAT-H, as discussed below.

During definitive or final design, a more rigorous analysis, using a model based on the Richards' equation, will be performed. Models that are based on the Richards' equation are considered more physically correct for characterizing water movement through a surface barrier or cover than models like HELP, which are based on enhanced water balance methods (ITRC, 2003, *Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers*). A more complex model (e.g., PNL-13249, *UNSAT-H version 3.0: Unsaturated soil water and heat flow model*) will provide enhanced precision and accuracy in predicting future barrier performance. In addition to using modeling for final design, 16 years of data from the Hanford Barrier and the 18 years from the Field Lysimeter Test Facility (FLTF) will also contribute to the design.

D3.1 Model Inputs—Weather

The HELP model requires climate data for daily total precipitation, daily average temperature, daily solar radiation, quarterly average humidity, and annual average wind speed. The model contains a limited database of values that allow the model to synthetically generate weather information for 139 cities within the United States if adequate weather data for the specific site is not available. The Hanford Site has kept weather records since 1912, with hourly temperature, dew point, atmospheric pressure, precipitation, relative humidity, solar radiation, and wind speed and direction recorded since July 1946. Daily maximum and minimum temperatures and total precipitation have been recorded since 1912. As discussed below, this data was used to develop the weather input that was used in the HELP modeling.

The Alternative Landfill Technologies Team of the Interstate Technology Regulatory Council (ITRC), and others, have suggested that when comprehensive weather data is available, a conservative but reasonable approach to modeling cover performance is to use the wettest ten year cycle on record (DRI, 2002). A ten-year span will usually include a combination of wet and dry years so that the cycle is not overly conservative.

Table D-1 provides a summary of Hanford Site monthly and annual precipitation totals (PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data*). During the years 1989 through 1998, the Hanford Site received 115 percent of normal precipitation. This period included the two wettest years on record (1995 and 1996), the wettest month on record (December 1996), the wettest winter on record (November 1996 through March 1997), the second highest snow accumulation on record (15 in. from January 15 to 20, 1993, which equates to a 50 year frequency accumulation), and a 150-year frequency, 24-hour storm (November 18 to 19, 1996) (PNNL-15160). The monthly total precipitation for the years 1946 through 2007 is provided in Table D-1. The far-right column shows the running 10-year average for the years 1958 through 2008, with the highest 10-year average occurring at the end of 1998.

Hourly total precipitation and solar radiation records for the years 1989 through 1998 at the Hanford Site were summed into daily total values, and a HELP input file was created for each. Hourly temperatures for the years 1989 through 1998 were averaged for each given day to create the daily average temperature input file. Quarterly relative humidity values were derived from the monthly averages provided in PNNL-15160 (Table 6.3), and the annual average wind speed was taken from PNNL-15160 (Table 5.1). All model runs use the same climate data with one exception—a simulation of the impact that a 1,000-year frequency storm would have on the proposed design. In that run, the amount of precipitation that fell over a 24-hour period on November 18 and 19, 1996 (a storm that produced 43 mm [1.70 in.] of precipitation) was increased to the amount a 1,000-year frequency storm would produce over a 24-hour period (54 mm [2.12 in.] of precipitation) (PNNL-15160, Tables 4.9 and 7.3).

D3.2 Model Inputs—Soil Properties

The HELP model requires input values for cover layer thickness, porosity, field capacity, wilting point, initial soil water content, and effective saturated hydraulic conductivity. The model contains a small database containing the physical properties of a number of default soil types; however, the model will predict more accurate information if properties of the soils that are or will be part of the cover is used.

The most likely source for the fine-grained soil that would be used in constructing the final cover for the SWL will be Area C, which is approximately 9.7 km (6 mi.) west-southwest of NRDWL/SWL. An extensive study of the soils contained within the southeast portion of Area C was performed recently to support the design of surface barriers or covers for several waste sites within the 200-UW-1 Operable Unit as part of a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* remedial action. A set of best-estimate parameter values for modeling the performance of the Area C soils was developed and documented in PNNL-17134, *Geotechnical, Hydrogeologic, and Vegetation Data Package for 200-UW-1 Waste Site Engineered Surface Barrier Design*.

During the 1990s, a set of studies were performed on the erosion resistance of a typical silt-loam soil under the Hanford Barrier Program. The mission was to identify components of a long-term (1,000 years) surface barrier design. Several of the studies concluded that to enhance resistance of a bare fine-grained soil to erosion, 10 mm (⅜ in.) pea gravel should be blended or tilled into the upper 30 cm (12 in.) of the surface (PNL-8478). As a bare soil surface deflates over time, more of the pea gravel becomes exposed, eventually creating a “desert pavement,” which is highly resistant to wind and water erosion. These studies also determined that a mixture of 15 percent by weight 10 mm pea gravel and silt would not inhibit native plant germination or growth. Recent analysis, using agricultural industry standard methods,

Table D-1. Summary of Monthly and Annual Precipitation Totals from the Hanford Meteorological Station Record

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	10-Year Running Average
1946	--	--	--	--	--	--	0.15	0.35	0.52	0.65	0.66	0.11	--	--
1947	0.32	0.27	0.42	0.7	0.02	1.07	0.71	0.68	**1.34**	2.2	0.81	0.75	9.29	--
1948	1.36	0.69	0.07	0.95	1.71	1.47	0.4	0.39	0.16	0.45	0.95	1.11	9.71	--
1949	0.13	0.68	1.12	0.02	0.16	0.01	0.01	0.03	0.23	0.1	1.47	0.16	4.12	--
1950	1.8	1.06	0.87	0.47	0.27	**2.92**	0.07	T	0.01	2.46	0.55	0.97	11.45	--
1951	0.84	0.51	0.46	0.53	0.43	1.38	0.37	0.15	0.1	0.71	0.82	0.7	7	--
1952	0.65	0.5	0.06	0.13	0.58	1.07	T	0.08	0.08	0.04	0.2	0.77	4.16	--
1953	2.16	0.25	0.17	0.77	0.28	0.55	T	0.96	0.13	0.2	0.96	0.49	6.92	--
1954	1.48	0.28	0.59	0.07	0.41	0.1	0.22	0.42	0.51	0.42	0.86	0.35	5.71	--
1955	0.56	0.22	0.17	0.4	0.59	0.28	0.57	0	0.77	0.4	1.54	2.03	7.53	--
1956	1.71	0.56	0.1	T	0.22	0.86	T	0.38	0.01	1.03	0.15	0.58	5.6	7.149
1957	0.48	0.23	**1.86**	0.38	0.82	0.47	0.05	0.02	0.34	**2.72**	0.39	0.53	8.29	7.049
1958	1.74	1.48	0.46	0.64	0.74	0.81	0.02	T	0.05	0.19	0.77	1.84	8.74	6.952
1959	2.05	1.17	0.4	0.2	0.5	0.23	T	0.03	1.26	0.56	0.41	0.26	7.07	7.247
1960	0.51	0.58	0.67	0.53	0.71	0.14	T	0.26	0.23	0.23	0.92	0.64	5.42	6.644
1961	0.33	**2.1**	1.02	0.48	0.8	0.42	0.15	0.09	T	0.07	0.49	0.89	6.84	6.628
1962	0.13	0.9	0.14	0.34	1.35	0.12	T	0.5	0.38	0.95	0.65	0.6	6.06	6.818
1963	0.95	0.69	0.53	1.17	0.43	0.28	0.31	0.01	0.02	0.04	0.74	1.14	6.31	6.757
1964	0.37	0.01	0.03	0.11	0.04	0.9	0.04	0.24	0.09	0.28	0.94	2.34	5.39	6.725
1965	0.93	0.14	0.03	0.09	0.15	0.49	0.11	0.03	0.11	0.01	1.17	0.39	3.65	6.337

Table D-1. Summary of Monthly and Annual Precipitation Totals from the Hanford Meteorological Station Record

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	10-Year Running Average
1966	0.68	0.03	0.39	0.03	0.05	0.43	0.81	T	0.27	0.39	2.25	0.6	5.93	6.37
1967	0.32	T	0.14	0.9	0.56	0.57	T	T	0.05	0.13	0.16	0.43	3.26	5.867
1968	0.88	0.58	**0.02**	0.01	0.06	0.19	0.04	0.51	0.25	0.93	1.23	1.25	5.95	5.588
1969	1.24	0.54	0.1	1.22	0.51	0.75	T	T	0.48	0.1	0.13	1.29	6.36	5.517
1970	**2.47**	0.75	0.27	0.45	0.54	0.25	0.01	T	0.03	0.24	0.71	0.61	6.33	5.608
1971	0.78	0.1	1.02	0.07	0.56	0.71	0.13	0.09	1.13	0.18	0.46	1.07	6.3	5.554
1972	0.19	0.27	0.58	0.1	**2.03**	0.66	0.16	0.56	0.02	T	0.55	1.27	6.39	5.587
1973	0.9	0.21	0.08	T	0.24	0.01	T	0.02	0.43	1.72	2.64	2.02	8.27	5.783
1974	0.9	0.41	0.52	0.46	0.28	0.12	0.71	T	0.01	0.21	0.71	0.97	5.3	5.774
1975	1.43	0.98	0.33	0.42	0.38	0.24	0.32	1.16	0.03	0.87	0.6	0.7	7.46	6.155
1976	0.56	0.36	0.23	0.41	0.08	0.11	0.13	0.96	T	0.04	**T**	**0.11**	**2.99**	5.861
1977	**0.08**	0.57	0.41	T	0.65	0.37	0.06	**1.36**	0.66	0.15	0.63	1.47	6.41	6.176
1978	1.72	0.92	0.3	0.46	0.41	0.09	0.52	0.57	0.11	T	1.21	0.26	6.57	6.238
1979	0.54	0.17	0.54	0.52	0.1	T	0.09	0.38	0.2	0.67	1.36	0.99	5.56	6.158
1980	1.32	1.3	0.3	0.86	1.41	0.96	T	0.02	0.85	0.33	0.44	1.89	9.68	6.493
1981	0.56	0.6	0.7	0.02	0.99	0.43	0.19	0.03	0.6	0.39	1.08	1.45	7.04	6.567
1982	0.33	0.57	0.3	0.75	0.28	0.75	0.22	0.2	0.55	1.33	0.91	1.79	7.98	6.726
1983	1.44	1.36	1	0.42	0.52	0.68	0.31	0.12	0.46	0.52	2.12	2.12	11.07	7.006
1984	0.23	0.94	1.01	0.6	0.55	0.99	0.06	T	0.42	0.07	1.83	0.57	7.27	7.203
1985	0.34	0.82	0.36	0.01	0.12	0.15	0.12	0.01	0.63	0.46	1.24	0.84	5.1	6.967

Table D-1. Summary of Monthly and Annual Precipitation Totals from the Hanford Meteorological Station Record

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	10-Year Running Average
1986	1.76	1.37	0.76	T	0.3	T	0.21	0.02	0.96	0.29	0.65	0.77	7.09	7.377
1987	0.8	0.19	1.05	0.14	0.17	0.11	0.5	0.07	0.01	**T**	0.4	1.63	5.07	7.243
1988	0.48	**T**	0.39	1.12	0.33	0.11	0.13	**0**	0.39	0.01	0.82	0.4	4.18	7.004
1989	0.21	1.67	1.56	0.84	0.59	0.01	0.01	0.26	0.02	0.42	1.04	0.29	6.92	7.14
1990	0.77	0.09	0.1	0.4	0.86	0.36	0.14	0.83	T	0.78	0.02	0.72	5.07	6.679
1991	0.33	0.19	1.12	0.45	0.49	1.44	0.29	0.07	0	0.53	1.44	0.4	6.75	6.65
1992	0.44	0.94	0.09	0.94	**T**	1.14	0.38	0.2	0.27	0.61	1.07	1.82	7.9	6.642
1993	1.3	1.17	0.67	0.71	0.6	0.12	**1.76**	0.24	0.04	0.09	0.19	0.94	7.83	6.318
1994	0.44	0.11	0.03	0.61	1.27	0.38	0.15	0.08	0.08	0.93	0.68	1.36	6.12	6.203
1995	2.14	0.69	0.95	1.54	0.79	0.77	0.34	0.07	0.79	0.87	1.04	2.32	**12.31**	6.924
1996	1.42	1.22	0.83	0.43	0.62	0.05	0.14	0.02	0.22	0.88	**2.67**	**3.69**	12.19	7.434
1997	1.51	0.25	0.7	0.33	0.33	0.46	0.19	0.06	0.32	0.92	1.01	0.31	6.39	7.566
1998	1.24	1.15	0.5	0.07	0.52	0.48	0.34	0.04	0.1	0.28	1.29	0.44	6.45	7.793
1999	0.89	0.7	0.06	**T**	0.34	0.31	0.07	0.57	**0**	0.48	0.26	0.07	3.75	7.476
2000	1.09	1.12	0.94	0.57	0.77	0.25	0.46	T	0.56	0.57	1.08	0.67	8.08	7.777
2001	0.29	0.42	0.67	0.83	0.08	1.27	0.05	0.08	0.13	0.37	1.67	0.8	6.66	7.768
2002	0.42	0.67	0.19	0.29	0.16	0.65	0.16	0.01	T	0.12	0.38	2.36	5.41	7.519
2003	1.87	0.82	0.26	**2.23**	0.08	**T**	**0**	0.46	0.24	0.07	0.15	1.96	8.14	7.55
2004	2.12	0.92	0.36	0.21	0.89	0.82	0.03	0.95	0.14	0.86	0.29	0.37	7.96	7.734
2005	0.93	0.04	0.31	0.26	0.79	0.06	0.09	0.06	0.66	0.29	0.89	2.01	6.39	7.142

Table D-1. Summary of Monthly and Annual Precipitation Totals from the Hanford Meteorological Station Record

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	10-Year Running Average
2006	1.18	0.41	0.24	1.3	0.57	1.33	T	T	0.21	0.76	0.71	1.75	8.46	6.769
2007	0.14	0.76	0.74	0.26	0.3	0.45	0.07	0.32	0.57	0.21	1.13	0.53	5.48	6.678
2008	1.28	0.55	0.2	0.08	0.56	0.39	T	0.48	0.04	0.22	0.74	0.95	5.49	6.582
2009	1.15	0.64	0.8	0.39	0.18	0.16	T	0.04	0.06	0.78	0.56	0.71	5.47	6.754
AVERAGE[a]	0.95	0.63	0.5	0.47	0.51	0.53	0.2	0.24	0.3	0.53	0.88	1.04	6.76	NA
NORMAL[b]	0.87	0.68	0.58	0.44	0.55	0.41	0.27	0.27	0.33	0.49	0.98	1.11	6.98	NA

Notes:

The shaded portion is the wettest 10 years on record. Values in bold type are greatest and least records for the period.

Measurements are in inches.

Source: PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data*, Table 4.1, with 2005, 2006, 2007, 2008, and 2009 updates.

a. The average is the mean value of the historic record, 1945-2005.

b. By convention, a climatological normal is the average over a 30-year period, in this case the period 1971-2000.

-- = not available
NA = not applicable
T = trace

predict that at a 2 percent slope, the gravel admix would be sufficient to limit erosion to an average of less than 6 mm (1/4 in.) every 100 years (200-UW1-C-001, *Engineered Surface Barrier Design-Soil Losses* Due to Water Erosion and 200-UW1-C-002, Engineered Surface Barrier Design-Soil Losses Due to Wind Erosion). A previous analysis using the same industry standard methods to calculate erosion loses conservatively excluded the 10 mm (3/8 in.) pea gravel to provide "worse-case" projections. That analysis projected a loss of 3 cm (1.2 in.) of soil over a 100-year period (DOE/RL-93-33).

To provide a life expectancy of at least 100 years, the top 20 cm (7.9 in.) of the final cover (Layer 1) for the NRDWL/SWL will consist of Area C silt-loam with 10 mm (3/8 in.) pea gravel blended/tilled into it at 15 percent by weight. Layer 2 will consist of 80 cm (31.5 in.) of Area C silt-loam soil. Most of the best-estimate parameters for the silt-loam soil and silt-loam soil gravel admix are found in PNNL-17134, Tables 3.4 and 3.5. Saturated hydraulic conductivity for the mean silt-loam soil and silt-loam admix is taken directly from the tables. The density values (particle density [ρ_s] and dry bulk density [ρ_b]) for the mean soil parameters were used to derive the porosity (ϕ_s) of the soil using the equation:

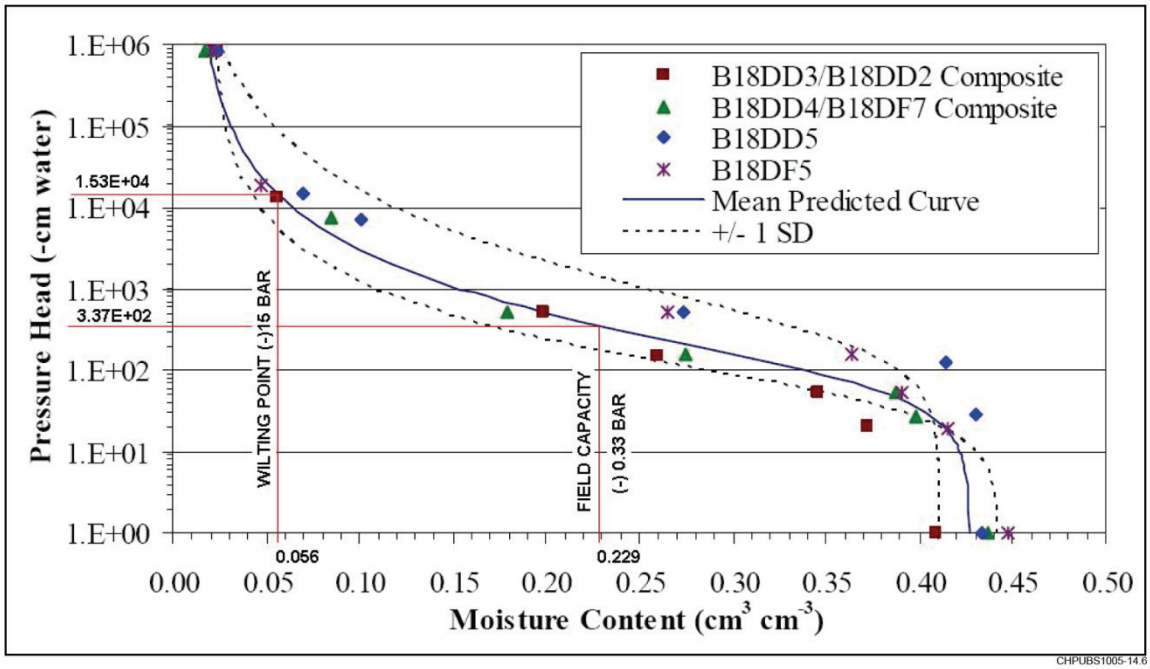
$$\phi_s = 1 - \frac{\rho_b}{\rho_s}$$

All of the values used, including porosity, for the cover soil in all of the model cases were either taken directly or derived from Area C sample data documented in D&D-25575, *Silt Borrow Source Field Investigation Report*, and expanded on in PNNL-17134.

Field capacity and wilting point for the silt-loam admix and the silt-loam soil were derived by interpolating the pore pressure and moisture content values provided in the data presented in PNNL-17134, Table B5 for the sample B18DD3/B18DD2 Composite. Pore pressures between field capacity (-3.37×10^2 cm of water [-0.33 BAR]) and wilting point (-1.53×10^4 cm of water [-15 BAR]) for composite blend B18DD3/B18DD2 plot on, or very close to, the "Mean Predicted Curve" shown in PNNL-17134, Figure 3.3. Interpolating from PNNL-17134, Table B5 provided values to three significant figures. Intersects were plotted on the "Mean Predicted Curve" shown on PNNL-17134, Figure 3.3 for pore pressures of -3.37×10^2 cm for field capacity and -1.53×10^4 cm for wilting point to confirm the interpolated results (Figure D-6). This process provided the resultant moisture content parameters of 0.229 vol/vol for field capacity and 0.056 vol/vol for the wilting point for the mean Area C silt-loam. A similar process, using Figure 3.4 of PNNL-17134, was performed to determine the field capacity and wilting point for the silt-loam soil gravel admix (Figure D-7).

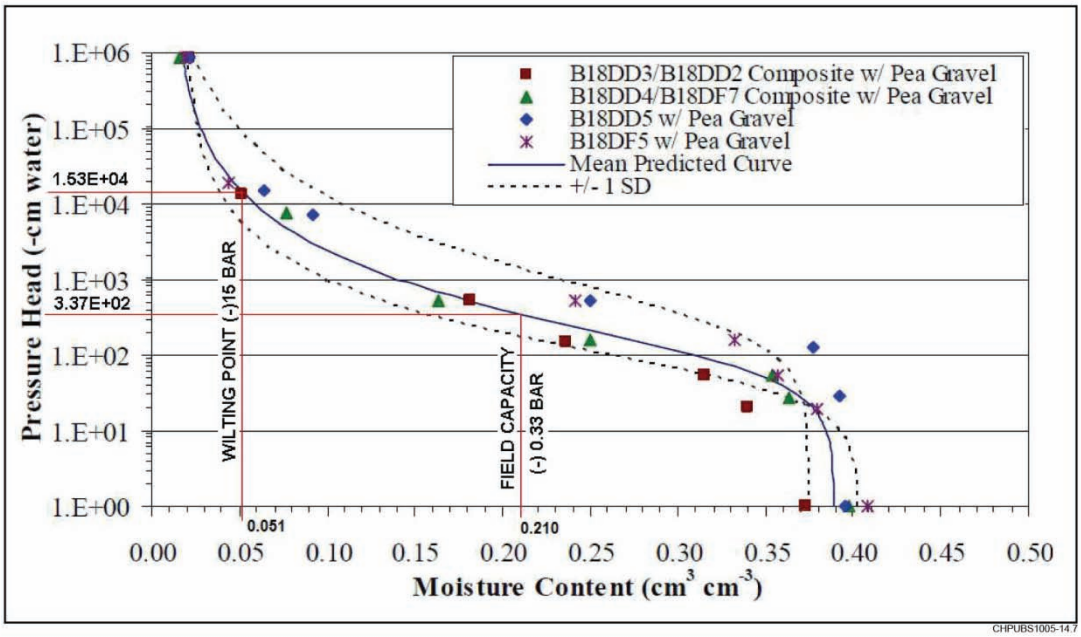
The initial moisture content was developed through an iterative process of repeatedly running the model to identify the water storage at the end of the 10-year period, then entering that value as the initial soil water content until the two sets of values were essentially the same. This equilibrates the model to infinite repeated wettest 10-year weather cycles.

Other than thickness and initial moisture content, the properties for the interim soil cover (Layer 3) and the waste layer (Layer 4) were entered by selecting generic materials from the HELP database that best approximate the NRDWL/SWL. The NRDWL interim cover is documented to be 1.2 to 3.0 m (4.0 to 10 ft) thick and the interim cover of the SWL is documented to be 0.6 to 1.2 m (2.0 to 4.0 ft) thick. The cover consists mostly of a coarse to fine sand, with gravel. For simplicity, and to address probable re-grading efforts, Layer 3 will be modeled in all simulations as a 1.2 m (4.0 ft) layer of soil having properties best described by HELP as Material Texture Number 3 (a well graded, gravelly sand with few fines, defined by the Unified Soil Classification System as SW). The 3.65-m (12-ft) thick waste layer will be defined as Layer 4, and will be modeled in all simulations as a waste layer having properties best described by HELP as Material Texture Number 18, Municipal Waste.



Source: PNNL-17134, *Geotechnical, Hydrogeologic, and Vegetation Data Package for 200-UW-1 Waste Site Engineered Surface Barrier Design*, Figure 3.3, modified to show field capacity and wilting point.

Figure D-6. Measured and Predicted Water Characteristics and Moisture Content Curve for the Silt-Loam Soil at Area C



Source: PNNL-17134, *Geotechnical, Hydrogeologic, and Vegetation Data Package for 200-UW-1 Waste Site Engineered Surface Barrier Design*, Figure 3.4, modified to show field capacity and wilting point.

Figure D-7. Predicted Water Characteristics and Moisture Content Curve for the Area C Silt-Loam Soil with Gravel Admix

As a sensitivity analysis on Area C soil properties, several comparative HELP model runs were made using the properties for a blend of some of the more coarse soil samples taken at Area C. Using the same process identified above for determining the properties for the mean Area C soil, properties for the sample blend B18DD3/B18DD2 were input into the model. A soil represented by sample blend B18DD3/B18DD2 will have a slightly lower porosity (0.402 vs. 0.409) and a slightly higher saturated hydraulic conductivity (3.96×10^{-5} cm/sec vs. 1.53×10^{-5} cm/sec) than the mean for Area C silt-loam soil, but will have very close to the same water storage capacity. (Note: Hydraulic conductivity is a calculated from porosity and hydraulic head. The relationship between the two parameters is not always linear.) The selection of the values used for modeling increase the conservative basis.

D3.3 Model Inputs—General Design and Evaporation Data

The HELP model requires the inputs for Soil Conservation Service (SCS) Runoff Curve Number (RCN), the fraction of the cover that will allow runoff (the portion of the area that is sloped in a manner that would permit drainage off the surface [EPA/600/R-94/168a, *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*]), the area of the cover, the latitude of the site, the maximum leaf area index (LAI), the Julian date for the start of the growing season, the Julian date of the end of the growing season, and the annual averaged depth of the evaporative zone.

The HELP model has a routine that assists in calculating the SCS RCN. The RCN is a widely used method in determining the approximate amount of runoff from a rainfall or snowmelt event over a particular area, and is based on that area's hydrologic soil group, land use, treatment (e.g., plant community), and hydrologic condition. The HELP model will only calculate the RCN when one of the default soils contained in the HELP database is used as the surface soil. To use the properties for an Area C soil for Layer 1 in the model, an iterative process was employed using the HELP default soils to identify an RCN that would be appropriate for a 147 m (480 ft) long, 2 percent slope consisting of a general Hanford silt-loam type of soil. A conservative value of 75 was selected for the majority of comparative runs with a value of 85 used in a sensitivity analysis. The lower RCN would produce less runoff; therefore, more water would be available to infiltrate the final cover. This correlates well with what has been observed at the Hanford Prototype Barrier (i.e., little runoff).

The HELP model also calculates when the temperature is near or below freezing and holds precipitation at the surface, simulating snow. When the model calculates the temperature has risen above freezing, it releases the stored water, inducing snow melt events to the simulation. A separate routine calculates when the ground could be frozen and, when it is, automatically changes the RCN to 95 for surfaces where the RCN is set to 80 or lower, and 98 when set above 80 (EPA/600/R-94/168b, *The Hydrologic Evaluation of Landfill Performance [Help] Model: Engineering Documentation for Version 3*). These RCN values are typical for a tight clay soil surface and the model will derive significantly more runoff. This feature cannot be turned off or adjusted by the user, and may result in the overprediction of runoff. With the exception of one day in one of the sensitivity runs, the only times the model predicted there would be runoff at the NRDWL/SWL were during snowmelt events on frozen soil. The entire surface of the final cover will be sloped at 2 to 5 percent towards the landfill perimeter; therefore, the fraction of landfill cover allowing runoff was set to 100 percent for all model runs, with the exception of a runoff area sensitivity run, for which the variable was set to a conservative 10 percent. The area of the cover over NRDWL and SWL will be approximately 31ha (76 ac).

The start and end of the growing season was derived by subjectively (and conservatively) averaging the growth state dates for the flora contained in PNNL-17134, Tables 5.15 for native flora (Leafy Spurge as a typical perennial forb), 5.16 (Indian Rice Grass), 5.17 (Thickspike Wheatgrass), 5.18 (Needle-and-Thread Grass), 5.19 (Sandberg Bluegrass), 5.21 (Big Sagebrush), and 5.22 (Rabbitbrush). These native species

are predominant in the area that surrounds the NRDWL/SWL. Leaf growth for the grasses typically starts around day 91 to day 98 (January 1 is day 1), earlier for the shrubs and perennial forbs. For conservatism, the start of the growing season was set to day 98. The end of the growing season is based on seed dissemination for the deeper-rooted shrubs, which occurs between day 278 (Rabbitbrush) and day 327 (Sagebrush), and plant senescence for the typical deep-rooted forb, which occurs near day 328. Dormancy occurs much earlier for the grasses because of the dry summer and the lack of shallow soil moisture. Day 304 was selected as the end of the growing season as a conservative average for the deeper-rooted plants.

For the maximum leaf area index, a poor stand of grass (LAI=1.0) was conservatively selected as the base case per the guidance given in the HELP user's guide (EPA/600/R-94/168a). The HELP model uses a single input parameter labeled "Evaporative Zone Depth" for both rooting (transpiration) depth and active evaporation depth. The depth of the evaporative zone was conservatively set at the bottom of the final cover, even though PNNL-17134, Table 5.11 notes that root depths for a majority of plant species native to the area could extend deeper, with certain species extending as far as 3 m (10 ft) deep.

Additional model runs using an LAI equal to 0 (bare soil) and an LAI of 2.14 were made as part of a sensitivity analysis. The LAI of 2.14 was derived from PNNL-17134, Tables 5.6, and 5.9, for a mature vegetation area at the Hanford Site (the BC Crib area, which is roughly 4.8 km [3 mi.] northwest of the NRDWL/SWL). PNNL-17134, Table 5.9, provides the Plant-Area Index for various plant groupings at selected areas at the Hanford Site; Table 5.6 provides empirical relationship equations for estimating leaf-area index from the plant-area index. Inputting the values for plant area index from PNNL-17134, Table 5.9 into the respective equation in Table 5.6 for forbs, grasses, and shrubs, and summing the results provides an LAI=2.14.

D3.4 HELP Model Simulation Results

Simulations were run for the proposed design (or base case), six Sensitivity Cases, and one extreme storm case. The Sensitivity Cases identify the variations that would occur in the results because of a change of a single input variable from that of the proposed design (i.e., the quality of vegetation) (two cases), cover thickness, cover soil properties (i.e., gradation), runoff factors (two cases), and a Sensitivity Case that looks at the effects of a combination of a coarser soil and increased cover soil thickness. The extreme storm case is identical to the base case with the exception that the amount of precipitation that fell during a 24-hour period on November 18 and 19, 1996, was increased to what would have fallen during a 1,000-year frequency storm.

D3.4.1 Proposed Design (Base Case)

The base case final cover consists of 80 cm (31.5 in.) of a typical (mean) Area C fine-grained soil plus 20 cm (7.9 in.) of the same fine-grained soil modified with 15 percent by weight pea gravel as a top soil, for a total thickness of 100 cm (39.4 in.). The cover has an assumed poor stand of grass (LAI=1.0). The evaporative zone depth is the thickness of the final cover (100 cm [39.4 in.]).

Model results for the proposed design are provided in output file AS1MPV1M.OUT (Section C5.1). Average annual percolation through the landfill (or flux) is predicted to be 0.03 mm (0.001 in.) of leachate, or approximately 0.015 percent of annual precipitation. Over 94.7 percent of the annual precipitation will be removed by ET and 5.3 percent removed as runoff. The model predicted runoff would only occur during periods when there was snowmelt on frozen ground and that there would be no runoff in six of the ten years of the wettest ten years on record. The model also predicted that there would be no runoff during a 150-year frequency precipitation event (November 18 to 19, 1996). With a flux of 0.03 mm/yr the proposed design would be expected to achieve performance equal to or better than EPA's prescriptive design for a *Resource Conservation and Recovery Act of 1976* (RCRA) Subtitle C

(hazardous/dangerous waste) final cover (EPA/542/F-03/015). In an arid to semi-arid climate, such as at Hanford, a conventional RCRA Subtitle C cover would be expected to produce a flux of 1.5 mm/yr (Albright et al., 2004, "Field Water Balance of Landfill Final Covers").

D3.4.2 Sensitivity Case 1—Bare Soil (No Plants)

Sensitivity Case 1 is the same as the base case except with bare soil (LAI=0.0), a shallower ET depth (45 cm [18 in.]), and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model to infinite repeated wettest 10-year weather cycles. The ET depth was set shallower than that of the base case as there would be no transpiration if there were no plants. The effective depth of evaporation would therefore be limited to the depth of capillary draw of water to the surface. For silts, the depth of capillary draw would be about 45 cm (18 in.) (EPA/600/R-94/168a, *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*). Model results for the bare soil Sensitivity Case are provided in output file AS1MNV45.OUT (Section C5.2). Though such a case is highly unlikely (repeated ten year cycles of bare cover), the average annual percolation through the landfill is predicted to be slightly less than 15 mm (0.58 in.) of leachate, which is 7.4 percent of the annual average precipitation that fell during the wettest ten years on record (1989 through 1998), and less than a third of the average annual leachate collected in the SWL lysimeter from 1996 to 2007 under the current interim cover conditions (i.e., coarse sand with sparse vegetation). Runoff was predicted to be slightly less than 7 percent of the annual precipitation, indicating that vegetation with an LAI=1.0 has only a slight impact to the amount of runoff generated. With an increase in percolation of more than two orders of magnitude over that of the base case, this Sensitivity Case indicates the importance of maintaining the cover vegetation.

In a burn study on the Hanford Barrier, in the winter surface evaporation from the bare surface increased in contrast to the unburned area where shrubs and other plants provided shade and surface soil was moister. However, in the summer, more water was stored in the burned area.

D3.4.3 Sensitivity Case 2—Increase in Plant Density

Sensitivity Case 2 is the same as the base case except with a good stand of shrubs and grass (LAI=2.14). The initial moisture content of each layer was set to the same value as the base case as the model equilibrated at the exact same values. Model results are provided in output file AS1MV45.OUT (Section C5.3). The average annual percolation (or flux) through the landfill is predicted to be 0.03 mm (0.001 in.). Though the model predicted the average annual flux would be identical to that of the base case, ET was predicted to be slightly lower (94.2 percent of annual precipitation verses 94.7 percent) and runoff was predicted to be slightly higher (5.8 percent versus 5.3 percent). This is counterintuitive, as one would expect that with a higher plant density ET would increase and runoff would decrease. Because the only difference in input between the increased plant density model run and the base case model run was the LAI variable, the differences in the results must be related to the LAI.

A close comparison of the output results for the two cases will find that runoff throughout the 10-year cycle was usually slightly less for the increased plant density case, with the notable exception of one day, February 7, 1996. On that day, the model had calculated three times as much runoff for the increased plant density case as it did for the base case, with no infiltration. The base case shown an increase in infiltration equivalent to the difference in the amount of runoff calculated for each case. Apparently, the correlation with the higher LAI and the weather conditions leading up to and during this event was sufficient for the model to consign virtually all of the snowmelt and rainfall that occurred on this one day to runoff.

While comparing the daily output results for the increased plant density case and the base case, it was also noticed that the soil in the evaporative zone of the increased plant density case would typically become

drier earlier and remain drier (lower moisture content) throughout most of the year, as would be expected. In a burn study on the Hanford Barrier, it was observed that in the winter there was more surface evaporation from the bare surface in contrast to the unburned area where shrubs and other plants would provide shade and surface soil was moister. However, in the summer, more water was stored in the burned area. The soil in the evaporative zone of the increased plant density case would typically reach the wilting point one to two months prior to when it would for the base case. The model ceases to attribute evapotranspiration to the water balance of the profile once the soil in the evaporative zone reaches the defined wilting point, and, in both cases, the soil in the evaporative zone reached the wilting point each year. As the model progressed from fall to winter, in both cases the moisture content of the evaporative zone soil would begin to increase at about the same time and rate. By mid winter, when evapotranspiration is at its lowest, the soil moisture content of the two cases would typically be close to each other, or "nearly similar." At the end of the 10-year cycle, they were identical. If the anomaly in the runoff calculation for the increased plant density case had been more typical of all the other runoff events calculated for the model, the total runoff volume for the case would have been slightly less than the base case. The calculated evapotranspiration for the increased plant density case would therefore have then been slightly higher than the base case.

Coupled with the results of Sensitivity Case 1 (bare soil), the results of increasing the LAI indicate that a nominal stand of vegetation should be sufficient for the proposed cover to function optimally.

D3.4.4 Sensitivity Case 3—Increase in Cover Thickness

Sensitivity Case 3 is the same as the base case except for an additional 20 cm (8 in.) in thickness of cover and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. This case consists of 100 cm (39.4 in.) of a typical (mean) Area C fine-grained soil plus 20 cm (7.98 in.) of the same fine-grained soil modified with 15 percent by weight pea gravel as a top soil, for a total thickness of 120 cm (47 in.). Evaporative zone is increased to the thickness of the fine-grained soil since it is still well within the root depth of several of the plants that are native to the area. The leaf area index is set to the same as the base case, or an LAI=1.0. Model results are provided in output file AS120P12.OUT (Section C5.4). The average annual percolation through the landfill is predicted to be 0.03 mm (0.001 in.), or 0.015 percent of annual precipitation, which is nearly identical to the base case. Runoff and ET values between the base case and this Sensitivity Case have a variance of approximately 0.6 percent. This demonstrates that a final cover having a total thicknesses greater than 100 cm (39.4 in.) would provide little if any additional protection.

Sensitivity Case 3 (increased thickness of cover) was expanded to provide an indication of the optimum thickness for a Monofill Barrier or cover at the NRDWL/SWL. A number of simulations were run with Layer 2 varying in thickness from 25 to 100 cm (10 to 39.4 in.). All other parameters were maintained the same in each simulation, including Layer 1 remaining as 20 cm (7.98 in.) of modified/blended Area C silt/silt-loam. The evaporative zone was initially set to 1.05 m (42 in.) in all simulations based on the typical root depth of sagebrush and some of the native bunch grasses (PNNL-17134), and for consistency in approach. However, the majority of the simulations could not be equilibrated (initial soil water content equal to, or close to the same values as the final soil water content) unless the evaporative zone depth was set close to, or at the same depth as the fine soil. For some profiles, percolation/leakage through the bottom layer of the profile was found to vary by almost an order of magnitude, depending on the magnitude of the differences between initial and final soil water content. Where the simulation would not converge on a set of moisture content values, but repeated in a sequence of a series of values, an average of the results of each run in the series was used.

All simulations used the mean properties for Area C silt/silt-loam soil for layers 1 and 2, and a leaf area index set at 1.0 (poor grass cover). Simulations were run for total final cover thicknesses (Layers 1 and 2)

of 45 cm (18 in.), 60 cm (24 in.), 65 cm (26 in.), 70 cm (28 in.), 75 cm (30 in.), 80 cm (32 in.), 85 cm (34 in.), 90 cm (36 in.), 95 cm (38 in.), 100 cm (39.4 in.), 106 cm (42 in.), and 120 cm (47 in.). Each simulation was repeated numerous times, reinitializing initial moisture conditions until the initial and final moisture values for all layers became as close to invariant as was possible. The results were used to produce a graph (Figure D-8) that compares the performance of the Monofill Barrier or cover based solely on cover thickness and annual flux, or leachate generation. The graph clearly indicates that the point of diminishing returns for the thickness of the monofill barrier is 70 cm (28 in.) (where additional soil material will not noticeably improve performance). The HELP model predicted that a 70-cm (28-m) thick final cover will limit leachate generation to 0.38 mm/yr (0.015 in./yr), which is well below the goal of being equivalent to the EPA RCR Subtitle C prescriptive design performance of 1.5 mm/yr (0.06 in./yr) (Albright et al., 2004, “Field Water Balance of Landfill Final Covers”).

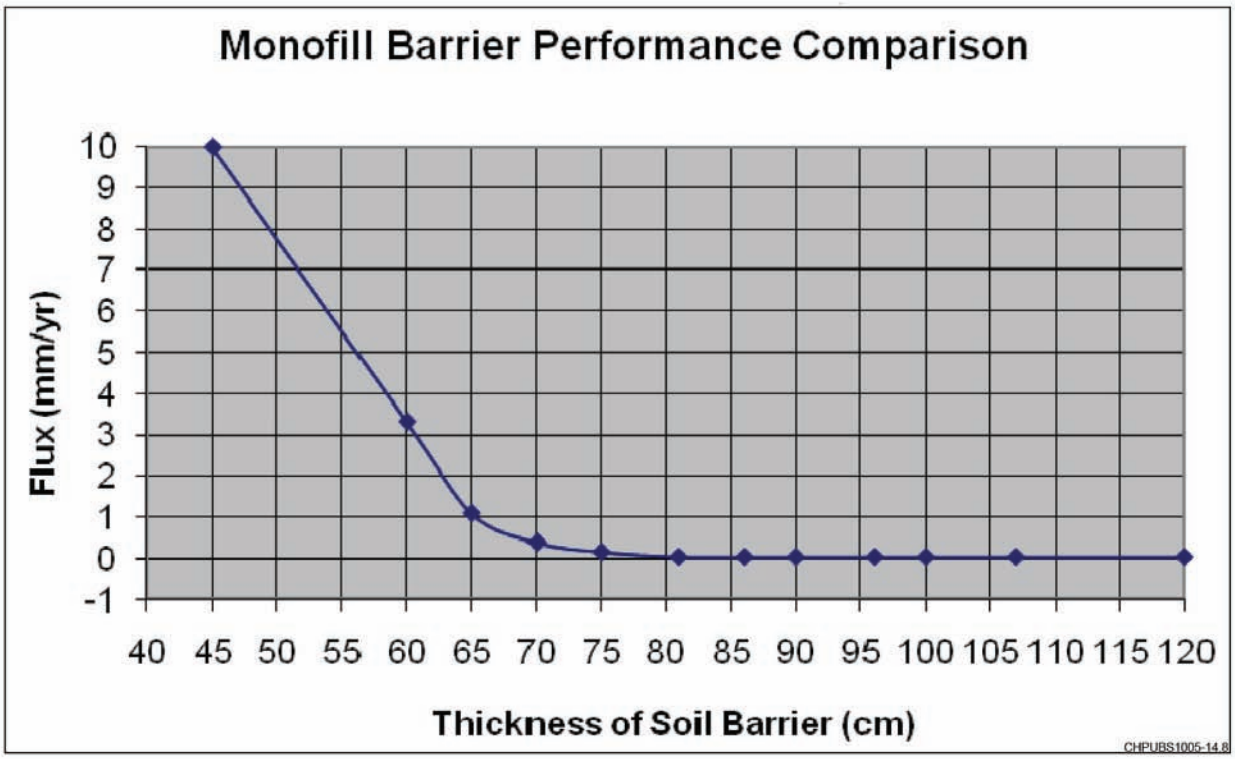


Figure D-8. Monofill Barrier Performance Based on Cover Thickness and Annual Flux

D3.4.5 Sensitivity Case 4—Coarser Soil

Sensitivity Case 4 is the same as the base case except for using a coarse blend of Area C soil (sample blend B18DD3/B18DD2) and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. The sample B18DD3/DD2 was a blend of two of the coarsest soil samples taken from the candidate borrow site at Area C, and was selected as a representative upper bounding case for borrow source production (D&D-25575). The porosity values noted were verified using the values provided in PNNL-17134, Tables DA3.4, and DA3.5 and found to be correct. This soil has a slightly lower porosity (0.402 verses 0.409) and a slightly higher saturated hydraulic conductivity (3.96 × 10-5 cm/sec verses 1.53 × 10-5 cm/sec) than the mean for Area C silt-loam soil, yet has almost the same water storage capacity. All other inputs are the same as the proposed design. Model results are provided in output file CS1MPV1M.OUT (Section C5.5). The average annual percolation through the landfill is predicted to be 0.12 mm (0.005 in.), or approximately

0.06 percent of annual precipitation. The percolation/leachate generation potential of this Sensitivity Case is four times higher than that of the base case. This Sensitivity Case demonstrates the importance in selecting the appropriate barrier soil and establishing adequate construction quality controls. Variations in soil gradation beyond design limits could reduce performance. Even then, this Sensitivity Case predicts that the performance of a Monofill ET cover using the coarsest soil blends discovered at Area C would still be more than equivalent to the theoretical performance of EPA's prescriptive design for a RCRA Subtitle C (hazardous/dangerous waste) final cover (EPA/542/F-03/015). In an arid to semi-arid climate, such as at Hanford, a conventional RCRA Subtitle C cover would be expected to produce a flux of 1.5 mm/yr (Albright et al., 2004).

D3.4.6 Sensitivity Case 5—Coarser Soil and Increase in Cover Thickness

Sensitivity Case 5 is the same as the base case except for using a coarse blend of Area C soil (sample blend B18DD3/B18DD2) and an additional 20 cm (8 in.) in thickness of cover and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. This case consists of 100 cm (39.4 in.) of the coarse blend of Area C soil plus 20 cm (7.98 in.) of the same soil modified with 15 percent by weight pea gravel as a top soil, for a total thickness of 120 cm (47 in.). Evaporative zone is increased to the thickness of the fine-grained soil as it is still well within the root depth of several of the plants that are native to the area. All other inputs are the same as the proposed design. Model results provided in output file C120P120.OUT (Section C5.6). The model predicted that there would be no percolation through the landfill with a very slight increase in total water storage (0.006 mm/yr [0.0002 in./yr]). This illustrates that added thickness could be used to overcome having to use a coarser soil.

D3.4.7 Sensitivity Case 6—Higher Runoff Curve Number

Sensitivity Case 6 is the same as the base case except for using an RCN of 85 instead of 75 and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. All other input values remained the same, including the amount of surface area that will allow runoff (set to 100 percent). Model results are provided in Section C5.7. As expected, the model calculated the amount of runoff would be greater than when a lower runoff curve number is used. Runoff increased from 5.3 percent to 7.5 percent of the annual precipitation with a corresponding decrease in ET from 94.7 percent for the base case to 92.5 percent. It also predicted the same amount of leachate that the base case model predicted when a RCN of 75 is used (0.03 mm/yr [0.001 in./yr]). With the exception of a single day in the entire 10-year cycle, the model predicted that runoff would only occur during periods where the model also predicted that the soil would be frozen. In all the other cases (i.e., proposed design and Sensitivity Cases), the model predicted that runoff would only occur when there was snow melt on frozen ground.

D3.4.8 Sensitivity Case 7—Less Area Allowing Runoff

Sensitivity Case 7 is the same as the base case except for reducing the amount of surface area that will allow runoff from 100 percent to 10 percent and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. All other input values remained the same as used in the proposed design model, including using an RCN of 75. Model results are provided in Section C5.8. Even though the potential area contributing to runoff was decreased by 90 percent, the model predicted that runoff would still be almost 93 percent of the base case value, or 4.9 percent of annual precipitation. The ET increased slightly to 95.1 percent of annual precipitation from the 94.7 percent predicted in the proposed design model. Flux (leachate generation) was predicted to be the same as the base case at 0.03 mm/yr (0.001 in./yr).

D3.4.9 Extreme Storm Event

The extreme storm event case is identical to the base case with the exceptions of an increase in precipitation on a single day in the ten year cycle and slight differences in initial moisture content of each layer due to the iterative process for developing these values to equilibrate the model. The amount of precipitation that fell on November 18 and 19, 1996, (a storm that produced 43 mm [1.70 in.] of precipitation over a 24-hour period) was increased to the amount a 1,000-year frequency storm would produce over the same 24-hour period (54 mm [2.12 in.] of precipitation) (PNNL-15160, Tables 4.9 and 7.3). Since the event occurs in the late fall, and would make the year 1996 the wettest year on record (320 mm [12.61 in.]), the water storage capabilities of the cover during a maximum credible event will be demonstrated. Model results are provided in Section C5.9. The model predicted that there would be no runoff produced during the 1,000-year frequency storm (the ground was not frozen at the time). The model also predicted that 0.09 mm/yr (0.004 in./yr) of leachate would be produced, which is three times the leachate produced in the base case (0.03 mm/yr [0.001 in./yr]). Even then, the performance expected from a 100 cm (39.4 in.) thick Monofill ET cover would be more than equivalent to the theoretical performance of EPA's prescriptive design for a RCRA Subtitle C (hazardous/dangerous waste) final cover.

D4 Conclusion

During the past couple of decades, there have been numerous studies and evaluations performed on cover system design that have demonstrated the benefits of employing a simple cover system that utilizes fine-grained soils coupled with the natural forces of ET (DOE/RL-93-33; DRI, 2002; EPA/542/F-03/015; ITRC, 2003; LA-UR-06-4715). At arid or semiarid sites, the use of ET covers for final covers at both dangerous and municipal waste sites is becoming the standard.

Performance modeling, using EPA's HELP model with site-specific weather data and soil information, indicates that a Monofill ET final cover, having a total thickness of 70 cm (27.51 in.), would produce a flux of 0.38 mm (0.01 in.) (see Section D3.4.4). This is basically equivalent to the theoretical performance of EPA's prescriptive design for a RCRA Subtitle C (hazardous/dangerous waste) final cover, which in an arid to semi-arid climate such as at Hanford, would be expected to produce a flux (leachate) of 1.5 mm/yr (Albright et al., 2004). The modeling also shows that a 100 cm (39.4 in.) thick monofill ET cover (consisting of 80 cm [31.5 in.] of uncompacted, fine-grained, low permeability soil, 20 cm [7.9 in.] of the same fine-grained soil modified with 15 percent by weight pea gravel to form an erosion resistant top soil, constructed at a general slope of 2 percent, and planted with native vegetation) will meet the closure requirements of WAC 173-303-610 and WAC 173-303-665(6). A thorough discussion of how the proposed design meets these requirements is provided in Chapter 7.

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D5 Model Input/Output Files

This section provides the output file for each of the simulations summarized in Section D3.4.

D5.1 Output File: Proposed Design (Base Case)

Section D3.4.1 summarizes the following output file for the proposed design.

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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:\HELP3\COMBINED\HANFORDP.D4
 TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
 SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
 EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET100.D11
 SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\AS1MPV1M.D10
 OUTPUT DATA FILE:      C:\HELP3\COMBINED\AS1MPV1M.OUT


 TIME: 13:14   DATE:  5/11/2010


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   TITLE: 100 CM SOIL COVER (AVE.[MEAN] AREA C SILT w/ P.VEG, ET100CM)

 ******************************************************************************


   NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
        WERE SPECIFIED BY THE USER.


                  LAYER 1
                  --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 60
       THICKNESS          =   20.00  CM
       POROSITY          =   0.3750 VOL/VOL
       FIELD CAPACITY       =   0.2100 VOL/VOL
       WILTING POINT        =   0.0510 VOL/VOL
       INITIAL SOIL WATER CONTENT =   0.2006 VOL/VOL
       EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC
```

```
                    LAYER 2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 61
     THICKNESS          =   80.00  CM
     POROSITY          =   0.4090 VOL/VOL
     FIELD CAPACITY       =   0.2290 VOL/VOL
     WILTING POINT        =   0.0560 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0636 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC

                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0779 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2685 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC




         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.100 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   40.220 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  116.719 CM
    TOTAL INITIAL WATER         =  116.719 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR
```

```
            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

       NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
            HANFORD CP      WASHINGTON

         STATION LATITUDE            = 46.51 DEGREES
         MAXIMUM LEAF AREA INDEX        =  1.00
         START OF GROWING SEASON (JULIAN DATE) =   98
         END OF GROWING SEASON (JULIAN DATE)  =  304
         EVAPORATIVE ZONE DEPTH         = 100.0 CM
         AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
       NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
            WAS ENTERED BY THE USER.



       NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
            WAS ENTERED BY THE USER.



       NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
            WAS ENTERED BY THE USER.
*******************************************************************************

               ANNUAL TOTALS FOR YEAR 1989
-------------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             175.77     54312.324  100.00

 RUNOFF                 16.701     5160.542   9.50

 EVAPOTRANSPIRATION           166.592     51476.789   94.78

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         -7.524     -2325.023   -4.28

 SOIL WATER AT START OF YEAR      1167.190    360661.594

 SOIL WATER AT END OF YEAR       1159.665    358336.594

 SNOW WATER AT START OF YEAR       0.000       0.000   0.00

 SNOW WATER AT END OF YEAR        0.000       0.000   0.00

 ANNUAL WATER BUDGET BALANCE       0.0001      0.019   0.00

*******************************************************************************

*******************************************************************************
```

```
                ANNUAL TOTALS FOR YEAR 1990
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             128.78     39792.402  100.00

 RUNOFF                  0.000       0.000   0.00

 EVAPOTRANSPIRATION           131.221     40547.164  101.90

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         -2.443     -754.733   -1.90

 SOIL WATER AT START OF YEAR      1159.665    358336.562

 SOIL WATER AT END OF YEAR       1153.242    356351.656

 SNOW WATER AT START OF YEAR       0.000       0.000   0.00

 SNOW WATER AT END OF YEAR        3.981     1230.171   3.09

 ANNUAL WATER BUDGET BALANCE       -0.0001      -0.029   0.00

*****************************************************************************

*****************************************************************************

                ANNUAL TOTALS FOR YEAR 1991
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             171.45     52978.051  100.00

 RUNOFF                  0.105      32.528   0.06

 EVAPOTRANSPIRATION           163.611     50555.809   95.43

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         7.734     2389.698   4.51

 SOIL WATER AT START OF YEAR      1153.242    356351.656

 SOIL WATER AT END OF YEAR       1164.956    359971.531

 SNOW WATER AT START OF YEAR       3.981     1230.171   2.32

 SNOW WATER AT END OF YEAR        0.000       0.000   0.00

 ANNUAL WATER BUDGET BALANCE       0.0001      0.020   0.00

*****************************************************************************

*****************************************************************************
```

```
                ANNUAL TOTALS FOR YEAR 1992
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             200.66     62003.945  100.00

 RUNOFF                  0.000       0.000   0.00

 EVAPOTRANSPIRATION           169.770     52458.957   84.61

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         30.890     9544.999   15.39

 SOIL WATER AT START OF YEAR      1164.956    359971.531

 SOIL WATER AT END OF YEAR       1180.262    364701.062

 SNOW WATER AT START OF YEAR       0.000       0.000   0.00

 SNOW WATER AT END OF YEAR        15.584     4815.462   7.77

 ANNUAL WATER BUDGET BALANCE       0.0000      -0.008   0.00

*****************************************************************************

*****************************************************************************

                ANNUAL TOTALS FOR YEAR 1993
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             198.88     61454.543  100.00

 RUNOFF                 11.746     3629.388   5.91

 EVAPOTRANSPIRATION           232.930     71975.445  117.12

 PERC./LEAKAGE THROUGH LAYER 4      0.302006     93.320   0.15

 CHANGE IN WATER STORAGE        -46.096    -14243.619  -23.18

 SOIL WATER AT START OF YEAR      1180.262    364701.062

 SOIL WATER AT END OF YEAR       1148.934    355020.469

 SNOW WATER AT START OF YEAR       15.584     4815.462   7.84

 SNOW WATER AT END OF YEAR        0.817      252.444   0.41

 ANNUAL WATER BUDGET BALANCE       0.0000      0.006   0.00

*****************************************************************************

*****************************************************************************
```

```
                ANNUAL TOTALS FOR YEAR 1994
-----------------------------------------------------------------------------
                        MM      CU. METERS  PERCENT
                     ----------    ----------  -------
 PRECIPITATION             155.45     48033.449  100.00

 RUNOFF                  0.000       0.000   0.00

 EVAPOTRANSPIRATION           122.354     37807.461   78.71

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         33.094     10225.938   21.29

 SOIL WATER AT START OF YEAR      1148.934    355020.500

 SOIL WATER AT END OF YEAR       1182.844    365498.875

 SNOW WATER AT START OF YEAR       0.817      252.444   0.53

 SNOW WATER AT END OF YEAR        0.000       0.000   0.00

 ANNUAL WATER BUDGET BALANCE       0.0002      0.049   0.00

*****************************************************************************

*****************************************************************************

                ANNUAL TOTALS FOR YEAR 1995
-----------------------------------------------------------------------------
                        MM      CU. METERS  PERCENT
                     ----------    ----------  -------
 PRECIPITATION             312.67     96616.281  100.00

 RUNOFF                  0.000       0.000   0.00

 EVAPOTRANSPIRATION           277.284     85680.828   88.68

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         35.390     10935.495   11.32

 SOIL WATER AT START OF YEAR      1182.844    365498.875

 SOIL WATER AT END OF YEAR       1217.078    376077.156

 SNOW WATER AT START OF YEAR       0.000       0.000   0.00

 SNOW WATER AT END OF YEAR        1.156      357.202   0.37

 ANNUAL WATER BUDGET BALANCE       -0.0001      -0.040   0.00

*****************************************************************************

*****************************************************************************
```

```
              ANNUAL TOTALS FOR YEAR 1996
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             309.63     95674.461  100.00

 RUNOFF                 65.610     20273.404   21.19

 EVAPOTRANSPIRATION           227.352     70251.898   73.43

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         16.664     5149.148   5.38

 SOIL WATER AT START OF YEAR      1217.078    376077.156

 SOIL WATER AT END OF YEAR       1227.741    379372.094

 SNOW WATER AT START OF YEAR       1.156      357.202   0.37

 SNOW WATER AT END OF YEAR        7.157     2211.420   2.31

 ANNUAL WATER BUDGET BALANCE       0.0000      0.008   0.00

*****************************************************************************

*****************************************************************************

              ANNUAL TOTALS FOR YEAR 1997
-----------------------------------------------------------------------------
                      MM      CU. METERS  PERCENT
                   ----------    ----------  -------
 PRECIPITATION             162.31     50152.562  100.00

 RUNOFF                 10.552     3260.710   6.50

 EVAPOTRANSPIRATION           211.598     65383.777  130.37

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE        -59.844    -18491.941  -36.87

 SOIL WATER AT START OF YEAR      1227.741    379372.094

 SOIL WATER AT END OF YEAR       1175.054    363091.562

 SNOW WATER AT START OF YEAR       7.157     2211.420   4.41

 SNOW WATER AT END OF YEAR        0.000       0.000   0.00

 ANNUAL WATER BUDGET BALANCE       0.0001      0.018   0.00

*****************************************************************************

*****************************************************************************
```

```
                ANNUAL TOTALS FOR YEAR 1998
-------------------------------------------------------------------------------
                        MM      CU. METERS  PERCENT
                    ----------    ----------  -------
 PRECIPITATION             163.83     50623.477  100.00

 RUNOFF                  0.000       0.000   0.00

 EVAPOTRANSPIRATION           171.872     53108.520  104.91

 PERC./LEAKAGE THROUGH LAYER 4      0.000000     0.000   0.00

 CHANGE IN WATER STORAGE         -8.042     -2485.023   -4.91

 SOIL WATER AT START OF YEAR      1175.054    363091.531

 SOIL WATER AT END OF YEAR       1167.011    360606.531

 SNOW WATER AT START OF YEAR       0.000       0.000   0.00

 SNOW WATER AT END OF YEAR        0.000       0.000   0.00

 ANNUAL WATER BUDGET BALANCE       -0.0001      -0.019   0.00

*******************************************************************************


*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         1.463  2.522  0.890  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  5.596

  STD. DEVIATIONS    3.237  5.364  2.108  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  17.697

 EVAPOTRANSPIRATION
 ------------------
  TOTALS         7.993  8.262  19.628  28.162  23.405  25.439
             40.354  9.180  4.610  6.079  7.363  6.983

  STD. DEVIATIONS    2.857  4.458  6.553  14.445  11.762  5.922
             17.727  8.656  4.415  2.366  2.947  2.556

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0302  0.0000  0.0000  0.0000  0.0000  0.0000
```

```
  STD. DEVIATIONS    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
              0.0955  0.0000  0.0000  0.0000  0.0000  0.0000

 ******************************************************************************

*******************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
               --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             10.471  ( 20.3753)    3235.66   5.290

 EVAPOTRANSPIRATION      187.458  ( 48.6162)   57924.66   94.704

 PERCOLATION/LEAKAGE THROUGH   0.03020 ( 0.09550)     9.332   0.01526
  LAYER 4

 CHANGE IN WATER STORAGE    -0.018  ( 1.2773)     -5.51   -0.009

 ******************************************************************************

*******************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ---------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  55.964    17292.7871

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.302006    93.31975

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1912

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

 ******************************************************************************

 ******************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.0122     0.2006

           2      5.0869     0.0636

           3      9.3491     0.0779

           4      98.2529     0.2685

         SNOW WATER    0.000

 ******************************************************************************
 ******************************************************************************
```

D5.2 Output File: Sensitivity Case 1

Section D3.4.2 summarizes the following output file for the Sensitivity Case 1.

```
******************************************************************************
******************************************************************************
**                                    **
**                                    **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HNV-ET45.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\AS1MNV45.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\AS1MNV45.OUT


TIME: 13:25   DATE:  5/11/2010


******************************************************************************

  TITLE: 100 CM SOIL COVER, AVE(MEAN) AREA C SILT w/NO VEG, 45 CM ET

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.

                 LAYER 1
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 60
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3750 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.2180 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC


                 LAYER 2
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 61
      THICKNESS          =   80.00  CM
      POROSITY          =   0.4090 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.1966 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
                 LAYER 3
```

```
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.1090 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2902 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC




         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =   45.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.275 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   17.725 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   2.420 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  139.381 CM
    TOTAL INITIAL WATER         =  139.381 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR



          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  0.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 45.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
    NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
```

```
          WAS ENTERED BY THE USER.



     NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
          WAS ENTERED BY THE USER.



     NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
          WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         2.793  2.026  2.888  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  5.948

  STD. DEVIATIONS    5.869  3.636  5.840  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.001  18.780

 EVAPOTRANSPIRATION
 ------------------
  TOTALS        12.478  13.685  29.085  18.533  14.412  11.374
             13.893  10.729  8.459  9.984  13.722  13.276

  STD. DEVIATIONS    8.124  12.588  16.957  11.343  8.669  3.390
             12.964  7.462  3.666  7.486  8.494  5.396

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.9241  0.8094  0.9165  0.6666  2.2582  1.5515
             1.6682  1.3565  1.3572  1.0479  1.0431  1.0990

  STD. DEVIATIONS    1.1315  0.6215  0.8429  0.6120  5.3270  3.7130
             2.2236  1.9924  2.1048  1.6719  0.9802  1.0696

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
               --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             13.655  ( 23.5692)    4219.36   6.898

 EVAPOTRANSPIRATION      169.630  ( 43.2005)   52415.57   85.697

 PERCOLATION/LEAKAGE THROUGH  14.69804 ( 19.80241)   4541.695   7.42542
  LAYER 4

 CHANGE IN WATER STORAGE    -0.040  ( 1.5752)    -12.47   -0.020

 ******************************************************************************


 *****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  59.396    18353.3574

    PERCOLATION/LEAKAGE THROUGH LAYER 4    1.376966    425.48251

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.3221

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0659

 *****************************************************************************


 *****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.3599     0.2180

           2      15.7178     0.1965

           3      13.0650     0.1089

           4     106.1981     0.2902

         SNOW WATER    0.000

 *****************************************************************************
 *****************************************************************************
```

D5.3 Output File: Sensitivity Case 2

Section D3.4.3 summarizes the following output file for the Sensitivity Case 2.

```
******************************************************************************
******************************************************************************
**                                      **
**                                      **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HGVET100.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\AS1MGV1M.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\AS1MGV1M.OUT


TIME: 13:24   DATE:  5/11/2010

******************************************************************************

  TITLE: 100 CM SOIL COVER, AVE(MEAN) AREA C SILT w/GOOD VEG, ET100CM

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 60
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3750 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.2006 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC


                 LAYER 2
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 61
      THICKNESS          =   80.00  CM
      POROSITY          =   0.4090 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0636 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
```

```
                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0779 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2685 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC




         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.100 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   40.220 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  116.719 CM
    TOTAL INITIAL WATER         =  116.719 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  2.14
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 100.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
    NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
```

```
          WAS ENTERED BY THE USER.



     NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
          WAS ENTERED BY THE USER.



     NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
          WAS ENTERED BY THE USER.


*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         1.460  3.639  0.847  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  5.594

  STD. DEVIATIONS    3.225  7.460  2.117  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  17.691

 EVAPOTRANSPIRATION
 ------------------
  TOTALS         7.817  7.532  17.744  28.158  31.445  53.994
             10.419  4.617  4.587  5.914  7.372  6.792

  STD. DEVIATIONS    2.653  4.353  7.735  13.690  13.787  17.069
             12.888  4.699  5.457  2.280  2.883  2.293

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0000  0.0000  0.0000  0.0000  0.0302  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.0000  0.0000  0.0000  0.0000  0.0955  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
              --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             11.540  ( 23.6188)    3565.94   5.830

 EVAPOTRANSPIRATION      186.389  ( 48.3243)   57594.34   94.164

 PERCOLATION/LEAKAGE THROUGH   0.03020 ( 0.09551)     9.333   0.01526
  LAYER 4

 CHANGE IN WATER STORAGE    -0.018  ( 1.2738)     -5.47   -0.009

 ******************************************************************************


 ****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ---------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  55.945    17286.9355

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.302036    93.32915

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1905

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

 ****************************************************************************


 ****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.0121     0.2006

           2      5.0866     0.0636

           3      9.3492     0.0779

           4      98.2534     0.2685

         SNOW WATER    0.000

 ****************************************************************************
 ****************************************************************************
```

D5.4 Output File: Sensitivity Case 3

Section D3.4.4 summarizes the following output file for the Sensitivity Case 3.

```
******************************************************************************
******************************************************************************
**                                    **
**                                    **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET120.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\AS120P12.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\AS120P12.OUT


TIME: 13:23   DATE:  5/11/2010


******************************************************************************

  TITLE: 120 CM SOIL COVER AVE.(MEAN) AREA C SILT w/ P.VEG, ET 120 CM

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 60
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3750 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.2139 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC


                 LAYER 2
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 61
      THICKNESS          =  100.00  CM
      POROSITY          =   0.4090 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0594 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
```

```

                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0779 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2684 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC




         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  120.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   10.218 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   48.400 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   6.620 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  117.800 CM
    TOTAL INITIAL WATER         =  117.800 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 120.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         1.290  4.132  0.613  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  5.705

  STD. DEVIATIONS    2.844  8.787  1.634  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  17.588

 EVAPOTRANSPIRATION
 ------------------
  TOTALS        11.713  10.785  24.113  29.581  22.342  24.411
             27.319  6.867  3.939  5.876  10.098  9.147

  STD. DEVIATIONS    5.113  5.322  8.725  16.514  13.339  5.061
             24.686  6.103  3.648  3.406  4.074  3.844

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0301  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.0952  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
               --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             11.741  ( 25.0282)    3627.85   5.931

 EVAPOTRANSPIRATION      186.192  ( 46.4426)   57533.19   94.064

 PERCOLATION/LEAKAGE THROUGH   0.03012 ( 0.09523)     9.306   0.01521
  LAYER 4

 CHANGE IN WATER STORAGE    -0.020  ( 1.3027)     -6.21   -0.010

 ******************************************************************************


 *****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  55.749    17226.4219

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.301156    93.05718

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1675

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0552

 *****************************************************************************


 *****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.2780     0.2139

           2      5.9393     0.0594

           3      9.3465     0.0779

           4      98.2165     0.2684

         SNOW WATER    0.000

 *****************************************************************************
 *****************************************************************************
```

D5.5 Output File: Sensitivity Case 4

Section D3.4.5 summarizes the following output file for the Sensitivity Case 4.

```
******************************************************************************
******************************************************************************
**                                    **
**                                    **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET100.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\CS1MPV1M.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\CS1MPV1M.OUT


TIME: 13:26   DATE:  5/11/2010


******************************************************************************

  TITLE: 100 CM SOIL COVER, COMPOSITE AREA C BLEND w/POOR VEG,ET100CM

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 62
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3630 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.1716 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.341000014000E-04 CM/SEC


                 LAYER 2
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 63
      THICKNESS          =   80.00  CM
      POROSITY          =   0.4020 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0627 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.395999996000E-04 CM/SEC
```

```

                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0836 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2919 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC



         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   8.448 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   39.420 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  125.315 CM
    TOTAL INITIAL WATER         =  125.315 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR



          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 100.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         1.593  1.105  0.841  0.000  0.000  0.025
             0.000  0.000  0.000  0.000  0.000  3.928

  STD. DEVIATIONS    3.696  2.268  2.022  0.000  0.000  0.078
             0.000  0.000  0.000  0.000  0.000  12.420

 EVAPOTRANSPIRATION
 ------------------
  TOTALS        12.834  12.240  25.649  29.044  21.303  24.111
             25.670  7.825  3.670  6.259  11.560  10.166

  STD. DEVIATIONS    5.712  6.876  10.897  16.538  13.657  7.276
             24.741  7.538  3.959  3.658  3.773  2.764

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0598  0.0000  0.0000  0.0599  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.1892  0.0000  0.0000  0.1894  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
               --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             7.491  ( 14.8456)    2314.69   3.784

 EVAPOTRANSPIRATION      190.332  ( 48.9546)   58812.65   96.155

 PERCOLATION/LEAKAGE THROUGH   0.11973 ( 0.25242)    36.997   0.06049
  LAYER 4

 CHANGE IN WATER STORAGE    -0.001  ( 1.5485)     -0.18   0.000

 ******************************************************************************


 *****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  39.276    12136.3164

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.598947    185.07451

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.2007

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

 *****************************************************************************


 *****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      3.4328     0.1716

           2      5.0122     0.0627

           3      10.0346     0.0836

           4     106.8351     0.2919

         SNOW WATER    0.000

 *****************************************************************************
 *****************************************************************************
```

D5.6 Output File: Sensitivity Case 5

Section D3.4.6 summarizes the following output file for the Sensitivity Case 5.

```
******************************************************************************
******************************************************************************
**                                    **
**                                    **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET120.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\C120P120.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\C120P120.OUT

TIME: 13:26   DATE:  5/11/2010


******************************************************************************

  TITLE: 120 CM SOIL COVER, COMPOSITE AREA C BLEND w/POOR VEG,ET120CM

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 62
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3630 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.1877 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.341000014000E-04 CM/SEC


                 LAYER 2
                 --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 63
      THICKNESS          =  100.00  CM
      POROSITY          =   0.4020 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0620 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.395999996000E-04 CM/SEC
```

```
                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0828 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2913 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC



         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  120.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.954 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   47.460 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   6.620 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  126.506 CM
    TOTAL INITIAL WATER         =  126.506 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR



          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 120.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*****************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         1.380  0.980  0.660  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  3.859

  STD. DEVIATIONS    3.164  2.033  1.612  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  12.204

 EVAPOTRANSPIRATION
 ------------------
  TOTALS        13.267  11.969  24.828  28.639  20.939  24.350
             26.844  7.779  4.197  6.391  11.502  10.354

  STD. DEVIATIONS    6.200  6.225  12.314  16.085  11.470  6.514
             26.123  8.210  5.512  4.019  4.470  4.068

 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

*****************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
                 --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             6.879  ( 14.2151)    2125.50   3.475

 EVAPOTRANSPIRATION      191.058  ( 49.7146)   59036.78   96.522

 PERCOLATION/LEAKAGE THROUGH   0.00000 ( 0.00000)     0.000   0.00000
  LAYER 4

 CHANGE IN WATER STORAGE     0.006  ( 1.5543)     1.86   0.003

 ******************************************************************************


 ****************************************************************************

         PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               35.31     10909.554

    RUNOFF                  38.592    11924.8906

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.000000     0.00000

    SNOW WATER                49.93     15428.7139


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1790

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0552

 ****************************************************************************


 ****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      3.7550     0.1877

           2      6.2006     0.0620

           3      9.9405     0.0828

           4     106.6158     0.2913

         SNOW WATER    0.000

 ****************************************************************************
 ****************************************************************************
```

D5.7 Output File: Sensitivity Case 6

Section D3.4.7 summarizes the following output file for the Sensitivity Case 6.

```
 ******************************************************************************
 ******************************************************************************
 **                                    **
 **                                    **
 **       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:\HELP3\COMBINED\HANFORDP.D4
 TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
 SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
 EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET100.D11
 SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\1MPVRC85.D10
 OUTPUT DATA FILE:      C:\HELP3\COMBINED\1MPVRC85.OUT


 TIME: 13:22   DATE:  5/11/2010

 ******************************************************************************

   TITLE: 100 CM SOIL COVER, AVE AREA C SILT, P.VEG,100% RUNOFF,RCN=85

 ******************************************************************************

   NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
        WERE SPECIFIED BY THE USER.


                  LAYER 1
                  --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 60
       THICKNESS          =   20.00  CM
       POROSITY          =   0.3750 VOL/VOL
       FIELD CAPACITY       =   0.2100 VOL/VOL
       WILTING POINT        =   0.0510 VOL/VOL
       INITIAL SOIL WATER CONTENT =   0.2006 VOL/VOL
       EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC


                   LAYER 2
                  --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 61
       THICKNESS          =   80.00  CM
       POROSITY          =   0.4090 VOL/VOL
       FIELD CAPACITY       =   0.2290 VOL/VOL
       WILTING POINT        =   0.0560 VOL/VOL
       INITIAL SOIL WATER CONTENT =   0.0636 VOL/VOL
       EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
```

```
                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0778 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2681 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC



         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   85.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.100 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   40.220 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  116.561 CM
    TOTAL INITIAL WATER         =  116.561 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR



          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 100.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         3.790  3.281  2.366  0.000  0.000  0.000
             0.001  0.000  0.000  0.000  0.000  5.450

  STD. DEVIATIONS    7.626  6.376  4.506  0.000  0.000  0.000
             0.002  0.000  0.000  0.000  0.000  16.378

 EVAPOTRANSPIRATION
 ------------------
  TOTALS         7.734  7.502  19.591  27.562  23.715  27.235
             36.689  8.179  4.618  6.061  7.337  6.803

  STD. DEVIATIONS    2.564  3.665  6.703  15.105  11.392  5.359
             16.843  8.472  4.413  2.366  2.914  2.365

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0298  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0943  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
               --------------------   -----------  ---------
 PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

 RUNOFF             14.888  ( 23.4037)    4600.38   7.521

 EVAPOTRANSPIRATION      183.025  ( 45.6324)   56554.75   92.464

 PERCOLATION/LEAKAGE THROUGH   0.02983 ( 0.09433)     9.218   0.01507
  LAYER 4

 CHANGE IN WATER STORAGE    -0.001  ( 1.3096)     -0.20   0.000

 ******************************************************************************


 ****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
   PRECIPITATION               35.31     10909.554

   RUNOFF                  52.012    16071.5830

   PERCOLATION/LEAKAGE THROUGH LAYER 4    0.298308    92.17728

   SNOW WATER                49.93     15428.7139


   MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1823

   MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

 ****************************************************************************


 ****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.0118     0.2006

           2      5.0869     0.0636

           3      9.3399     0.0778

           4      98.1214     0.2681

         SNOW WATER    0.000

 ****************************************************************************
 ***************************************************************************
```

D5.8 Output File: Sensitivity Case 7

Section D3.4.8 summarizes the following output file for the Sensitivity Case 7.

```
******************************************************************************
******************************************************************************
**                                      **
**                                      **
**       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:\HELP3\COMBINED\HANFORDP.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET100.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\1MPVRO10.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\1MPVRO10.OUT


TIME: 13:23   DATE:  5/11/2010

******************************************************************************

  TITLE: 100 CM SOIL COVER, AVE AREA C SILT, P.VEG, 10% RUNOFF,RCN=75

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 60
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3750 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.2006 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC



                 LAYER 2
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 61
      THICKNESS          =   80.00  CM
      POROSITY          =   0.4090 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0636 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
```

```

                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0779 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC



                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2684 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC



         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =   10.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.100 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   40.220 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  116.682 CM
    TOTAL INITIAL WATER         =  116.682 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 100.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  26.54  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  18.50  28.07

 RUNOFF
 ------
  TOTALS         5.864  2.189  0.744  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  0.940

  STD. DEVIATIONS    13.108  4.301  2.288  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  2.973

 EVAPOTRANSPIRATION
 ------------------
  TOTALS         9.357  9.264  18.953  26.838  22.772  26.600
             40.307  9.253  4.603  6.062  7.363  6.812

  STD. DEVIATIONS    3.850  4.344  7.925  15.435  12.383  6.649
             14.953  7.023  4.425  2.356  2.939  2.362

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0301  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.0952  0.0000  0.0000  0.0000  0.0000  0.0000
             0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
                    MM       CU. METERS   PERCENT
                 --------------------   -----------  ---------
PRECIPITATION         197.94  ( 63.124)   61164.2   100.00

RUNOFF             9.736  ( 14.5784)    3008.51   4.919

EVAPOTRANSPIRATION      188.185  ( 48.2721)   58149.16   95.071

PERCOLATION/LEAKAGE THROUGH   0.03012 ( 0.09523)     9.306   0.01521
 LAYER 4

CHANGE IN WATER STORAGE    -0.009  ( 1.8960)     -2.84   -0.005

*****************************************************************************


*****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------
                        (MM)    (CU. METERS)
                      ----------  ------------
   PRECIPITATION               35.31     10909.554

   RUNOFF                   9.403     2905.4114

   PERCOLATION/LEAKAGE THROUGH LAYER 4    0.301156    93.05718

   SNOW WATER                49.93     15428.7139


   MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.1930

   MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

*****************************************************************************


*****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
  ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.0122     0.2006

           2      5.0869     0.0636

           3      9.3473     0.0779

           4      98.2267     0.2684

         SNOW WATER    0.000

*****************************************************************************
*****************************************************************************
```

D5.9 Output File: Extreme Storm Event

Section D3.4.9 summarizes the following output file for the extreme storm event case.

```
******************************************************************************
******************************************************************************
**                                      **
**                                      **
**       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:\HELP3\COMBINED\HNFD1000.D4
TEMPERATURE DATA FILE:   C:\HELP3\COMBINED\HANFORDT.D7
SOLAR RADIATION DATA FILE: C:\HELP3\COMBINED\HANFORDS.D13
EVAPOTRANSPIRATION DATA:  C:\HELP3\COMBINED\HPVET100.D11
SOIL AND DESIGN DATA FILE: C:\HELP3\COMBINED\AS1M1000.D10
OUTPUT DATA FILE:      C:\HELP3\COMBINED\AS1M1000.OUT


TIME: 13:25   DATE:  5/11/2010

******************************************************************************

  TITLE: 100CM SOIL COVER, AVE AREA C SILT, P.VEG,ET100CM,1000yrSTORM

******************************************************************************

  NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
       WERE SPECIFIED BY THE USER.


                 LAYER 1
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 60
      THICKNESS          =   20.00  CM
      POROSITY          =   0.3750 VOL/VOL
      FIELD CAPACITY       =   0.2100 VOL/VOL
      WILTING POINT        =   0.0510 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.2005 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.130999997000E-04 CM/SEC


                 LAYER 2
                 --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER 61
      THICKNESS          =   80.00  CM
      POROSITY          =   0.4090 VOL/VOL
      FIELD CAPACITY       =   0.2290 VOL/VOL
      WILTING POINT        =   0.0560 VOL/VOL
      INITIAL SOIL WATER CONTENT =   0.0635 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  = 0.153000001000E-04 CM/SEC
```

```
                    LAYER 3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  3
     THICKNESS          =  120.00  CM
     POROSITY          =   0.4570 VOL/VOL
     FIELD CAPACITY       =   0.0830 VOL/VOL
     WILTING POINT        =   0.0330 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.0784 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.310000009000E-02 CM/SEC


                    LAYER 4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 18
     THICKNESS          =  366.00  CM
     POROSITY          =   0.6710 VOL/VOL
     FIELD CAPACITY       =   0.2920 VOL/VOL
     WILTING POINT        =   0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT =   0.2685 VOL/VOL
     EFFECTIVE SAT. HYD. COND.  = 0.100000005000E-02 CM/SEC




         GENERAL DESIGN AND EVAPORATIVE ZONE DATA
         ----------------------------------------

    NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

    SCS RUNOFF CURVE NUMBER       =   75.00
    FRACTION OF AREA ALLOWING RUNOFF  =  100.0  PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =   30.9000 HECTARES
    EVAPORATIVE ZONE DEPTH       =  100.0  CM
    INITIAL WATER IN EVAPORATIVE ZONE  =   9.090 CM
    UPPER LIMIT OF EVAPORATIVE STORAGE =   40.220 CM
    LOWER LIMIT OF EVAPORATIVE STORAGE =   5.500 CM
    INITIAL SNOW WATER         =   0.000 CM
    INITIAL WATER IN LAYER MATERIALS  =  116.769 CM
    TOTAL INITIAL WATER         =  116.769 CM
    TOTAL SUBSURFACE INFLOW       =   0.00  MM/YR


          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

    NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         HANFORD CP      WASHINGTON

      STATION LATITUDE            = 46.51 DEGREES
      MAXIMUM LEAF AREA INDEX        =  1.00
      START OF GROWING SEASON (JULIAN DATE) =   98
      END OF GROWING SEASON (JULIAN DATE)  =  304
      EVAPORATIVE ZONE DEPTH         = 100.0 CM
      AVERAGE ANNUAL WIND SPEED       = 12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %
```

```
   NOTE: PRECIPITATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: TEMPERATURE DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



   NOTE: SOLAR RADIATION DATA FOR   Hanford CP     Washington
        WAS ENTERED BY THE USER.



*******************************************************************************

      AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

            JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
            ------- ------- ------- ------- ------- -------
 PRECIPITATION
 -------------
  TOTALS        24.89  19.00  16.64  16.05  15.42  13.23
             9.50   4.75   4.67  16.03  27.61  31.22

  STD. DEVIATIONS    16.14  14.30  12.55  10.38   8.48  11.93
             12.72   6.14   6.15   7.50  21.25  28.07

 RUNOFF
 ------
  TOTALS         1.535  2.537  0.890  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  5.616

  STD. DEVIATIONS    3.438  5.359  2.108  0.000  0.000  0.000
             0.000  0.000  0.000  0.000  0.000  17.759

 EVAPOTRANSPIRATION
 ------------------
  TOTALS         8.003  8.341  19.941  28.228  23.298  25.440
             40.094  10.025  4.612  6.088  7.304  6.986

  STD. DEVIATIONS    2.867  4.530  6.670  14.471  11.779  5.919
             18.008  9.119  4.416  2.365  2.922  2.539

 PERCOLATION/LEAKAGE THROUGH LAYER 4
 -----------------------------------
  TOTALS         0.0302  0.0000  0.0302  0.0000  0.0000  0.0000
             0.0302  0.0000  0.0000  0.0000  0.0000  0.0000

  STD. DEVIATIONS    0.0955  0.0000  0.0955  0.0000  0.0000  0.0000
             0.0955  0.0000  0.0000  0.0000  0.0000  0.0000

*******************************************************************************
```

```
*****************************************************************************

  AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                   MM       CU. METERS   PERCENT
              --------------------   -----------  ---------
 PRECIPITATION         199.01  ( 65.274)   61493.8   100.00

 RUNOFF             10.579  ( 20.4365)    3268.76   5.316

 EVAPOTRANSPIRATION      188.359  ( 49.2049)   58202.85   94.648

 PERCOLATION/LEAKAGE THROUGH   0.09062 ( 0.14591)    28.001   0.04553
  LAYER 4

 CHANGE IN WATER STORAGE    -0.019  ( 1.4053)     -5.82   -0.009

 ******************************************************************************


 ****************************************************************************

        PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                         (MM)    (CU. METERS)
                       ----------  ------------
    PRECIPITATION               45.97     14205.966

    RUNOFF                  56.160    17353.4180

    PERCOLATION/LEAKAGE THROUGH LAYER 4    0.302115    93.35341

    SNOW WATER                54.09     16714.8359


    MAXIMUM VEG. SOIL WATER (VOL/VOL)         0.2014

    MINIMUM VEG. SOIL WATER (VOL/VOL)         0.0550

 ****************************************************************************


 ****************************************************************************

         FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
          LAYER     (CM)     (VOL/VOL)
          -----     ------    ---------
           1      4.0092     0.2005

           2      5.0790     0.0635

           3      9.4067     0.0784

           4      98.2552     0.2685

         SNOW WATER    0.000

 ****************************************************************************
 ***************************************************************************


   ******************************************************************************
```

```
******************************************************************************
**                                                                          **
**                                                                          **
**          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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPVET100.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS45P100.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS45P100.OUT



TIME:   8:36     DATE:   2/ 2/2010



******************************************************************************

   TITLE:  45 CM SOIL COVER (AVE.[MEAN] AREA C SILT) w/POOR VEG,ET100CM

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                        LAYER  1
                        --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  60
          THICKNESS              =    20.00   CM
          POROSITY               =     0.3750 VOL/VOL
          FIELD CAPACITY         =     0.2100 VOL/VOL
          WILTING POINT          =     0.0510 VOL/VOL
```

```
INITIAL SOIL WATER CONTENT  =      0.1931 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                LAYER  2
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  61
THICKNESS              =     25.00   CM
POROSITY               =      0.4090 VOL/VOL
FIELD CAPACITY         =      0.2290 VOL/VOL
WILTING POINT          =      0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0678 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                LAYER  3
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   3
THICKNESS              =    120.00   CM
POROSITY               =      0.4570 VOL/VOL
FIELD CAPACITY         =      0.0830 VOL/VOL
WILTING POINT          =      0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0765 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                LAYER  4
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  18
THICKNESS              =    366.00   CM
POROSITY               =      0.6710 VOL/VOL
FIELD CAPACITY         =      0.2920 VOL/VOL
WILTING POINT          =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2888 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

      SCS RUNOFF CURVE NUMBER            =     75.00
      FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
      EVAPORATIVE ZONE DEPTH             =    100.0    CM
      INITIAL WATER IN EVAPORATIVE ZONE   =      9.764  CM
      UPPER LIMIT OF EVAPORATIVE STORAGE  =     42.860  CM
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.235  CM
      INITIAL SNOW WATER                 =      0.000  CM
      INITIAL WATER IN LAYER MATERIALS    =    120.438  CM
      TOTAL INITIAL WATER                =    120.438  CM
      TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR



                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                  =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              = 100.0  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP          Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP          Washington
              WAS ENTERED BY THE USER.



        NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
```

```
                WAS ENTERED BY THE USER.



*****************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.390    4.145    0.662    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.585

  STD. DEVIATIONS      3.096    8.758    1.773    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.660

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              14.277   11.344   26.494   25.988   19.663   21.270
                      14.849    5.491    4.155    6.974   13.496   12.137

  STD. DEVIATIONS      6.544    6.634   15.732   14.961   11.898    8.676
                      12.700    6.320    5.446    5.643    5.851    5.087

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.5423   0.3788   0.6513   0.2735   0.7469   0.5571
                       0.9430   1.4325   1.7679   1.2610   0.8143   0.6528

  STD. DEVIATIONS      0.6273   0.5125   0.7970   0.2883   1.6388   0.9510
                       1.8301   1.6483   2.2936   1.4739   0.8962   0.7174

*****************************************************************************



*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
```

```
                                MM            CU. METERS     PERCENT
                        --------------------    -----------   ---------
PRECIPITATION                197.94    (  63.124)       8115.6     100.00

RUNOFF                        11.782   ( 25.0975)        483.05      5.952

EVAPOTRANSPIRATION           176.139   ( 40.5007)       7221.68     88.985

PERCOLATION/LEAKAGE THROUGH    10.02142 ( 11.32886)       410.878     5.06280
  LAYER  4

CHANGE IN WATER STORAGE        0.000   (  1.3476)          0.02      0.000

*******************************************************************************
```

```
*****************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ------------------------------------------------------------------------
                                  (MM)      (CU. METERS)
                                ----------  ------------
     PRECIPITATION                          35.31        1447.546

     RUNOFF                            55.845        2289.6521

     PERCOLATION/LEAKAGE THROUGH LAYER  4      1.093998       44.85392

     SNOW WATER                          49.93        2047.1757


     MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.1694

     MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0424

*****************************************************************************



****************************************************************************

              FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
              LAYER        (CM)        (VOL/VOL)
              -----       ------       ---------
                1          3.8614       0.1931

                2          1.6957       0.0678

                3          9.1811       0.0765

                4        105.7000       0.2888

             SNOW WATER      0.000

****************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**          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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\T\HPV-ET42.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\T\AS-PV-24.D10
OUTPUT DATA FILE:           C:\HELP3\T\PV42AS24.OUT



TIME:  16:36     DATE:  12/21/2009



******************************************************************************

    TITLE:  24-INCH SOIL COVER (AVE.[Mean] AREA C SILT PROP w/ POOR VEG)

******************************************************************************



    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
           WERE SPECIFIED BY THE USER.



                    LAYER  1
                    --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
        THICKNESS              =     8.00   INCHES
        POROSITY               =     0.3750 VOL/VOL
        FIELD CAPACITY         =     0.2100 VOL/VOL
```

```
WILTING POINT              =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2019 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                =    16.00   INCHES
POROSITY                 =     0.4090 VOL/VOL
FIELD CAPACITY             =     0.2290 VOL/VOL
WILTING POINT              =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0650 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   3
THICKNESS                =    48.00   INCHES
POROSITY                 =     0.4570 VOL/VOL
FIELD CAPACITY             =     0.0830 VOL/VOL
WILTING POINT              =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0817 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  18
THICKNESS                =   144.00   INCHES
POROSITY                 =     0.6710 VOL/VOL
FIELD CAPACITY             =     0.2920 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2876 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

        SCS RUNOFF CURVE NUMBER            =     75.00
        FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE  =     10.000  ACRES
        EVAPORATIVE ZONE DEPTH             =     42.0    INCHES
        INITIAL WATER IN EVAPORATIVE ZONE   =      4.126  INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE  =     17.770  INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.898  INCHES
        INITIAL SNOW WATER                 =      0.000  INCHES
        INITIAL WATER IN LAYER MATERIALS    =     47.991  INCHES
        TOTAL INITIAL WATER                =     47.991  INCHES
        TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR



                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                    =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              = 106.7  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.
```

```
NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.



*******************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.340    4.137    0.624    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.580

  STD. DEVIATIONS      2.977    8.766    1.669    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.645

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              13.765   11.123   24.937   27.534   21.078   24.298
                      19.242    5.508    4.260    6.939   12.849   11.425

  STD. DEVIATIONS      6.459    6.123   14.443   15.765   11.606    6.944
                      17.462    6.436    5.549    5.405    6.036    5.453

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.2674   0.1054   0.2122   0.1061   0.1060   0.2557
                       0.0528   0.3710   0.5517   0.6519   0.3750   0.2649

  STD. DEVIATIONS      0.6798   0.3332   0.5125   0.3354   0.3353   0.6443
                       0.1670   1.0011   1.5687   1.7227   1.0146   0.6730

*******************************************************************************
```

```
*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8010.6     100.00

RUNOFF                      11.681   ( 25.0873)       472.71      5.901

EVAPOTRANSPIRATION         182.957   ( 45.9068)      7404.17     92.430

PERCOLATION/LEAKAGE THROUGH     3.31993 (  7.28641)      134.356     1.67722
 LAYER  4

CHANGE IN WATER STORAGE       -0.016   (  1.3414)        -0.63     -0.008

*****************************************************************************



*****************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -------------------------------------------------------------------
                                 (MM)      (CU. METERS)
                              ----------   ------------
    PRECIPITATION                      35.31        1428.814

    RUNOFF                            55.797        2258.0688

    PERCOLATION/LEAKAGE THROUGH LAYER  4      1.103346       44.65179

    SNOW WATER                         49.93        2020.6846


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.1684

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0452

*****************************************************************************
```

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.1032        0.2019

                   2         2.6403        0.0650

                   3         9.9634        0.0817

                   4        105.1752        0.2876

                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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPV-ET65.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS65PV65.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS65PV65.OUT



TIME:  13:24     DATE:   2/ 4/2010



******************************************************************************

   TITLE:  65 CM SOIL COVER (AVE.[MEAN] AREA C SILT) w/POOR VEG, ET65CM

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                    LAYER  1
                    --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  60
        THICKNESS              =    20.00   CM
        POROSITY               =    0.3750 VOL/VOL
        FIELD CAPACITY         =    0.2100 VOL/VOL
```

```
WILTING POINT              =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2174 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  61
THICKNESS                =    45.00   CM
POROSITY                 =     0.4090 VOL/VOL
FIELD CAPACITY             =     0.2290 VOL/VOL
WILTING POINT              =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0631 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   3
THICKNESS                =   120.00   CM
POROSITY                 =     0.4570 VOL/VOL
FIELD CAPACITY             =     0.0830 VOL/VOL
WILTING POINT              =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0954 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  18
THICKNESS                =   366.00   CM
POROSITY                 =     0.6710 VOL/VOL
FIELD CAPACITY             =     0.2920 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2919 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER            =     75.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
EVAPORATIVE ZONE DEPTH             =     65.0    CM
INITIAL WATER IN EVAPORATIVE ZONE   =      7.188  CM
UPPER LIMIT OF EVAPORATIVE STORAGE  =     25.905  CM
LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.540  CM
INITIAL SNOW WATER                 =      0.000  CM
INITIAL WATER IN LAYER MATERIALS    =    125.471  CM
TOTAL INITIAL WATER                =    125.471  CM
TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR



        EVAPOTRANSPIRATION AND WEATHER DATA
        -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
       HANFORD CP          WASHINGTON

   STATION LATITUDE                    =  46.51 DEGREES
   MAXIMUM LEAF AREA INDEX             =   1.00
   START OF GROWING SEASON (JULIAN DATE)  =     98
   END OF GROWING SEASON (JULIAN DATE)    =    304
   EVAPORATIVE ZONE DEPTH              =  65.0  CM
   AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
   AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
   AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
   AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
   AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.



NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.
```

```
NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.



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        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               2.096    2.739    1.432    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.627

  STD. DEVIATIONS      4.533    5.522    3.132    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.796

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              10.156   10.912   24.958   25.219   19.356   25.606
                      35.221    4.098    4.409    6.505    8.763    9.768

  STD. DEVIATIONS      5.322    7.380   13.894   16.564    9.864    5.350
                      17.728    2.836    4.137    4.386    3.985    2.683

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.1812   0.0608   0.0607   0.0607   0.1209   0.0608
                       0.2413   0.0608   0.1207   0.0007   0.0000   0.1215

  STD. DEVIATIONS      0.2918   0.1921   0.1921   0.1921   0.2548   0.1922
                       0.3116   0.1921   0.2545   0.0022   0.0000   0.2562

*****************************************************************************



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   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
```

```
-------------------------------------------------------------------------------
                                MM            CU. METERS     PERCENT
                        --------------------   -----------   ---------
PRECIPITATION                197.94    (  63.124)      8115.6     100.00

RUNOFF                       11.894   ( 21.1071)       487.66      6.009

EVAPOTRANSPIRATION           184.971   ( 49.6730)      7583.80     93.447

PERCOLATION/LEAKAGE THROUGH     1.09014 (  0.38567)       44.696     0.55074
  LAYER  4

CHANGE IN WATER STORAGE       -0.013   (  1.2969)        -0.52     -0.006

*******************************************************************************
```

****

PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998

	(MM)	(CU. METERS)
PRECIPITATION	35.31	1447.546
RUNOFF	56.274	2307.2542
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.607788	24.91929
SNOW WATER	49.93	2047.1757

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2510

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0545

****

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                LAYER        (CM)        (VOL/VOL)
                -----       ------       ---------
                  1          4.3483        0.2174

                  2          2.8380        0.0631

                  3         11.4449        0.0954

                  4        106.8271        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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPV-ET70.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS70PV70.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS70PV70.OUT



TIME:   9:13     DATE:   2/ 4/2010



******************************************************************************

   TITLE:  70 CM SOIL COVER (AVE.[MEAN] AREA C SILT) w/POOR VEG, ET70CM

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                    LAYER  1
                    --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  60
        THICKNESS              =    20.00   CM
        POROSITY               =    0.3750 VOL/VOL
        FIELD CAPACITY         =    0.2100 VOL/VOL
```

```
WILTING POINT              =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2086 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  61
THICKNESS                =    50.00   CM
POROSITY                 =     0.4090 VOL/VOL
FIELD CAPACITY             =     0.2290 VOL/VOL
WILTING POINT              =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0650 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   3
THICKNESS                =   120.00   CM
POROSITY                 =     0.4570 VOL/VOL
FIELD CAPACITY             =     0.0830 VOL/VOL
WILTING POINT              =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0852 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  18
THICKNESS                =   366.00   CM
POROSITY                 =     0.6710 VOL/VOL
FIELD CAPACITY             =     0.2920 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2700 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER            =     75.00
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
EVAPORATIVE ZONE DEPTH             =     70.0    CM
INITIAL WATER IN EVAPORATIVE ZONE   =      7.422  CM
UPPER LIMIT OF EVAPORATIVE STORAGE  =     27.950  CM
LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.820  CM
INITIAL SNOW WATER                 =      0.000  CM
INITIAL WATER IN LAYER MATERIALS    =    116.466  CM
TOTAL INITIAL WATER                =    116.466  CM
TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR



        EVAPOTRANSPIRATION AND WEATHER DATA
        -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
       HANFORD CP          WASHINGTON

   STATION LATITUDE                    =  46.51 DEGREES
   MAXIMUM LEAF AREA INDEX             =   1.00
   START OF GROWING SEASON (JULIAN DATE)  =     98
   END OF GROWING SEASON (JULIAN DATE)    =    304
   EVAPORATIVE ZONE DEPTH              =  70.0  CM
   AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
   AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
   AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
   AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
   AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.



NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.
```

```
NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.



*****************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
  PRECIPITATION
  -------------
   TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

   STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

  RUNOFF
  ------
   TOTALS               1.989    2.684    1.295    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.624

   STD. DEVIATIONS      4.307    5.466    2.876    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.786

  EVAPOTRANSPIRATION
  ------------------
   TOTALS               9.895   10.472   23.964   26.461   19.268   25.667
                      36.823    4.572    4.463    6.432    8.560    9.384

   STD. DEVIATIONS      5.058    6.929   12.839   17.562    8.115    4.693
                      18.867    3.255    4.258    3.962    3.869    2.403

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  -------------------------------------
   TOTALS               0.0632   0.0000   0.0317   0.0317   0.0000   0.0000
                       0.0000   0.0633   0.0633   0.0000   0.0317   0.0950

   STD. DEVIATIONS      0.1333   0.0000   0.1001   0.1001   0.0000   0.0000
                       0.0000   0.1334   0.1335   0.0000   0.1002   0.1529

*****************************************************************************
```

```
*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8115.6     100.00

RUNOFF                     11.593   ( 20.8935)       475.33      5.857

EVAPOTRANSPIRATION         185.961   ( 50.4710)      7624.38     93.947

PERCOLATION/LEAKAGE THROUGH     0.37983 (  0.24961)       15.573     0.19189
 LAYER  4

CHANGE IN WATER STORAGE        0.008   (  1.3240)        0.35      0.004

*****************************************************************************



*****************************************************************************

          PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -----------------------------------------------------------------------
                                (MM)      (CU. METERS)
                              ----------   ------------
    PRECIPITATION                      35.31        1447.546

    RUNOFF                           56.245        2306.0415

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.316969       12.99572

    SNOW WATER                         49.93        2047.1757


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.2380

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0546

*****************************************************************************
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```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1          4.1730        0.2086

                   2          3.2505        0.0650

                   3         10.2226        0.0852

                   4         98.8284        0.2700

                SNOW WATER       0.000

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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                  **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************



PRECIPITATION DATA FILE:    C:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPV-ET75.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS75PV75.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS75PV75.OUT



TIME:  13:21     DATE:   2/ 1/2010



******************************************************************************

   TITLE:  75 CM SOIL COVER (AVE.[MEAN] AREA C SILT) w/POOR VEG, ET75CM

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                    LAYER  1
                    --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  60
        THICKNESS              =    20.00   CM
        POROSITY               =    0.3750 VOL/VOL
        FIELD CAPACITY         =    0.2100 VOL/VOL
```

```
WILTING POINT              =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2011 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  61
THICKNESS                =    55.00   CM
POROSITY                 =     0.4090 VOL/VOL
FIELD CAPACITY             =     0.2290 VOL/VOL
WILTING POINT              =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0662 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   3
THICKNESS                =   120.00   CM
POROSITY                 =     0.4570 VOL/VOL
FIELD CAPACITY             =     0.0830 VOL/VOL
WILTING POINT              =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0795 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  18
THICKNESS                =   366.00   CM
POROSITY                 =     0.6710 VOL/VOL
FIELD CAPACITY             =     0.2920 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2689 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

        SCS RUNOFF CURVE NUMBER            =     75.00
        FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
        EVAPORATIVE ZONE DEPTH             =     75.0    CM
        INITIAL WATER IN EVAPORATIVE ZONE   =      7.663  CM
        UPPER LIMIT OF EVAPORATIVE STORAGE  =     29.995  CM
        LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.100  CM
        INITIAL SNOW WATER                 =      0.000  CM
        INITIAL WATER IN LAYER MATERIALS    =    115.620  CM
        TOTAL INITIAL WATER                =    115.620  CM
        TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR



                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                    =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              =  75.0  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.
```

```
NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.



*******************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.856    2.670    1.230    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.616

  STD. DEVIATIONS      4.022    5.476    2.784    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.758

 EVAPOTRANSPIRATION
 ------------------
  TOTALS               9.411   10.041   22.951   26.805   20.308   25.353
                      38.877    5.404    4.466    5.837    8.107    8.861

  STD. DEVIATIONS      4.844    6.604   11.757   17.555   10.933    4.892
                      18.370    4.098    4.291    2.407    3.248    2.139

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.0306   0.0000   0.0306   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0918

  STD. DEVIATIONS      0.0966   0.0000   0.0968   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.1477

*******************************************************************************
```

```
*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8115.6     100.00

RUNOFF                      11.371   ( 20.8773)       466.22      5.745

EVAPOTRANSPIRATION         186.422   ( 49.5915)      7643.31     94.180

PERCOLATION/LEAKAGE THROUGH     0.15292 (  0.16119)        6.270     0.07725
 LAYER  4

CHANGE IN WATER STORAGE       -0.004   (  1.3302)        -0.17     -0.002

*******************************************************************************
```

```
*******************************************************************************

          PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -------------------------------------------------------------------
                                (MM)      (CU. METERS)
                             ----------   ------------
    PRECIPITATION                      35.31        1447.546

    RUNOFF                          56.157        2302.4199

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.305993       12.54570

    SNOW WATER                         49.93        2047.1757


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.2274

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0547

*******************************************************************************
```

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.0212        0.2011

                   2         3.6416        0.0662

                   3         9.5349        0.0795

                   4        98.4185        0.2689

                SNOW WATER      0.000

*****************************************************************************
*****************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**          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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\T\HPV-ET42.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\T\AS-PV-32.D10
OUTPUT DATA FILE:           C:\HELP3\T\PV42AS32.OUT



TIME:  14:44     DATE:  12/29/2009



******************************************************************************

   TITLE:  32-INCH SOIL COVER (AVE.[Mean] AREA C SILT PROP w/ POOR VEG)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                         LAYER  1
                         --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
          THICKNESS              =     8.00   INCHES
          POROSITY               =     0.3750 VOL/VOL
          FIELD CAPACITY         =     0.2100 VOL/VOL
```

```
WILTING POINT              =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2023 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                =    24.00   INCHES
POROSITY                 =     0.4090 VOL/VOL
FIELD CAPACITY             =     0.2290 VOL/VOL
WILTING POINT              =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0622 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   3
THICKNESS                =    48.00   INCHES
POROSITY                 =     0.4570 VOL/VOL
FIELD CAPACITY             =     0.0830 VOL/VOL
WILTING POINT              =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0777 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER  18
THICKNESS                =   144.00   INCHES
POROSITY                 =     0.6710 VOL/VOL
FIELD CAPACITY             =     0.2920 VOL/VOL
WILTING POINT              =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2685 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

      SCS RUNOFF CURVE NUMBER            =     75.00
      FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE  =     10.000  ACRES
      EVAPORATIVE ZONE DEPTH              =     42.0    INCHES
      INITIAL WATER IN EVAPORATIVE ZONE   =      3.888  INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE  =     17.386  INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.082  INCHES
      INITIAL SNOW WATER                  =      0.000  INCHES
      INITIAL WATER IN LAYER MATERIALS    =     45.505  INCHES
      TOTAL INITIAL WATER                 =     45.505  INCHES
      TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                    =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              = 106.7  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  SOLAR RADIATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.
```

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*****************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS              1.351    4.137    0.632    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000    5.581

  STD. DEVIATIONS     2.997    8.766    1.695    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000   17.649

 EVAPOTRANSPIRATION
 ------------------
  TOTALS             13.870   11.238   24.670   27.912   21.533   24.981
                     21.999    5.537    4.232    6.704   12.403   11.132

  STD. DEVIATIONS     6.759    6.442   14.374   16.257   11.584    7.057
                     22.825    6.453    5.502    5.168    5.774    5.486

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                      0.0000   0.0000   0.0302   0.0000   0.0000   0.0000

  STD. DEVIATIONS     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                      0.0000   0.0000   0.0955   0.0000   0.0000   0.0000

*****************************************************************************
```

```
*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8010.6     100.00

RUNOFF                     11.701   ( 25.0920)       473.55      5.911

EVAPOTRANSPIRATION         186.211   ( 47.0985)      7535.86     94.073

PERCOLATION/LEAKAGE THROUGH     0.03020 (  0.09551)        1.222     0.01526
 LAYER  4

CHANGE IN WATER STORAGE        0.000   (  1.3084)        -0.02      0.000

*****************************************************************************



*****************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -----------------------------------------------------------------------
                                 (MM)      (CU. METERS)
                               ----------   ------------
    PRECIPITATION                      35.31        1428.814

    RUNOFF                            55.810        2258.5833

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.302044       12.22357

    SNOW WATER                         49.93        2020.6846


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.1733

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0496

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*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.1111        0.2023

                   2         3.7942        0.0622

                   3         9.4739        0.0777

                   4        98.2024        0.2685

                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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\T\HPV-ET34.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\T\AS-PV-34.D10
OUTPUT DATA FILE:           C:\HELP3\T\PV34AS34.OUT



TIME:  10:59     DATE:   1/ 4/2010



******************************************************************************

   TITLE:  34-INCH SOIL COVER (AVE.[Mean] AREA C SILT PROP w/ POOR VEG)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                        LAYER  1
                        --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER   0
          THICKNESS              =     8.00   INCHES
          POROSITY               =     0.3750 VOL/VOL
```

```
FIELD CAPACITY            =     0.2100 VOL/VOL
WILTING POINT             =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1897 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                LAYER  2
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   0
THICKNESS                 =    26.00   INCHES
POROSITY                  =     0.4090 VOL/VOL
FIELD CAPACITY            =     0.2290 VOL/VOL
WILTING POINT             =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0640 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                LAYER  3
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   3
THICKNESS                 =    48.00   INCHES
POROSITY                  =     0.4570 VOL/VOL
FIELD CAPACITY            =     0.0830 VOL/VOL
WILTING POINT             =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                LAYER  4
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  18
THICKNESS                 =   144.00   INCHES
POROSITY                  =     0.6710 VOL/VOL
FIELD CAPACITY            =     0.2920 VOL/VOL
WILTING POINT             =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2684 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER            =     75.00
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     10.000  ACRES
EVAPORATIVE ZONE DEPTH             =     34.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      3.183  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =     13.641  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.865  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     45.570  INCHES
TOTAL INITIAL WATER                =     45.570  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR



        EVAPOTRANSPIRATION AND WEATHER DATA
        -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
       HANFORD CP          WASHINGTON

  STATION LATITUDE                    =  46.51 DEGREES
  MAXIMUM LEAF AREA INDEX             =   1.00
  START OF GROWING SEASON (JULIAN DATE) =     98
  END OF GROWING SEASON (JULIAN DATE)   =    304
  EVAPORATIVE ZONE DEPTH              =  86.4  CM
  AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
  AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
  AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
  AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
  AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.



NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
       WAS ENTERED BY THE USER.
```

```
NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.



*****************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.670    2.584    1.073    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.611

  STD. DEVIATIONS      3.660    5.394    2.562    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.745

 EVAPOTRANSPIRATION
 ------------------
  TOTALS               8.333    8.038   19.602   28.023   22.470   27.329
                      42.463    4.753    4.573    6.031    7.767    7.601

  STD. DEVIATIONS      3.578    4.693   10.625   16.013   11.421    4.765
                      19.512    3.446    4.437    2.428    2.882    1.462

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.0301   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS      0.0952   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*****************************************************************************
```

```
*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
                              MM            CU. METERS     PERCENT
                        --------------------   -----------  ---------
 PRECIPITATION                197.94    (  63.124)      8010.6     100.00

 RUNOFF                      10.938   ( 20.5978)       442.64      5.526

 EVAPOTRANSPIRATION          186.983   ( 49.0179)      7567.09     94.463

 PERCOLATION/LEAKAGE THROUGH     0.03012 (  0.09523)        1.219     0.01521
  LAYER  4

 CHANGE IN WATER STORAGE       -0.008   (  1.2996)        -0.34     -0.004

*****************************************************************************



*****************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ---------------------------------------------------------------------
                                  (MM)      (CU. METERS)
                                ----------   ------------
    PRECIPITATION                      35.31         1428.814

    RUNOFF                            56.115         2270.9365

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.301153       12.18750

    SNOW WATER                         49.93         2020.6846


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.2049

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0548

*****************************************************************************
```

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1          3.8538       0.1897

                   2          4.2255       0.0640

                   3          9.4962       0.0779

                   4         98.1650       0.2684

                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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPV-ET90.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS90PV90.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS90PV90.OUT



TIME:  13:30     DATE:   2/ 1/2010



******************************************************************************

   TITLE:  90 CM SOIL COVER (AVE.[MEAN] AREA C SILT w/ POOR VEG., ET90)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                        LAYER  1
                        --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  60
          THICKNESS              =    20.00   CM
          POROSITY               =    0.3750 VOL/VOL
```

```
FIELD CAPACITY            =     0.2100 VOL/VOL
WILTING POINT             =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1916 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                LAYER  2
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  61
THICKNESS                 =    70.00   CM
POROSITY                  =     0.4090 VOL/VOL
FIELD CAPACITY            =     0.2290 VOL/VOL
WILTING POINT             =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0635 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                LAYER  3
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   3
THICKNESS                 =   120.00   CM
POROSITY                  =     0.4570 VOL/VOL
FIELD CAPACITY            =     0.0830 VOL/VOL
WILTING POINT             =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                LAYER  4
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  18
THICKNESS                 =   366.00   CM
POROSITY                  =     0.6710 VOL/VOL
FIELD CAPACITY            =     0.2920 VOL/VOL
WILTING POINT             =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2684 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

       SCS RUNOFF CURVE NUMBER            =     75.00
       FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
       AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
       EVAPORATIVE ZONE DEPTH              =     90.0    CM
       INITIAL WATER IN EVAPORATIVE ZONE   =      8.277  CM
       UPPER LIMIT OF EVAPORATIVE STORAGE  =     36.130  CM
       LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.940  CM
       INITIAL SNOW WATER                  =      0.000  CM
       INITIAL WATER IN LAYER MATERIALS    =    115.859  CM
       TOTAL INITIAL WATER                 =    115.859  CM
       TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR



                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                    =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              =  90.0  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  SOLAR RADIATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.
```

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        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS              1.625    2.566    1.020    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000    5.612

  STD. DEVIATIONS     3.579    5.382    2.438    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000   17.745

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              8.165    7.858   19.923   28.807   24.033   27.947
                     38.790    5.781    4.615    6.079    7.722    7.366

  STD. DEVIATIONS     3.251    4.217    9.446   15.195   10.664    3.647
                     21.094    5.659    4.417    2.412    2.850    1.566

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -----------------------------------
  TOTALS              0.0301   0.0000   0.0000   0.0000   0.0000   0.0000
                      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS     0.0952   0.0000   0.0000   0.0000   0.0000   0.0000
                      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*****************************************************************************
```

```
*****************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8115.6     100.00

RUNOFF                      10.823   ( 20.5376)       443.73      5.468

EVAPOTRANSPIRATION         187.086   ( 48.8234)      7670.52     94.515

PERCOLATION/LEAKAGE THROUGH     0.03012 (  0.09523)        1.235     0.01521
 LAYER  4

CHANGE IN WATER STORAGE        0.004   (  1.3055)        0.15      0.002

*****************************************************************************



*****************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -----------------------------------------------------------------------
                                 (MM)      (CU. METERS)
                              ----------   ------------
    PRECIPITATION                      35.31         1447.546

    RUNOFF                            56.115         2300.7178

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.301156        12.34739

    SNOW WATER                         49.93         2047.1757


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.2016

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0549

*****************************************************************************
```

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1          3.8314       0.1916

                   2          4.4482       0.0635

                   3          9.3480       0.0779

                   4         98.2355       0.2684

                SNOW WATER      0.000

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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                  **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************



PRECIPITATION DATA FILE:    C:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\T\HPV-ET38.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\T\AS-PV-38.D10
OUTPUT DATA FILE:           C:\HELP3\T\PV38AS38.OUT



TIME:  12:32     DATE:   1/ 4/2010



******************************************************************************

   TITLE:  38-INCH SOIL COVER (AVE.[Mean] AREA C SILT PROP w/ POOR VEG)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                        LAYER  1
                        --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   0
          THICKNESS               =     8.00   INCHES
          POROSITY                =     0.3750 VOL/VOL
```

```
FIELD CAPACITY            =     0.2100 VOL/VOL
WILTING POINT             =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1973 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                LAYER  2
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   0
THICKNESS                 =    30.00   INCHES
POROSITY                  =     0.4090 VOL/VOL
FIELD CAPACITY            =     0.2290 VOL/VOL
WILTING POINT             =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0642 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                LAYER  3
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   3
THICKNESS                 =    48.00   INCHES
POROSITY                  =     0.4570 VOL/VOL
FIELD CAPACITY            =     0.0830 VOL/VOL
WILTING POINT             =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                LAYER  4
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  18
THICKNESS                 =   144.00   INCHES
POROSITY                  =     0.6710 VOL/VOL
FIELD CAPACITY            =     0.2920 VOL/VOL
WILTING POINT             =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2685 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

     SCS RUNOFF CURVE NUMBER          =     75.00
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =     10.000  ACRES
     EVAPORATIVE ZONE DEPTH           =     38.0    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      3.504  INCHES
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     15.267  INCHES
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.088  INCHES
     INITIAL SNOW WATER               =      0.000  INCHES
     INITIAL WATER IN LAYER MATERIALS    =     45.908  INCHES
     TOTAL INITIAL WATER              =     45.908  INCHES
     TOTAL SUBSURFACE INFLOW          =      0.00   INCHES/YEAR



           EVAPOTRANSPIRATION AND WEATHER DATA
           -----------------------------------

     NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          HANFORD CP          WASHINGTON

       STATION LATITUDE                  =  46.51 DEGREES
       MAXIMUM LEAF AREA INDEX              =   1.00
       START OF GROWING SEASON (JULIAN DATE)  =     98
       END OF GROWING SEASON (JULIAN DATE)    =    304
       EVAPORATIVE ZONE DEPTH               =  96.5  CM
       AVERAGE ANNUAL WIND SPEED            =  12.16 KPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



     NOTE:  PRECIPITATION DATA FOR     Hanford CP          Washington
          WAS ENTERED BY THE USER.



     NOTE:  TEMPERATURE DATA FOR     Hanford CP          Washington
          WAS ENTERED BY THE USER.



     NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
          WAS ENTERED BY THE USER.
```

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        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS              1.519    2.541    0.932    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000    5.603

  STD. DEVIATIONS     3.360    5.374    2.210    0.000    0.000    0.000
                      0.000    0.000    0.000    0.000    0.000   17.718

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              8.075    8.244   19.021   27.725   22.964   25.685
                     42.392    8.111    4.604    6.098    7.399    7.016

  STD. DEVIATIONS     2.827    4.566    8.007   15.109   12.133    5.963
                     19.397    6.102    4.427    2.388    2.940    2.556

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -----------------------------------
  TOTALS              0.0000   0.0000   0.0000   0.0000   0.0000   0.0302
                      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS     0.0000   0.0000   0.0000   0.0000   0.0000   0.0955
                      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*****************************************************************************
```

```
*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION              197.94    (  63.124)      8010.6     100.00

RUNOFF                      10.595   ( 20.4468)       428.78      5.353

EVAPOTRANSPIRATION         187.333   ( 48.5735)      7581.26     94.640

PERCOLATION/LEAKAGE THROUGH     0.03021 (  0.09552)        1.222     0.01526
 LAYER  4

CHANGE IN WATER STORAGE       -0.016   (  1.2745)        -0.66     -0.008

*******************************************************************************



*******************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  -------------------------------------------------------------------------
                                  (MM)      (CU. METERS)
                                ----------   ------------
    PRECIPITATION                      35.31         1428.814

    RUNOFF                            56.029        2267.4756

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.302066        12.22445

    SNOW WATER                         49.93         2020.6846


    MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.1954

    MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0549

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                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.0101        0.1973

                   2         4.8905        0.0642

                   3         9.4988        0.0779

                   4        98.1895        0.2685

                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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPVET100.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS1MPV1M.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS1MPV1M.OUT



TIME:   9: 2     DATE:   2/ 3/2010



******************************************************************************

   TITLE:  100 CM SOIL COVER (AVE.[MEAN] AREA C SILT w/ P.VEG, ET100CM)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.



                        LAYER  1
                        --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  60
          THICKNESS              =    20.00   CM
          POROSITY               =    0.3750 VOL/VOL
```

```
FIELD CAPACITY            =     0.2100 VOL/VOL
WILTING POINT             =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2006 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                LAYER  2
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  61
THICKNESS                 =    80.00   CM
POROSITY                  =     0.4090 VOL/VOL
FIELD CAPACITY            =     0.2290 VOL/VOL
WILTING POINT             =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0636 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                LAYER  3
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER   3
THICKNESS                 =   120.00   CM
POROSITY                  =     0.4570 VOL/VOL
FIELD CAPACITY            =     0.0830 VOL/VOL
WILTING POINT             =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC



                LAYER  4
                --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
          MATERIAL TEXTURE NUMBER  18
THICKNESS                 =   366.00   CM
POROSITY                  =     0.6710 VOL/VOL
FIELD CAPACITY            =     0.2920 VOL/VOL
WILTING POINT             =     0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2685 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

```
                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

        NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

      SCS RUNOFF CURVE NUMBER            =     75.00
      FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
      EVAPORATIVE ZONE DEPTH             =    100.0    CM
      INITIAL WATER IN EVAPORATIVE ZONE   =      9.100  CM
      UPPER LIMIT OF EVAPORATIVE STORAGE  =     40.220  CM
      LOWER LIMIT OF EVAPORATIVE STORAGE  =      5.500  CM
      INITIAL SNOW WATER                 =      0.000  CM
      INITIAL WATER IN LAYER MATERIALS    =    116.719  CM
      TOTAL INITIAL WATER                =    116.719  CM
      TOTAL SUBSURFACE INFLOW            =      0.00   MM/YR


                EVAPOTRANSPIRATION AND WEATHER DATA
                -----------------------------------

        NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
              HANFORD CP          WASHINGTON

          STATION LATITUDE                    =  46.51 DEGREES
          MAXIMUM LEAF AREA INDEX             =   1.00
          START OF GROWING SEASON (JULIAN DATE)  =     98
          END OF GROWING SEASON (JULIAN DATE)    =    304
          EVAPORATIVE ZONE DEPTH              = 100.0  CM
          AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
          AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
          AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
          AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
          AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



        NOTE:  PRECIPITATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  TEMPERATURE DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.



        NOTE:  SOLAR RADIATION DATA FOR     Hanford CP         Washington
              WAS ENTERED BY THE USER.
```

```
*****************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-----------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.463    2.522    0.890    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.596

  STD. DEVIATIONS      3.237    5.364    2.108    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.697

 EVAPOTRANSPIRATION
 ------------------
  TOTALS               7.993    8.262   19.628   28.162   23.405   25.439
                      40.354    9.180    4.610    6.079    7.363    6.983

  STD. DEVIATIONS      2.857    4.458    6.553   14.445   11.762    5.922
                      17.727    8.656    4.415    2.366    2.947    2.556

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0302   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS      0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                       0.0955   0.0000   0.0000   0.0000   0.0000   0.0000

*****************************************************************************
```

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998

	MM	CU. METERS	PERCENT
PRECIPITATION	197.94 (63.124)	8115.6	100.00
RUNOFF	10.471 (20.3753)	429.33	5.290
EVAPOTRANSPIRATION	187.458 (48.6162)	7685.80	94.704
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.03020 (0.09550)	1.238	0.01526
CHANGE IN WATER STORAGE	-0.018 (1.2773)	-0.73	-0.009

****

****

PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998

	(MM)	(CU. METERS)
PRECIPITATION	35.31	1447.546
RUNOFF	55.964	2294.5122
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.302006	12.38223
SNOW WATER	49.93	2047.1757

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.1912

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0550

****

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                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.0122        0.2006

                   2         5.0869        0.0636

                   3         9.3491        0.0779

                   4        98.2529        0.2685

                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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\T\HPV-ET42.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\T\AS-PV-42.D10
OUTPUT DATA FILE:           C:\HELP3\T\PV42AS42.OUT



TIME:  12:12     DATE:  12/21/2009



******************************************************************************

   TITLE:  42-INCH SOIL COVER (AVE.[mean] AREA C SILT PROP W/ POOR VEG)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.
```

```
                    LAYER  1
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER   0
THICKNESS              =     8.00   INCHES
POROSITY               =     0.3750 VOL/VOL
FIELD CAPACITY         =     0.2100 VOL/VOL
WILTING POINT          =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2030 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER   0
THICKNESS              =    34.00   INCHES
POROSITY               =     0.4090 VOL/VOL
FIELD CAPACITY         =     0.2290 VOL/VOL
WILTING POINT          =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0619 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER   3
THICKNESS              =    48.00   INCHES
POROSITY               =     0.4570 VOL/VOL
FIELD CAPACITY         =     0.0830 VOL/VOL
WILTING POINT          =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC
```

```
                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  18
     THICKNESS              =   144.00   INCHES
     POROSITY               =     0.6710 VOL/VOL
     FIELD CAPACITY         =     0.2920 VOL/VOL
     WILTING POINT          =     0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT  =     0.2683 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC



        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

   NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

  SCS RUNOFF CURVE NUMBER          =     75.00
  FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
  AREA PROJECTED ON HORIZONTAL PLANE  =    10.000  ACRES
  EVAPORATIVE ZONE DEPTH           =     42.0    INCHES
  INITIAL WATER IN EVAPORATIVE ZONE   =     3.729  INCHES
  UPPER LIMIT OF EVAPORATIVE STORAGE  =    16.906  INCHES
  LOWER LIMIT OF EVAPORATIVE STORAGE  =     2.312  INCHES
  INITIAL SNOW WATER               =     0.000  INCHES
  INITIAL WATER IN LAYER MATERIALS    =    46.103  INCHES
  TOTAL INITIAL WATER              =    46.103  INCHES
  TOTAL SUBSURFACE INFLOW          =     0.00   INCHES/YEAR



        EVAPOTRANSPIRATION AND WEATHER DATA
        -----------------------------------

   NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
        HANFORD CP          WASHINGTON

     STATION LATITUDE                  =  46.51 DEGREES
     MAXIMUM LEAF AREA INDEX             =   1.00
     START OF GROWING SEASON (JULIAN DATE)  =     98
     END OF GROWING SEASON (JULIAN DATE)    =    304
     EVAPORATIVE ZONE DEPTH              = 106.7  CM
     AVERAGE ANNUAL WIND SPEED           =  12.16 KPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %
```

```
NOTE:  PRECIPITATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


NOTE:  TEMPERATURE DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


*******************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.385    3.622    0.781    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.586

  STD. DEVIATIONS      3.055    7.454    1.947    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.663

 EVAPOTRANSPIRATION
 ------------------
  TOTALS               7.698    7.426   19.135   27.215   22.943   26.516
                      40.377   10.558    4.582    6.050    7.286    6.772

  STD. DEVIATIONS      2.605    3.636    6.401   14.628   11.666    5.880
                      16.519   10.636    4.338    2.329    2.903    2.363

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
```

```
TOTALS              0.0300   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

STD. DEVIATIONS     0.0949   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

*******************************************************************************


*******************************************************************************

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                    --------------------   -----------  ---------
PRECIPITATION             197.94    (  63.124)      8010.6     100.00

RUNOFF                    11.374   ( 23.5625)       460.29      5.746

EVAPOTRANSPIRATION        186.557   ( 47.9345)      7549.88     94.248

PERCOLATION/LEAKAGE THROUGH     0.03001 (  0.09489)        1.214     0.01516
 LAYER  4

CHANGE IN WATER STORAGE       -0.019   (  1.2767)        -0.77     -0.010

*******************************************************************************



*******************************************************************************

          PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
  ---------------------------------------------------------------------
                                (MM)      (CU. METERS)
                              ----------   ------------
   PRECIPITATION                      35.31        1428.814

   RUNOFF                           55.856        2260.4453

   PERCOLATION/LEAKAGE THROUGH LAYER  4      0.300059       12.14323

   SNOW WATER                         49.93        2020.6846


   MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.1839

   MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0550

*******************************************************************************
```

```
*****************************************************************************

                FINAL WATER STORAGE AT END OF YEAR 1998
   ---------------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1          4.1250       0.2030

                   2          5.3485       0.0619

                   3          9.4935       0.0779

                   4         98.1154       0.2683

                SNOW WATER      0.000

*****************************************************************************
*****************************************************************************
```

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**          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:\HELP3\NRDWL\HANFORDP.D4
TEMPERATURE DATA FILE:      C:\HELP3\NRDWL\HANFORDT.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\NRDWL\HANFORDS.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\NRDWL\METRIC\HPVET120.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\NRDWL\METRIC\AS120P12.D10
OUTPUT DATA FILE:           C:\HELP3\NRDWL\METRIC\AS120P12.OUT



TIME:   7:46     DATE:   2/ 9/2010



******************************************************************************

   TITLE:  120 CM SOIL COVER (AVE.[MEAN] AREA C SILT w/ P.VEG, ET120CM)

******************************************************************************



   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
          WERE SPECIFIED BY THE USER.
```

```
                    LAYER  1
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  60
THICKNESS              =    20.00   CM
POROSITY               =     0.3750 VOL/VOL
FIELD CAPACITY         =     0.2100 VOL/VOL
WILTING POINT          =     0.0510 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2139 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.130999997000E-04 CM/SEC



                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  61
THICKNESS              =   100.00   CM
POROSITY               =     0.4090 VOL/VOL
FIELD CAPACITY         =     0.2290 VOL/VOL
WILTING POINT          =     0.0560 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0594 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.153000001000E-04 CM/SEC



                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER   3
THICKNESS              =   120.00   CM
POROSITY               =     0.4570 VOL/VOL
FIELD CAPACITY         =     0.0830 VOL/VOL
WILTING POINT          =     0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0779 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.310000009000E-02 CM/SEC
```

```
                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER  18
     THICKNESS              =   366.00   CM
     POROSITY               =     0.6710 VOL/VOL
     FIELD CAPACITY         =     0.2920 VOL/VOL
     WILTING POINT          =     0.0770 VOL/VOL
     INITIAL SOIL WATER CONTENT  =     0.2684 VOL/VOL
     EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC



        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

    NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

   SCS RUNOFF CURVE NUMBER          =     75.00
   FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE  =      4.1000 HECTARES
   EVAPORATIVE ZONE DEPTH           =    120.0    CM
   INITIAL WATER IN EVAPORATIVE ZONE   =     10.218  CM
   UPPER LIMIT OF EVAPORATIVE STORAGE  =     48.400  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE  =      6.620  CM
   INITIAL SNOW WATER               =      0.000  CM
   INITIAL WATER IN LAYER MATERIALS    =    117.800  CM
   TOTAL INITIAL WATER              =    117.800  CM
   TOTAL SUBSURFACE INFLOW          =      0.00   MM/YR



         EVAPOTRANSPIRATION AND WEATHER DATA
         -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          HANFORD CP          WASHINGTON

      STATION LATITUDE                  =  46.51 DEGREES
      MAXIMUM LEAF AREA INDEX              =   1.00
      START OF GROWING SEASON (JULIAN DATE)  =     98
      END OF GROWING SEASON (JULIAN DATE)    =    304
      EVAPORATIVE ZONE DEPTH               = 120.0  CM
      AVERAGE ANNUAL WIND SPEED            =  12.16 KPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %
```

```
NOTE:  PRECIPITATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


NOTE:  TEMPERATURE DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
       WAS ENTERED BY THE USER.


*******************************************************************************

        AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              24.89    19.00    16.64    16.05    15.42    13.23
                       9.50     4.75     4.67    16.03    26.54    31.22

  STD. DEVIATIONS     16.14    14.30    12.55    10.38     8.48    11.93
                      12.72     6.14     6.15     7.50    18.50    28.07

 RUNOFF
 ------
  TOTALS               1.290    4.132    0.613    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000    5.705

  STD. DEVIATIONS      2.844    8.787    1.634    0.000    0.000    0.000
                       0.000    0.000    0.000    0.000    0.000   17.588

 EVAPOTRANSPIRATION
 ------------------
  TOTALS              11.713   10.785   24.113   29.581   22.342   24.411
                      27.319    6.867    3.939    5.876   10.098    9.147

  STD. DEVIATIONS      5.113    5.322    8.725   16.514   13.339    5.061
                      24.686    6.103    3.648    3.406    4.074    3.844

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 -------------------------------------
  TOTALS               0.0301   0.0000   0.0000   0.0000   0.0000   0.0000
```

```
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS      0.0952   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 ******************************************************************************



 ******************************************************************************

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ----------------------------------------------------------------------------
                          MM            CU. METERS     PERCENT
                   --------------------   -----------  ---------
 PRECIPITATION              197.94    (  63.124)      8115.6     100.00

 RUNOFF                    11.741   ( 25.0282)       481.37      5.931

 EVAPOTRANSPIRATION          186.192   ( 46.4426)      7633.85     94.064

 PERCOLATION/LEAKAGE THROUGH     0.03012 (  0.09523)        1.235     0.01521
   LAYER  4

 CHANGE IN WATER STORAGE       -0.020   (  1.3027)        -0.82     -0.010

 ******************************************************************************



 ******************************************************************************

            PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
   ---------------------------------------------------------------------
                                  (MM)      (CU. METERS)
                               ----------   ------------
     PRECIPITATION                      35.31         1447.546

     RUNOFF                           55.749        2285.7065

     PERCOLATION/LEAKAGE THROUGH LAYER  4      0.301156        12.34739

     SNOW WATER                         49.93         2047.1757


     MAXIMUM VEG. SOIL WATER (VOL/VOL)               0.1675

     MINIMUM VEG. SOIL WATER (VOL/VOL)               0.0552

 ******************************************************************************
```

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*****************************************************************************

                 FINAL WATER STORAGE AT END OF YEAR 1998
        ---------------------------------------------------------------
                 LAYER        (CM)        (VOL/VOL)
                 -----       ------       ---------
                   1         4.2780        0.2139

                   2         5.9393        0.0594

                   3         9.3465        0.0779

                   4        98.2165        0.2684

                SNOW WATER      0.000

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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:\HELP3\COMBINED\HANFORDP.D4
 TEMPERATURE DATA FILE:      C:\HELP3\COMBINED\HANFORDT.D7
 SOLAR RADIATION DATA FILE:  C:\HELP3\COMBINED\HANFORDS.D13
 EVAPOTRANSPIRATION DATA:    C:\HELP3\COMBINED\HPVET100.D11
 SOIL AND DESIGN DATA FILE:  C:\HELP3\COMBINED\RCRA-C.D10
 OUTPUT DATA FILE:           C:\HELP3\COMBINED\RCRA-C.OUT



 TIME:   8:43     DATE:   7/ 2/2010




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      TITLE:  HELP EXAMPLE SUBTITLE C COVER w/ HANFORD WETTEST 10 YEARS


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```
NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
         WERE SPECIFIED BY THE USER.



                                LAYER  1
                                --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   9
          THICKNESS                   =     30.00   INCHES
          POROSITY                    =      0.5010 VOL/VOL
          FIELD CAPACITY              =      0.2840 VOL/VOL
          WILTING POINT               =      0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.1589 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                                LAYER  2
                                --------

                     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  =      0.0396 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.999999978000E-02 CM/SEC
          SLOPE                       =      4.00   PERCENT
          DRAINAGE LENGTH             =    200.0    FEET



                                LAYER  3
                                --------

                     TYPE 4 - FLEXIBLE MEMBRANE LINER
                       MATERIAL TEXTURE NUMBER  36
          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.   =  0.399999993000E-12 CM/SEC
          FML PINHOLE DENSITY         =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS    =     10.00   HOLES/ACRE
          FML PLACEMENT QUALITY       =  4 - POOR
```

```
                                LAYER  4
                                --------

                     TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER  28
        THICKNESS                    =     36.00   INCHES
        POROSITY                     =      0.4520 VOL/VOL
        FIELD CAPACITY               =      0.4110 VOL/VOL
        WILTING POINT                =      0.3110 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.4520 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.120000004000E-05 CM/SEC



                                LAYER  5
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   3
        THICKNESS                    =     48.00   INCHES
        POROSITY                     =      0.4570 VOL/VOL
        FIELD CAPACITY               =      0.0830 VOL/VOL
        WILTING POINT                =      0.0330 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.0811 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC



                                LAYER  6
                                --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER  18
        THICKNESS                    =    144.00   INCHES
        POROSITY                     =      0.6710 VOL/VOL
        FIELD CAPACITY               =      0.2920 VOL/VOL
        WILTING POINT                =      0.0770 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2810 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC



                GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                ----------------------------------------

      NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

     SCS RUNOFF CURVE NUMBER             =     75.00
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
     AREA PROJECTED ON HORIZONTAL PLANE  =     76.000  ACRES
     EVAPORATIVE ZONE DEPTH              =     39.4    INCHES
     INITIAL WATER IN EVAPORATIVE ZONE   =      5.138  INCHES
```

```
UPPER LIMIT OF EVAPORATIVE STORAGE  =     18.937  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      4.219  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     65.871  INCHES
TOTAL INITIAL WATER                 =     65.871  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR



                    EVAPOTRANSPIRATION AND WEATHER DATA
                    -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  HANFORD CP            WASHINGTON

             STATION LATITUDE                       =  46.51 DEGREES
             MAXIMUM LEAF AREA INDEX                =   1.00
             START OF GROWING SEASON (JULIAN DATE)  =     98
             END OF GROWING SEASON (JULIAN DATE)    =    304
             EVAPORATIVE ZONE DEPTH                 = 100.0  CM
             AVERAGE ANNUAL WIND SPEED              =  12.16 KPH
             AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  68.30 %
             AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  43.30 %
             AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  37.00 %
             AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  70.00 %



         NOTE:  PRECIPITATION DATA FOR     Hanford CP          Washington
                  WAS ENTERED BY THE USER.



         NOTE:  TEMPERATURE DATA FOR     Hanford CP          Washington
                  WAS ENTERED BY THE USER.



         NOTE:  SOLAR RADIATION DATA FOR     Hanford CP          Washington
                  WAS ENTERED BY THE USER.



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             AVERAGE MONTHLY VALUES (MM) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
---

                         JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV
JUN/DEC
                         -------  -------  -------  -------  -------  ------
-
   PRECIPITATION
```

```
   -------------
     TOTALS                24.89    19.00    16.64    16.05    15.42    13.23
                            9.50     4.75     4.67    16.03    26.54    31.22

     STD. DEVIATIONS       16.14    14.30    12.55    10.38     8.48    11.93
                           12.72     6.14     6.15     7.50    18.50    28.07

   RUNOFF
   ------
     TOTALS                 1.312    0.940    0.615    0.000    0.000
0.000
                            0.000    0.000    0.000    0.000    0.000
3.820

     STD. DEVIATIONS        3.046    1.946    1.579    0.000    0.000
0.000
                            0.000    0.000    0.000    0.000    0.000
12.080

   EVAPOTRANSPIRATION
   ------------------
     TOTALS                14.431   11.775   26.434   24.465   20.211
22.764
                           20.803    5.476    4.243    7.181   15.336
13.827

     STD. DEVIATIONS        6.361    7.730   16.051   15.065   12.144
7.346
                           20.623    6.413    5.557    5.825    6.155
4.678

   LATERAL DRAINAGE COLLECTED FROM LAYER  2
   ----------------------------------------
     TOTALS                 0.0036   0.0269   0.8253   0.9647   0.6427
0.4172
                            0.6429   0.4425   0.1646   0.0657   0.0243
0.0096

     STD. DEVIATIONS        0.0056   0.0825   2.6084   3.0453   1.9863
1.0505
                            1.0329   0.6872   0.2558   0.1020   0.0378
0.0150

   PERCOLATION/LEAKAGE THROUGH LAYER  4
   -----------------------------------
     TOTALS                 0.0001   0.0006   0.0153   0.0177   0.0125
0.0088
                            0.0137   0.0099   0.0041   0.0018   0.0007
0.0003

     STD. DEVIATIONS        0.0002   0.0018   0.0483   0.0559   0.0380
0.0215
                            0.0216   0.0151   0.0062   0.0027   0.0011
0.0005

   PERCOLATION/LEAKAGE THROUGH LAYER  6
   -----------------------------------
```

```
     TOTALS                 0.0439   0.0000   0.0000   0.0439   0.0000
0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000
0.0000

     STD. DEVIATIONS        0.1388   0.0000   0.0000   0.1389   0.0000
0.0000
                            0.0000   0.0000   0.0000   0.0000   0.0000
0.0000


 ---------------------------------------------------------------------------
---
                  AVERAGES OF MONTHLY AVERAGED DAILY HEADS (CM)
 ---------------------------------------------------------------------------
---


   DAILY AVERAGE HEAD ON TOP OF LAYER  3
   -------------------------------------
     AVERAGES               0.0010   0.0085   0.2352   0.2841   0.1832
0.1229
                            0.1832   0.1261   0.0485   0.0187   0.0072
0.0027

     STD. DEVIATIONS        0.0016   0.0260   0.7433   0.8967   0.5660
0.3093
                            0.2943   0.1958   0.0753   0.0291   0.0111
0.0043


*****************************************************************************
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**

      AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1989 THROUGH 1998
 ---------------------------------------------------------------------------
---
                                        MM              CU. METERS
PERCENT
                              --------------------     -----------   -------
--
  PRECIPITATION                197.94    (  63.124)      60880.7     100.00

  RUNOFF                         6.687   ( 13.9837)       2056.80      3.378

  EVAPOTRANSPIRATION           186.945   ( 46.6466)      57498.26     94.444

  LATERAL DRAINAGE COLLECTED     4.23016 ( 10.09654)      1301.060
2.13707
    FROM LAYER  2

```

```
  PERCOLATION/LEAKAGE THROUGH     0.08555 (  0.19551)        26.314
0.04322
    LAYER  4

  AVERAGE HEAD ON TOP             1.018 (    2.433)
    OF LAYER  3

  PERCOLATION/LEAKAGE THROUGH     0.08780 (  0.18510)        27.005
0.04436
    LAYER  6

  CHANGE IN WATER STORAGE        -0.008   (  1.6770)         -2.48     -0.004


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                  PEAK DAILY VALUES FOR YEARS 1989 THROUGH 1998
     ------------------------------------------------------------------------
                                                    (MM)       (CU. METERS)
                                                 ----------    ------------
        PRECIPITATION                             35.31         10858.988

        RUNOFF                                    38.201        11749.5508

        DRAINAGE COLLECTED FROM LAYER  2           0.37115        114.15300

        PERCOLATION/LEAKAGE THROUGH LAYER  4       0.006718         2.06636

        AVERAGE HEAD ON TOP OF LAYER  3           32.786

        MAXIMUM HEAD ON TOP OF LAYER  3           60.764

        LOCATION OF MAXIMUM HEAD IN LAYER  2
              (DISTANCE FROM DRAIN)                4.4 METERS

        PERCOLATION/LEAKAGE THROUGH LAYER  6       0.439200       135.08380

        SNOW WATER                                49.93         15357.2021


        MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.2548

        MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1072


         ***  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 1998
     -------------------------------------------------------------------
                     LAYER          (CM)         (VOL/VOL)
                     -----         ------        ---------
                       1           12.1030         0.1588

                       2            1.2064         0.0396

                       3            0.0000         0.0000

                       4           41.3309         0.4520

                       5            9.8910         0.0811

                       6          102.7730         0.2810

                   SNOW WATER       0.000


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Appendix E

Supplemental Information

This appendix includes additional information on the technology, design, background, and science on other ET covers. It is provided in support of the closure plan for NRDWL/SWL.

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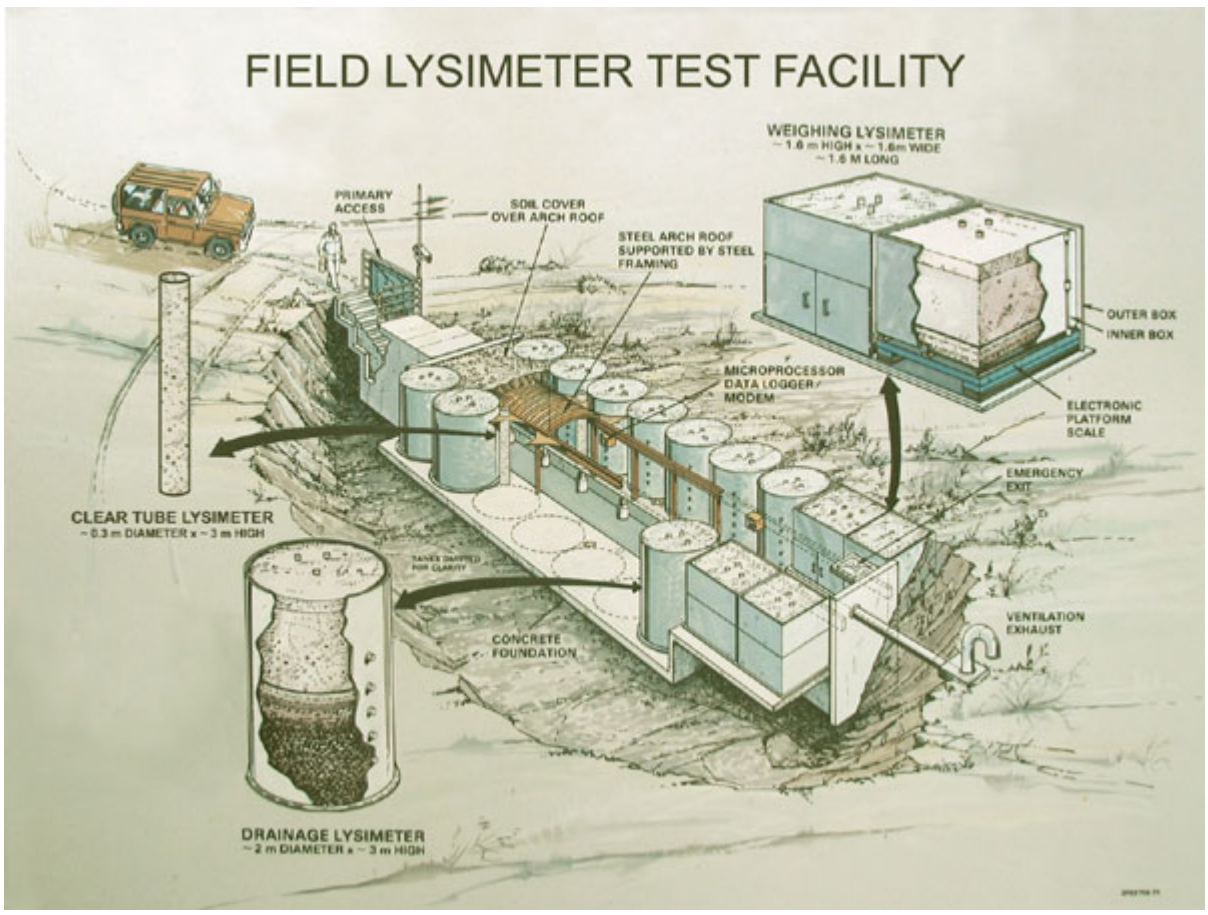
E1 Surface Barrier Studies at Hanford

Cover design has been studied at the Hanford Site since the 1980s. Several natural analog test sites, test plots, and pan and weighing lysimeter studies have been completed or are ongoing. Some sites have been studied for over 20 years. All of these tests and studies have verified that, because of the arid climate, the Hanford Site is well suited for employing alternative covers that rely upon the natural processes of evapotranspiration to minimize or eliminate percolation through alternative covers and through the waste.

In the late 1980s, the Field Lysimeter Test Facility (FLTF) was constructed to evaluate infiltration through native materials associated with the Hanford site (Figure D-1). The FLTF is located in the 600 Area of the Hanford Site just east of the 200 West Area and adjacent to the Hanford Meteorological Station. The FLTF has been used to assess the effectiveness of selected protective barrier configurations in controlling water infiltration. The facility consists of 14 large drainage lysimeters (2 m [6.5 ft] × 3 m [9.8 ft]) and four precision weighing lysimeters 1.5 m × 1.5 m × 1.7 m (4.9 ft × 4.9 ft × 5.6 ft) deep. The lysimeters are buried at grade and aligned in a parallel configuration, with nine lysimeters on each side of an underground instrument chamber. The lysimeters are filled with materials to simulate a multilayer protective barrier system. Data gathered from the FLTF are being used to compare key barrier components and to calibrate and test models for predicting long-term barrier performance (Fayer and Gee, 2006).



Source: http://hydrology.pnl.gov/resources/fltf.asp.

Figure E-1. Field Lysimeter Test Facility (FLTF) at Hanford

Some of the first tests performed at the FLTF were done to measure water infiltration, ET, redistribution of moisture within the soil profile, and drainage through native soils. Vegetation representative of the native plant community at Hanford was seeded and transplanted into 10 of the 18 lysimeters. The results summarized below indicated the effectiveness of ET covers at Hanford.

- Surface evaporation and ET rates in irrigated and non-irrigated lysimeters were significant even in the winter months.
- Water losses by ET during the winter and early spring were sufficiently high to maintain a water deficiency in the surface soil, thus preventing all drainage through the cover and into the waste. The vegetated lysimeters exhibited more water loss for the 8-month (November 1987 through June 1988) initial test period than the bare surface (non-vegetated) lysimeters.
- Under ambient precipitation conditions, a surface cover composed of 1.5 m (4.9 ft) of silt loam above a capillary break (similar to what is proposed for NRDWL/SWL) successfully reduced drainage to well below the design goal of 0.5 mm/year (0.019 in/year) for test duration up to 17 years (Fayer and Gee, 2006).

Also of particular relevance to the NRDWL/SWL is the Hanford Barrier (a large test cover). It is a prototype barrier (Figure E-2) that was designed and constructed in 1994 partially over a radioactive burial site. This above-grade barrier is several acres in size and consisted of a 2-m (6.6-ft) thick silt-loam soil overlying layers of sand gravel basalt rock and low permeability asphalt. There were two side-slope configurations, clean-fill gravel on a 10:1 slope, and a basalt riprap on a 2:1 slope. Although the Hanford Barrier is more robust than the cover proposed for NRDWL/SWL, some valuable lessons can be learned. Design considerations for this prototype barrier included constructability, water-balance monitoring, wind and water erosion control and monitoring, research purposes, surface vegetation, biointrusion control, subsidence, side-slope stability, control of radioactive material, and the performance/durability of the asphalt layer. A brief summary of some of the lessons learned from the Hanford Barrier are listed below.

- Despite being stressed for the first three years with three times the annual average precipitation and an additional precipitation event that exceeded a 1,000-year probability of occurrence, the cover performance at the Hanford Cover has been undiminished for over 15 years, documenting the reliability and longevity of ET covers.
- In late 2008, a controlled burn was initiated over half of the barrier to evaluate barrier performance after the fire. The barrier was allowed to revegetate naturally. After a year of monitoring, the barrier has continued to perform as designed and has maintained 600 mm (24 in.) of water storage capacity, which is equivalent to the design capacity (Ward et al., 2010). In addition, there has been only minor runoff and erosion.

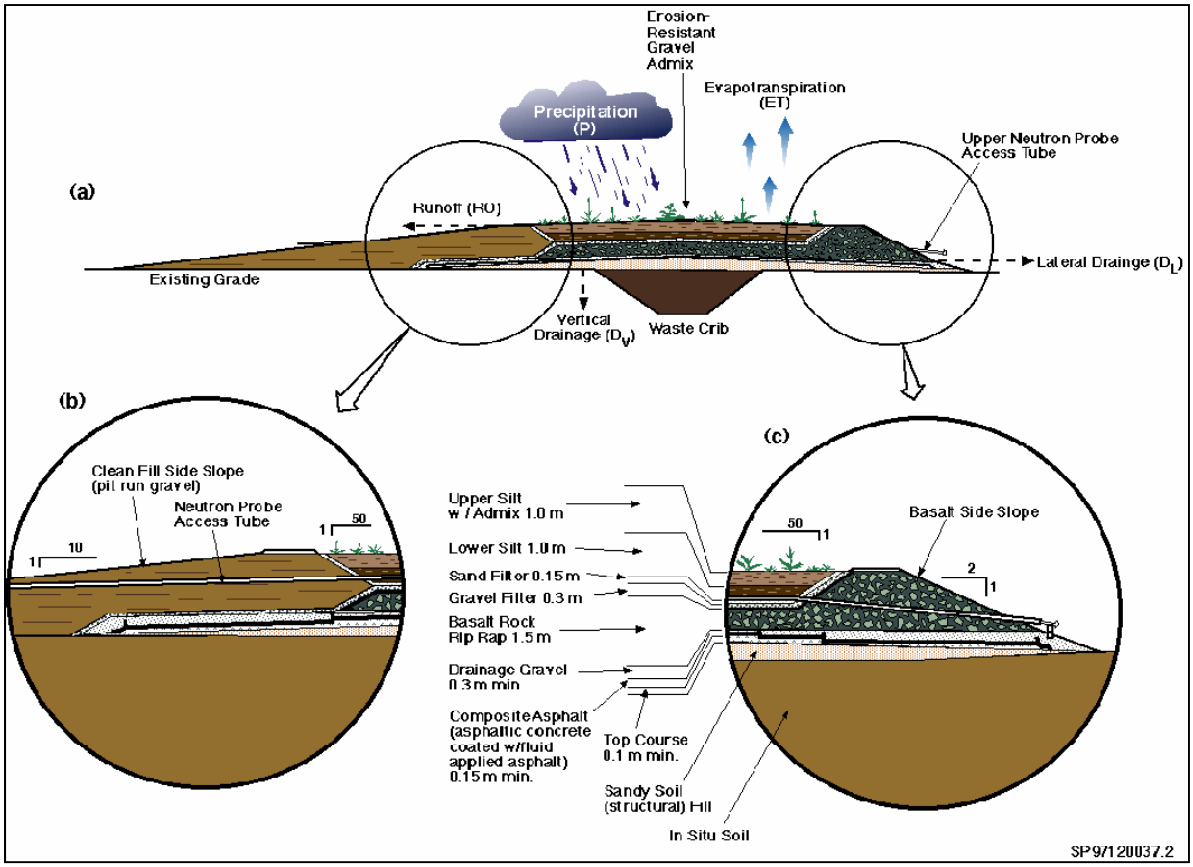


Figure E-2. Hanford Prototype Barrier Cross Section (PNNL, 14143)

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E2 History of Evapotranspiration Barriers

Alternative landfill cover systems, such as Evapotranspiration (ET) Barriers emerged in the mid 1990s as a cost-effective option to conventional covers that typically rely on thick compacted clay layers and synthetic geotextiles to reduce infiltration. Since then, ET Barriers have been applied at landfills and other waste management units (waste piles and surface impoundments) as an alternative to a conventional compacted clay or geomembrane cover (EPA 542-F-03-015).

Between 1997 and 2002, the Sandia National Laboratory conducted a large-scale demonstration study comparing conventional landfill covers (i.e., RCRA Subtitle C and D), and four alternative cover types including the ET cover design. Performance of the covers was based on their ability to minimize the movement of water through each cover design. The ET covers were among the best performers. The ET cover had annual flux rate of 0.16 mm/yr versus 1.39 mm/yr for a Subtitle D Cover and 0.48 mm/yr for a Subtitle C (GCL) Cover. The Subtitle D Cover was an unprotected barrier layer that was subjected to periodic desiccation cracking biointrusion (roots, animals, ants, and earthworms), and damage due to freeze/thaw cycles. These flaws were noted in the Subtitle D cap and contributed to increased saturated hydraulic conductivity for the layer. The flaws also led to preferential flow through the cover that led to the relatively high flux rates measured as compared to the ET over.

The ET cover, Anisotropic Barrier, and Subtitle C Covers were the best performing designs having the lowest measured flux rates. The ET cover and Anisotropic Barriers were estimated to cost less than half that of the Subtitle C Cover to install (SAND98-1988). The low flux rate measured through the Subtitle C Cover was shown to be primarily a function of the low effective hydraulic conductivity of the geomembrane. The geomembranes placed in the Subtitle C and Geocomposite Clay Liner (GCL) covers have unknown serviceable lives with no field data to reflect the effect on a cover's flux rate after degradation of the geomembrane. Although Koerner and Daniel (1997) claim that these geomembranes can continue to function as designed for several hundred years. However, there is a lack of empirical data on a serviceable life for the geomembranes. Therefore, this unknown data is a limiting factor when considering their use as landfill covers for long-lived waste, such as radioactive waste or other waste where extended postclosure periods may be anticipated.

The EPA has developed a website and database about alternative covers including ET covers (EPA/OSWER, 2010). The database has been developed from technical journals, conferences, technology vendors, and site managers (EPA/OSWER, 2010). The database tracks ET cover demonstration projects and full-scale operating facilities in locations representing a range of physical environmental conditions across the country. Annual rainfall associated with the alternative landfill cover projects ranges from a low of 8.89 cm (3.5 in.) to a high of 142 cm (56 in.) per year. To date, there are 92 demonstration ET covers projects in 18 states ranging from Alaska to Tennessee and many states in between. There are 20 solid waste/industrial waste/construction debris demonstration projects in the database. There are also two hazardous waste and three mixed-waste demonstration projects. ET covers are becoming more common as a landfill cover, particularly in arid or semiarid climates, but they have also been successful in humid areas such as Georgia, Tennessee, and Missouri. They have been installed at municipal landfills, landfills at other National Labs including Sandia, Los Alamos, and Idaho National Engineering Laboratory, Air Force Bases in California, Marine Corp Bases, and chemical and industrial sites in California and Texas. The EPA database indicates that alternative covers are being successfully installed at a variety of landfills across the country.

Another comprehensive study on ET cover design was performed for the DOE at the Los Alamos National Laboratory (LANL). Several test plots constructed at LANL demonstrated that a properly designed ET cover will minimize or eliminate leachate flux. However, a properly constructed

conventional Resource Conservation and Recovery Act (RCRA) Subtitle C landfill cover made of compacted clay may not function well in an arid environment because it could dry and crack, thereby allowing infiltration of precipitation until the clay re-hydrated and swelled. This is one of the reasons an alternative landfill cover approach was adopted as the standard for barrier design at Idaho National Laboratory for hazardous and radioactive mixed waste sites (Siuru, 1996, "Landfills: New Landfill Cover Testing May Result in Reduced Costs") and at the LANL (LA-UR-06-471, *Cover System Design Guidance and Requirements*).

The ITRC, which has been instrumental in promoting alternative landfill covers, was established in 1995 as a state-led, national coalition of personnel from the environmental regulation agencies of some 40 states, the District of Columbia, three federal agencies, several Native American Tribes, and numerous public and industry stakeholders. The ITRC is devoted to reducing obstacles in developing and deploying better, more cost-effective, and innovative environmental techniques. The Alternative Landfill Technologies Team was formed from within the ITRC. In 2003, this team published *Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers*, *ALT-2* (ITRC, 2003). This guide focuses on a particular class or type of alternative final landfill cover (i.e., the ET cover) indicating a preference for the ET cover concept.

The guide is based on extensive studies performed by the Alternative Landfill Technologies Team, some of whom have indicated that compacted clay liners dry and desiccate when placed near the surface, especially in arid and semiarid climates such as the Hanford Site. Desiccation creates preferential leak paths through the clay layer, which in return creates an increase in hydraulic conductivity of the flexible membrane liner/clay soil composite of up to two or three orders of magnitude. For this principal reason, the Alternative Landfill Technologies Team recommends that ET covers should be used in arid and semiarid climates, rather than the conventional RCRA Subtitle C cover.

E3 Natural Analogs

For ET covers to be effective, the design construction and maintenance must take into consideration long-term environmental processes (e.g., ecological, climate, soil pedogensis, etc.). The performance of the ET cover is modeled using current and possible future environmental scenarios. Natural analogs are useful in evaluating the performance by helping to identify and evaluate shifts in the cover environment, evaluating the stability of soils (e.g., issues from erosion, frost heave, soil piping, soil pedogensis, etc.), helping to design covers that mimic natural systems, and bounding possible future conditions for model inputs. Natural analogs also provide evidence of the efficacy of numerical predictions.

Bjornstad and Teel, 1993, (PNL-8840, *Natural Analog Study of Engineered Protective Barriers at the Hanford Barrier*) evaluated natural analogs as they related to engineered barriers at Hanford. They determined that the natural physical, chemical, and/or biological processes could adversely affect an engineered barrier over the next 1,000 years, including deflation by wind, soil compaction, soil eluviation/illuviation, bioturbation, and cryoturbation. Based on the present barrier design and the types of alteration that have taken place in Holocene soils observed throughout the Pasco Basin, none of these processes alone appears to be a significant threat to the engineered protective barriers over the next 1,000 years. However, a combination of these processes acting together (e.g., deflation in combination with compaction or bioturbation) could conceivably reduce the effective thickness of protective layers, although the likelihood of this combination of events occurring is small.

Natural analog studies for cover systems involve evaluating a natural, and sometimes archeological, material or setting that is analogous in some aspect to a proposed cover system material. The studies also involve a setting to determine what properties are effective in a given environment or what processes may lead to possible modes of failure (Gross, 2005). Designing a system that mimics the natural environment in using low precipitation, high evaporation, soil moisture balance, and hearty, native plant species, will let very little moisture infiltrate the cover system, and a minimal amount of effort will be required to keep the system working for the long term (ITRC, 2003). Although there is considerable consensus in peer-reviewed journal articles that ET covers should be analogous to natural systems, limited research has been conducted on systems analogous to an ET cover. Perhaps the closest analogous system has been the research conducted at the FLTF.

The FLTF examined native soils from the Hanford site in a controlled environment and estimated the amount of percolation through the native soils under varying climatic conditions, both simulated and real. One of the lysimeters at the FLTR had 1.5 m (4.9 ft) of a silt/loam similar to the material proposed for the NRDWL cap. Under ambient conditions (no additional simulated precipitation added) over a period of 17 years, there was 0.0 mm/yr (0.0 in./yr) of drainage (Fayer and Gee, 2006). In another experiment where three times the average precipitation was applied to the Hanford Barrier, no drainage was recorded. This indicated that under any expected increases in precipitation under various climate change scenarios, the NRDWL would still be able to prevent any drainage into the underlying waste.

Natural analog studies are needed to identify and evaluate likely shifts in cover environments, to design covers that mimic favorable natural systems, to bound possible future conditions for input to models, and to provide clues about the possible evolution of engineered covers as a basis for monitoring precursors of failure. Natural analogs also provide tangible evidence of the reliability of numerical predictions and the data supports that natural covers should survive for a long time. Understanding how inevitable environmental processes may alter the long-term performance of engineered covers is crucial to designing, constructing, and maintaining cover systems. In addition, studying and applying the lessons learned regarding natural analogs provides confidence to the design engineers, stakeholders, regulatory

agencies, tribal communities, and others that an ET cover will function for a long time since they are very similar to natural analog systems.

Environmental Services Laboratory (ESL), which is operated by S.M. Stoller Corp. for DOE, has conducted analog studies at Monticello, Utah (Contract DE-AC01-02GJ79491). They characterized natural and archaeological soils considered representative of pedogenic changes in engineered cover soils. For example, key soil physical and hydraulic properties at natural and archaeological soil profiles at climate analog sites were measured to infer possible future pedogenic changes (e.g., changes in soil physical, chemical, or biological properties over time) in the performance of the Monticello ET cover.

Relatively low precipitation, high potential ET, and thick unsaturated soils favor long-term hydrologic isolation of buried waste at arid and semiarid sites. The cover constructed at the Monticello site mimics this natural soil-water balance. The Monticello cover relies on a thick soil sponge layer overlying a sand and gravel capillary barrier to store precipitation while plants are dormant and on native vegetation to dry the sponge layer during the growing season. Lysimeter results show that less than 0.05 mm/yr (0.002 in./yr) of drainage has occurred since 2000, an amount well below the EPA target of less than 3.0 mm/yr (0.12 in./yr).

Given unprecedented longevity requirements for sites containing radioactive substances, a stewardship objective should be to design or retrofit covers to accommodate long-term environmental processes with the goal of sustaining performance and as little maintenance as possible. Investigations of natural analogs can provide insights into how environmental processes may influence the performance of engineered covers. Evidence from the natural analogs studies described by ESL has improved our understanding of meteorological variability associated with possible long-term changes in climate, vegetation responses to climate change and disturbances, effects of vegetation dynamics on ET, soil permeability, soil erosion, and animal burrowing, and effects of pedogenic on water storage and permeability.

Deployment of an ET cover in an arid climate takes advantage of several natural systems specific to Hanford's rainfall, soils, and vegetation. The site has a low annual precipitation of approximately 173 mm/yr (6.8 in./yr). The high water storage capacity of the fine-grained soils proposed for the cover (e.g., locally available silt and silt loam soils from Borrow Area C soils that have a total water storage capacity of up to 30 percent vol/vol [volume of water per volume of soil] [PNNL-14143, *The Hanford Site 1000-Year Cap Design Test*]) is also advantageous. It is noted that the properties of the silt loam from Borrow C were conducted on disturbed soil and submitted for laboratory analysis. Therefore, the properties used for modeling the performance should be comparative to the properties the soil will exhibit after it is placed. The ability of the native, semiarid vegetation to extract water stored within those fine-grained soils and a potential evapotranspiration rate of approximately 1,270 mm/yr (50 in./yr) results in a significantly limited water flux-approaching zero (PNNL-6750, *Status of FY 1988 Soil-Water Balance Studies on the Hanford Site*).

E4 Evolution of Evapotranspiration Barriers from RCRA C Clay Barriers

Evapotranspiration covers offer an alternative to compacted clay covers (i.e., conventional RCRA Subtitle C—Clay Covers). Alternatives to Subtitle C Covers were sought because of basic performance issues associated with the components of RCRA C Covers. For example, the clay component could potentially desiccate and form cracks that could fill with sand and form preferential pathways. In addition, clay and geotextiles components covers are prone to problems associated with subsidence of waste.

During the evolution of ET covers, the U.S. Department of Energy (DOE) and EPA sponsored the Alternative Landfill Cover Demonstration (ALCD) Project at Sandia National Labs. The ALCD was a large-scale field test of two conventional designs (RCRA Subtitle C and Subtitle D) and four alternative landfill covers (monolithic ET cover, capillary barrier ET cover, geosynthetic clay liner cover, and anisotropic [layered capillary barrier] ET cover). The ALCD collected information on construction, cost, and the performance requirements needed to compare alternative cover designs with conventional covers. The RCRA Covers were constructed in 1995 and the ET covers were constructed in 1996. The covers (43 ft × 328 ft) were seeded with native vegetation. The purpose of the project was to use the performance data to demonstrate equivalency between ET covers and RCRA Covers and refine the numerical models to be able to more accurately predict cover system performance. The ALCD collected data on percolation using lysimeters and soil moisture probes to monitor cover performance. Total precipitation and percolation volumes were measured over 5 years (Table E-1).

The ET covers generally performed equally well as the Subtitle C Cover and better than the Subtitle D Cover. With the exception of the first two years (1997 and 1998) of monitoring, which was also the first two years after the ET covers were constructed and when the covers were dewatering, the monolithic and capillary ET covers had 0.00 mm/year of percolation through the covers between 1997 and 2002, which was identical to the Subtitle C Cover and 0.74 mm/year for the Subtitle D Cover. The higher percolation rate (measured using lysimeters buried beneath the covers) in the first 2 years of the study can be attributed to the vegetation becoming established on the cover and water used during construction for soil compaction percolating through the cover. The exception was in the third year, 1999, when 0.01 mm (0.0003 in.) of percolation was monitored in the monolithic cover. However, this is well (50x) below the generally accepted design flux rate of 3.0 mm/year. The EPA created the Alternative Cover Assessment Program (ACAP) in 1997 to compare traditional RCRA Clay caps and alternative covers. Tests sites were located in California, Georgia, Iowa, Montana, Nebraska, Ohio, and Oregon and were selected to encompass a variety of climates, soils, and stable vegetation. The test sites were set up to monitor runoff, soil moisture, meteorological data, and percolation through the cover. The key findings of the ACAP were:

- The alternative covers performed as well as or better than compacted clay covers.
- Installation cost savings of greater than $200 million for 30 sites.
- The data and design methodologies have been used to support regulatory decisions to approve permit and installation of alternative cover systems at conventional and Superfund Sites (*EPA Summer 2007, Number 40, Office of Research and Development Superfund and Technology Liaison Region 9 Newsletter*).

Alternative covers constructed in arid, semiarid, and sub-humid locations were generally effective with the performance comparable to a conventional composite cover (Albright et al., 2004). The percolation rate for the alternative final covers was generally less than 1.5 mm/yr (0.05 in./yr).

The ITRC has also performed extensive research on alternative final covers to determine if they are equivalent to conventional covers and concluded that alternative landfill covers, including ET covers, can be as protective and economically feasible as traditional capping technologies.

Table E-1. Summary of Performance of Various Covers from Alternative Landfill Cover Demonstration

	1997 (5/1–12/31)		1998		1999		2000		2001		2002 (1/1–6/25)	
	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)	Precip. (mm)	Perc. (mm)
Monolithic ET	267.00	0.08	291.98	0.22	225.23	0.01	299.92	0.00	254.01	0.00	144.32	0.00
Capillary Barrier ET	267.00	0.54	291.98	0.41	225.23	0.00	299.92	0.00	254.01	0.00	144.32	0.00
Anisotropic ET	267.00	0.05	291.98	0.07	225.23	0.14*	299.92	0.00	254.01	0.00	144.32	0.00
Geosynthetic Clay Liner	267.00	0.51	291.98	0.19	225.23	2.15*	299.92	0.00	254.01	0.0	144.32	0.00
Subtitle C	267.00	0.04	291.98	0.15	225.23	0.02	299.92	0.00	254.01	0.00	144.32	0.00
Subtitle D	267.00	3.56	291.98	2.48	225.23	1.56*	299.92	0.00	254.01	0.00	144.32	0.74

Source: EPA/542/F-03/015, 2003, *Evapotranspiration Landfill Cover Systems Fact Sheet*

To convert from millimeters (mm) to inches (in.), multiply by 0.0393.

* The reason for the spike in percolation in 1999 along with a drop in the precipitation is not understood.

ET = Evapotranspiration

Perc. = Percolation

Precip. = Precipitation

E5 Equivalency of Evapotranspiration Covers to RCRA Subtitle C Covers

Under RCRA and WAC 173-303-665(6), alternative final covers, such as ET covers, can be proposed and approved if it can be demonstrated that they have equivalent performance to a conventional RCRA Subtitle C Cover for percolation, resistance to erosion, and control of gas through the cover. They must also meet the requirements of WAC 173-303-665(6). These provisions for alternative covers have provided the incentive to develop the ET cover to address potential performance problems of conventional barriers in arid environments. To meet the low permeability requirements, ET covers rely on soils with high water-storage capacity, vegetation that transpires moisture to the atmosphere, and evaporation of moisture from the surface. This alternative cover approach has produced the equivalent low hydraulic conductivity by minimizing percolation instead of installation of a low hydraulic conductivity barrier such as a synthetic geomembrane on compacted clay. ET covers are already in use in a variety of settings and field-testing is being conducted at pre-Subtitle D unlined facilities, Subtitle D lined faculties, pre-Subtitle C unlined facilities, and Subtitle C lined facilities (EPA/542/F-03/015, 2003). ET covers have also received regulatory approval for installation at radioactive landfills. There are Subtitle D alternative cover designs in place or approved at industrial, municipal, and construction debris landfills.

Properly constructed and maintained ET covers have several potential benefits over the conventional landfill covers, while being equally protective of human health and the environment. Some of the benefits cited for alternative covers include more readily available construction materials, ease of construction, less complex quality assurance/quality control programs, self-healing for mild to moderate subsidence, increased long-term cover integrity, and stability. Alternative covers have been constructed and are fully operational at industrial waste, construction debris, municipal solid waste, and hazardous waste landfills.

This closure plan demonstrates the equivalency of an ET cover to a conventional RCRA Subtitle C cover. Several specific advantages of the ET cover compared to the RCRA Subtitle C cover are discussed herein that support the selection of an ET cover for the NRDWL/SWL. A conventional landfill cover for landfills containing dangerous waste (RCRA Subtitle C Cover) is designed using multiple layers. The base is constructed of low-permeability materials and typically consists of a geomembrane on compacted clay (EPA/530-SW-89-047, *Technical Guidance Document: Final Conversion Hazardous Waste Landfills and Surface Impoundments*). It is designed to reduce or eliminate infiltration of precipitation into the waste layers. The generation of leachate and the potential for contaminants to enter the environment is also greatly reduced.

Based on studies by Waugh et al. (1999) there are durability issues associated with RCRA Subtitle C covers. The RCRA Subtitle C covers are reported to develop cracks over time because the clay in the covers shrinks when it desiccates during the summer. These cracks may close in the winter but they can also fill with sand and create preferential pathways. In addition, RCRA Subtitle C covers do not tolerate minor settling or subsidence because the geotextiles may become compromised by rips or tears resulting from differential subsurface forces. The cracks that may form due to subsidence do not self-heal. By contrast, ET covers are not similarly affected and are capable of self-healing under similar circumstances.

The selection of an alternative to a RCRA Subtitle C cover, such as an ET cover, is site specific and is influenced by the climate, soils, landfill waste characteristics, hydrogeology, and potential for gas production, seismic environment, and proposed reuse, if any, of the waste management unit. The Hanford site is well suited to ET covers.

1

E6 Uranium Mine Tailings Remedial Action Cover Sites

Early generation Uranium Mine Tailings Remedial Action (UMTRA) Covers located at the DOE Moab, Utah facility were constructed of three layers: a compacted soil layer (CSL), a surface layer of durable rock for erosion protection, and a lateral drainage layer consisting of coarse sand or gravel between the CSL and the rock layer. There were several issues with this design that attributed to the under-performance of the cover. For example, the surface rock layer reduced evaporation and increased soil water storage, which potentially increased infiltration to the waste. Additionally, the rock later promoted the encroachment of plants and the growth of deep-rooted plants, which could potentially uptake contaminants and create conduits for infiltration of precipitation.

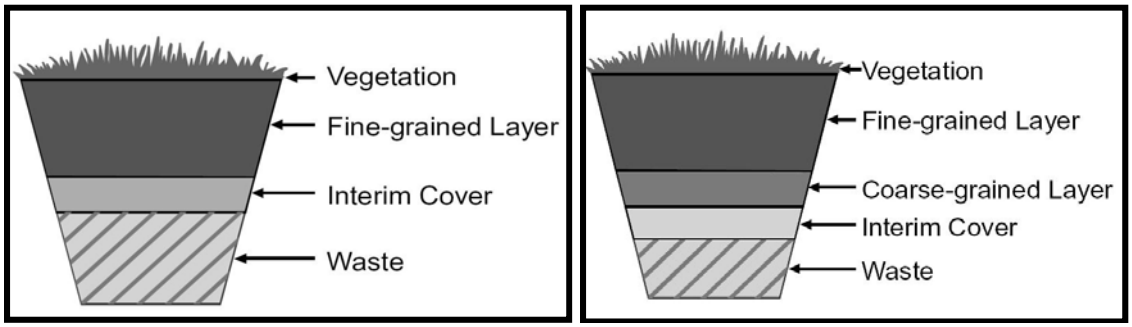
Later UMTRA designs promoted an engineered cover system with an emphasis on incorporating natural analog systems, including taking advantage of areas with low relative precipitation, the use of high potential evapotranspiration soils and plants, and thick unsaturated soils. However, these designs did not take into account the relationship between precipitation and evapotranspiration and, therefore, the alternative cover systems had upwards of 60 percent recharge to the subsurface. On the other hand, UMTRA cover design has further developed to take advantage of the lessons learned from past barrier design features that resulted in underperformance.

The ET cover proposed for NRDWL/SWL will incorporate the lessons learned at the UMTRA sites. For example, the surface rock layer has been eliminated from the design. To manage erosion, pea gravel (15 percent by weight) will be blended to the top 20 cm (8 in.) of the cap. The gravel will not impact evaporation from the cover and will reduce water and wind erosion on the surface cover. Over time, the pea gravel will form a protective desert pavement-like surface to further reduce the potential for erosion. The compacted soil layer has been replaced with silt loam cover that is less prone to cracking and more tolerant of minor subsidence.

1

E7 Capillary Versus Monolithic Type Covers

Two common types of ET covers include monofill (or monolithic) covers, which rely on a relatively thick single layer of fine-grained soil, and capillary covers, which consist of a fine-grained soil layer overlying a relatively coarse-grained soil layer (Figure E-3).



Monofill (monolithic) ET Cover **Capillary ET Cover**

Source: EPA/542/F-03/015, Evapotranspiration Landfill Cover Systems Fact Sheet.

Figure E-3. Common ET Cover Designs

In the capillary ET cover, the distinct textural interface between the fine- and coarse-grained soil layers creates a capillary break, which functionally increases the water holding capacity of the fine-grained soil. Water will not flow into the coarse layer until the water content in the fine-grained soil approaches saturation. Given the same soil type, to achieve an equivalent water-holding capacity, the monofill ET cover typically requires additional soil thickness relative to a capillary ET cover.

The site-specific decision on whether to use a monofill or capillary type of ET cover design is based on soil characteristics (e.g., water-holding capacity), rooting depth of native plants, potential for subsidence (e.g., settlement), and cost of construction. Monofill and capillary ET cover designs utilize the same fine-grained soils and require the same minimum rooting depth for native plants. Therefore, the only effective variables are the potential for subsidence and the cost of construction.

The monolithic ET cover is better able to accommodate differential subsidence relative to a capillary ET cover, which relies on maintaining a planar textural interface. If the textural interface is compromised or disrupted because of differential subsidence or some other occurrence, water-holding capacity and thickness of the capillary cover would diminish to that of a monofill cover. In addition, if subsidence were significant enough in the case of deploying a capillary barrier, a large break in the capillary barrier could result in preferential flow and focused recharge.

1

E8 Advantages of Evapotranspiration Barriers

Evapotranspiration covers have distinct advantages over conventional covers. They are a man-made landform; a natural analog, and are ideally suited for the arid environments found at Hanford. They tend to be self-healing to mild to moderate settlement. In addition, the potential for the formation of desiccation cracks is reduced because of the low clay content of the high-silt content soils that are typically used. In contrast, the drainage sand and top soil that is common on top of a geomembrane cover is not as likely to self-repair under similar environmental conditions. Compacted clay placed near the surface will desiccate and the cracks will fill with sand caused by the initial wetting front, creating preferential flow paths through the clay layer. The proposed ET cover also has pea gravel in the upper 20 cm (8 in.) to reduce the potential for wind erosion.

Below are some other commonly acknowledged advantages to using an ET cover.

- Enhanced confidence of long-term performance due to the evaluation and subsequent mimicking of natural analog sites. Reduced or eliminated cover elements such as geosynthetics, which do not last as long as native materials.
- Reduced quality control/quality assurance (QC/QA) testing due to the elimination of some construction materials and construction steps.
- Reduced construction costs associated with locally available cover soils, therefore reduced soil hauling costs, reduced soil engineering or required energy (mixing, wetting, compacting) to achieve low-permeability specifications.
- Reduced construction time due to the reduced number of cover elements (silt loam and pea gravel).
- Reduced long-term monitoring cost related to progressive monitoring plans based on continued stability of an ET cover.
- Long-term stewardship (operation and maintenance) liabilities are reduced.
- Lower maintenance related to reduced erosion because of established plant communities and gravel/admix additions.
- Lower maintenance related to lack of potential geosynthetic failure.
- Increased stability, which reduces the potential for cover failure and the release of waste that could impact human health and the environment.

The purpose of the ET cover, is to isolate the waste materials from humans and the environment, including ecological receptors and vectors, and minimize moisture flux through the cover and into the waste. The ET cover will dramatically reduce the amount of infiltration and minimize the generation of leachate from precipitation by relying on the natural evaporation and transpiration processes inherent to surface barriers. Minimizing the generation of leachate reduces the need to manage liquids passing through the waste and reduces the potential of contaminants from the landfill impacting the environment (i.e., soils, groundwater, or surface water). ET covers are endorsed by the EPA (EPA 542-F-03-015 *Evapotranspiration Landfill Cover Systems Fact Sheet*) and the Interstate Technology and Regulatory Council (ITRC) (ITRC, 2003). In addition, there are over 17 years of performance data on the Hanford Barrier, which has demonstrated the effectiveness of an ET cover in limiting flux to the groundwater. There is also over 25 years of natural analog data on the materials (silt loam) proposed for the

NRDWL/SWL barrier construction from the Field Lysimeter Test Facility (FLTF) located on the Hanford Site that show that the proposed silt-loam cover material is capable of limiting flux.

An ET cover relies on the inherent properties of the soil, such as the soils' ability to retain or store water, evaporation from the near surface, and plant transpiration to minimize or eliminate water movement through the cover. Most of the precipitation infiltrates only the near surface of an ET cover, and is retained in the soil layer until natural evaporation and transpiration (evapotranspiration) processes release the water back to the atmosphere; preventing it from infiltrating into the subsurface waste. ET covers are particularly suitable for semiarid and arid climates with a low annual amount of precipitation and a relatively high evapotranspiration potential, such as the Hanford Site. Simply put, the ET cover operates so that when precipitation exceeds evapotranspiration, water will be stored in the subsurface (100 cm [39.4 in.] cover), and when evapotranspiration exceeds precipitation, water will be removed. Therefore, the net flux through the cover will be essentially zero.

E9 Root Depth

In a study of rooting depth, water availability, and vegetation cover along an aridity gradient, (Schulze et al., 1996) showed that rooting depth compensates for low rainfall with the depth zonation controlled by water supply. Sites ranging from those with forest with high annual rainfall (770 mm [30.2 in.]), to scrub (520 mm [20.4 in]), Festuca (290 mm [11.4 in.]), and Stipa (160 mm [6.3 in.]) grasslands into desert vegetation (125 mm [4.9 in.]) formed the aridity gradient. Along the gradient both mean above- and below-ground biomass and leaf area index decreased. In all habitats, roots reached water-saturated soils or groundwater at 2–3 m (6.5 – 9.8 ft.) depth. While the depth of the soil horizon that contained 90 percent of the root biomass was similar for forests and grasslands (about 0.80–0.50 m [2.6 – 1.6 ft.]), it was shallower in the desert, reaching only 0.30 m (1 ft.). Schenk and Jackson (2002) provided a comprehensive literature synthesis of rooting depths, lateral root spread, and below-ground to above-ground biomass ratios that have also proven useful in estimating root distributions by plant functional groups. Based on over 1,300 records of root-system sizes for plant functional groups collected from different precipitation zones, it was concluded that root-system sizes differed among growth forms and increased with above-ground size according to annuals < perennial forbs = grasses < semi-shrubs < shrubs. Absolute rooting depths increased with mean annual precipitation (MAP) in all plant functional groups except shrubs. In general, root systems tended to be shallower and wider in dry and hot climates and deeper and narrower in cold and wet climates. Shrubs were more shallowly rooted under climates with summer precipitation than those with winter precipitation regimes.

Using an independent data set of 20 test locations, Schenk and Jackson (2002) predicted rooting depths from mean annual precipitation using regression models for three broad growth forms. These models were successful in explaining 62 percent of the observed variance in median rooting depths and are therefore used to estimate rooting characteristics for species without site-specific data. Rainfall was a much stronger predictor for rooting depth than mean annual evapotranspiration (PET) in all growth forms.

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E10 Additional Project Considerations

There are a variety of project considerations associated with the successful design, construction, and maintenance of landfill systems. These considerations can negatively impact closure. However, by identifying these factors, risk of failure can be successfully mitigated during the implementation of landfill closure design, construction, and postclosure care. There are several components that have been identified that potentially contribute to risk at NRDWL/SWL: the local geology, the chemicals disposed at NRDWL/SWL, the potential for the production of landfill gas (predominantly methane), the presence of waste derived VOCs in the soil gas or the groundwater, percolation of precipitation through the waste and migration of contaminated leachate into the groundwater, and the original landfill construction design (i.e., the presence or lack of a bottom liner). Each of these items is discussed below.

Waste in the NRDWL/SWL is located in eolian deposits and Hanford formation strata. These types of strata have relatively high permeability and are conducive to liquid, vapor, and gaseous transport. To reduce the transport risks associated with the local geology, waste materials need to be covered with a low permeable barrier to reduce or eliminate the amount of percolation of surface water or precipitation through the waste to minimize transport of leachate into the underlying geologic formation and into the groundwater.

There were large varieties of waste types placed in NRDWL/SWL. By volume, most of the waste was basic sanitary/municipal landfill waste or asbestos materials with little or no toxicity. At NRDWL/SWL, 13 of the 19 trenches were dedicated asbestos disposal locations. In the six chemical trenches, chemical wastes were disposed of in bulk, in absorbents and in overpack drums. Appendix B lists the over 2,700 chemicals that were disposed at NRDWL/SWL. Collectively, most of the chemicals consisted of small quantities for laboratory-derived waste, such as metallic salts, acids, bases, oxidizers, organic compounds, and flammable compounds that were disposed. The waste also consisted of bulk quantities of cleaners, paint, oil, and solvent waste. Characterizing the location of the waste material by a review of the operating records and then evaluating the quantity, toxicity, persistence, and mobility of these wastes provides a baseline for evaluating the potential for and significance of transport of leachate from the source material to groundwater. In addition, knowledge of over 20 years of groundwater monitoring at the site provides information on constituents that are more mobile and persistent at the site. Capping the NRDWL/SWL with low permeability material can minimize this risk.

Additional characterization of the waste quantities and type is possible, but to a limited degree, because the records (i.e., manifests) are incomplete. In addition, further characterization will not reduce the amount of risk associated with the site since both the location, quantity, and type of waste are established and enough is known to locate and construct a cover to reduce leachate. Use of intrusive techniques for additional waste characterization are unnecessary, potentially dangerous and impractical given the area (>70 acres) involved. For example, drilling random boreholes to further characterize the waste mass would not likely be representative unless hundreds of holes or many linear feet of trench were excavated. Given the extensive knowledge of waste type, location, and existing groundwater data, further characterization would not impact the current selection of cover type, location, or design and therefore unnecessary to further reduce risk.

Landfill gases, such as methane, may be present at NRDWL/SWL, originating from volatilization and degradation of the waste material. However, considering the type of the majority of the waste material (high percentage of dry wood and office paper waste) and the amount of time that has passed since closure (20-30 years), it is unlikely that significant landfill gas production is presently taking place. Methane generation in typical municipal landfills peaks within 10-15 years of closure then declines over time. Decline in soil gas levels of methane over the past decade at the NRDWL/SWL site are consistent

with these observations. With native soils surrounding the trench, the current NRDWL/SWL interim cover has a relatively high permeability and silt/silt-loam soils of the monofill ET cover has a moderate gas permeability. Therefore, any gas generated from NRDWL/SWL would likely diffuse and disperse and spread over a large enough area to not accumulate at hazardous levels and able to reach the atmosphere without requiring any special features for cover ventilation. Thus, ET barriers have a lower inherent risk to gas migration and control compared to Subtitle C Covers using low gas permeability cover material.

In addition, landfill gases are primarily the product of microbial activity, specifically methanogenic microorganisms that produce methane in an anaerobic environment. One of the required components for methanogenic organisms to produce methane is adequate moisture. The proposed ET cover will significantly reduce moisture entering the waste from the surface. After the cap is installed, with little or no moisture capable of entering the waste, the potential for generated landfill gas will likely be reduced because of the reduced microbial activity. In addition, the current soil gas-monitoring program indicates that lower methane levels are present compared to past readings, suggesting that methane generation has declined over the years as the more easily degradable compounds have already decomposed.

ET covers, as natural soils and plants, have been reported to be biologically active and consume methane. Since the amount of methane being produced in the landfill has recently been declining, the ET cover should be able to consume the small amount of methane that is still being produced.

Soil gas monitoring in the vadose zone adjacent to NRDWL/SWL was performed in 1992, 1993, and 1997. Initially, some VOCs were detected but the frequency of the detections and the concentrations of the constituents in those detections have declined. In addition, the biodegradation rate of compounds disposed in NRDWL/SWL will decline after the cover is constructed. Biodegradation takes place when the cover eliminates moisture from entering the waste. If a traditional clay or GCL barrier was used, any VOCs escaping would be accumulate toward the outer perimeter of the barrier, thereby representing a greater potential threat.

Installation of a barrier is protective of human health and the environment by breaking the direct exposure pathways to the actual waste and minimizing the migration of contaminants to the groundwater.

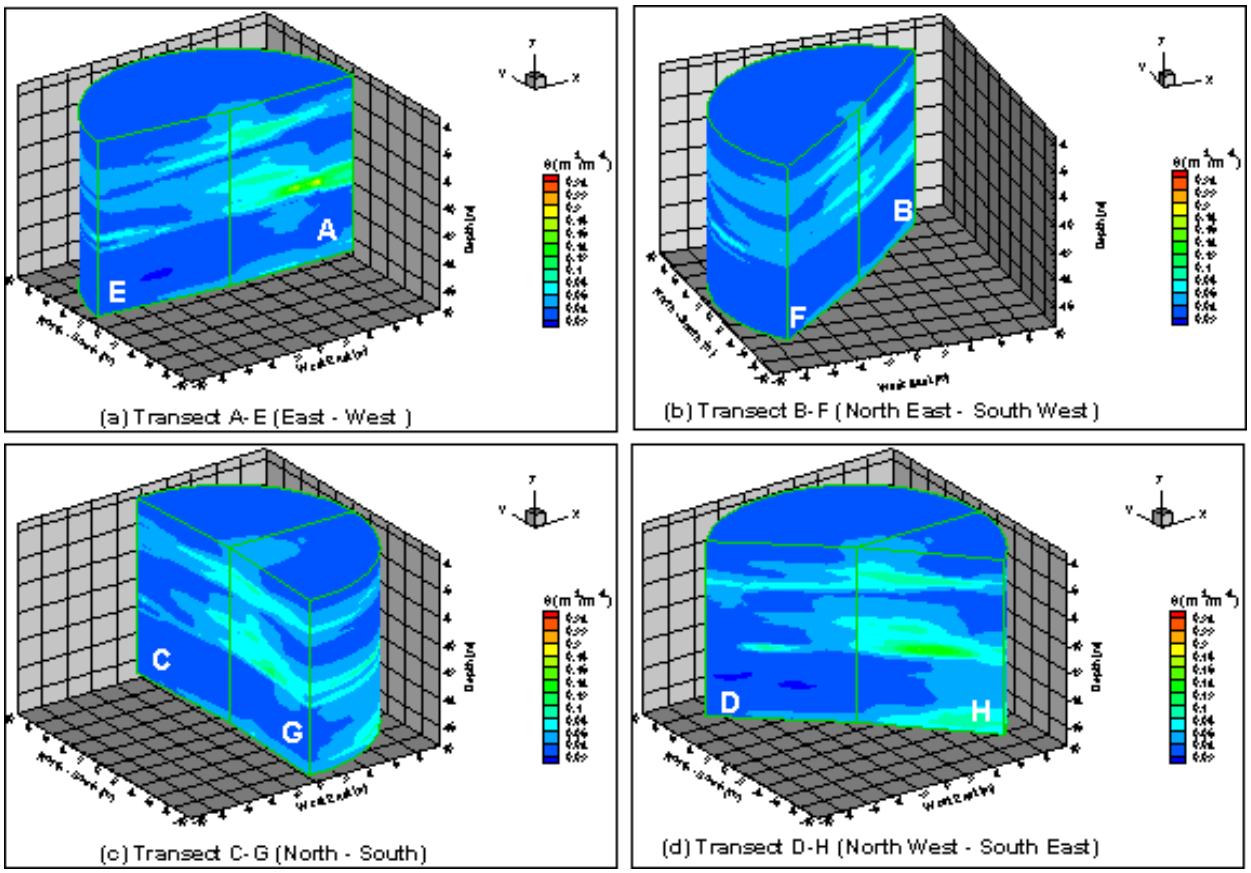
E11 Lateral Flow

Depending on the subsurface geology, the distribution of water and contaminant plumes in Hanford's vadose zone can show extensive lateral spreading, with splitting along flow paths, and multiple zones of elevated water and contaminant concentrations even in soils that appear homogeneous and isotropic at the field scale (PNNL-14143; Ward et al., 2006). Lateral spreading is commonly attributed to anisotropy in the hydraulic conductivity tensor caused by local-scale changes in lithology associated with sedimentary facies. However, very few data are available to support model parameterization to account for these features.

Observations at several of Hanford's waste sites suggest that vadose zone transport is controlled by a complex interplay between recharge, layered heterogeneity, geometric anisotropy, and saturation dependent anisotropy. Phenomena like saturation-dependent anisotropy become particularly important in the deep vadose zone where antecedent soil water content is generally low. As part of the Science and Technology Project (PNNL), a series of studies were conducted at the Sisson and Lu Site (south of PUREX) over a two-year period to investigate the impacts of layered heterogeneity and anisotropy on field-scale transport (Ward et al., 2006). The flow field, which was monitored using a variety of geophysical tools (neutron thermalization, electrical resistivity/conductivity, and ground-penetrating radar) and destructive sampling, showed significant asymmetry resulting from fine-scale stratigraphic changes. Part of the complexity arises from the natural capillary breaks that form when fine-textured layers are underlain by coarser sediments. During variably saturated flow, these structures can redirect flow laterally until the matric potential in the fine layer is sufficient to overcome the entry pressure of the underlying coarse layers.

Figure E-4 shows the moisture distributions after the injection of 30,400 L (8,031 gal) of water. The effect of local capillary breaks is evident in the nonuniform distribution of moisture. A low-permeability layer at the 12 m (39 ft) depth was quite effective in stopping the downward migration of water except in the southeast corner (5-5d) where water bypassed this layer, perhaps via a well bore. The fine-scale layering enhanced the lateral movement of water resulting in water leaving the monitored domain via the southeastern quadrant (Figure E-4), which highlights the importance of stratigraphy and lineation (strike and dip) of the depositional environment, even for unsaturated flow processes.

To gain further insight into the stratigraphic effects on the behavior of the water plume, the time dependence of the zeroth spatial moments was calculated. Figure E-5 compares the time dependence of recovered mass of water with the injected mass of water in kilograms. Until the third injection, injected mass and the recovered mass were in good agreement. During the test, the target pump rate was steady for the duration of the test and the cumulative injected mass approximated a straight line. A total of 11,983.37 kg (26,419 lbs) of water was injected by end of the third injection on June 15, 2000, and a total of 19,972.29 kg (44,031 lbs) injected by June 28, 2000. Mass recovery from the June 16, 2000 logging accounted for 11,404 kg (25,142 lbs) or 95.2 percent of the injected mass. Given the 24-hour delay in measurement and the error in the neutron probe resulting from the use of a single calibration curve for a layered system, the mass recovery is quite remarkable. By the fourth injection, 15,977.8 kg (35,225 lbs) of water had been injected but the recovered mass was only 13,803 kg (30,430 lbs) or 86.4 percent. From this point on, there is increasing discrepancy between the injected and recovered mass. By the end of the monitoring period on June 31, 2000, mass recovery was only 10,262 kg (22,624 lbs), or 51.4 percent of the amount initially injected.

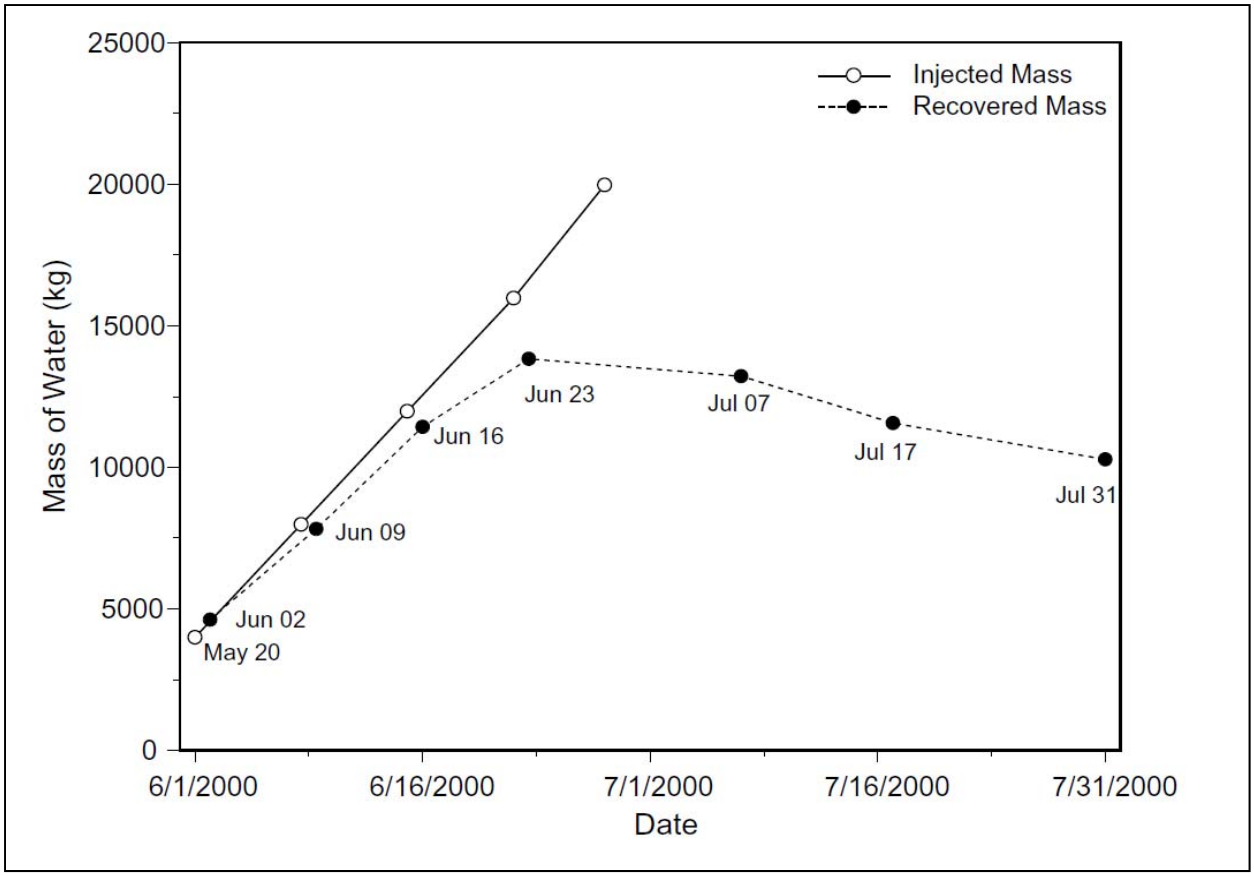


Note: After an Injection of 30,400 L of Hypersaline Water (a) Transect E-A, (b) Transect F-B, (c) Transect C-G, and (d) Transect B-F.

Figure E-4. Spatial Distribution of Soil Water Content, Interpolated from Neutron Probe Measurements in the 32 Wells at Vadose-Zone Test on May 10, 2001

The most rational explanation for the divergence between the injected and recovered mass is water leaving the monitored domain. While the boreholes used for monitoring extend to a maximum of 8 m (26 ft) from the injection point, there is no physical subsurface boundary so the water is free to redistribute in three-dimensional space in response to the potential gradients. The effective anisotropy ratios (Kx:Kz)—estimated from the deviation of the mean centroid trajectory from the direction of the mean head gradient—ranged from 1 to 40 compared to 10, which is typically used in model simulations. Inverse modeling with a saturation-dependent anisotropy model gave anisotropy ratios ranging from 4 to 25 for the major layers. Moisture content data were also analyzed by spatial moments and variogram modeling to determine the cause of asymmetry. Geostatistical analysis of the spatial correlation structure of moisture content showed significant anisotropy and a time dependence in the spatial continuity of moisture. The direction of maximum continuity was to the east and correlation lengths were approximately 100 m (328 ft), suggesting that these zones of preferential flow could extend for at least 100 m (328 ft).

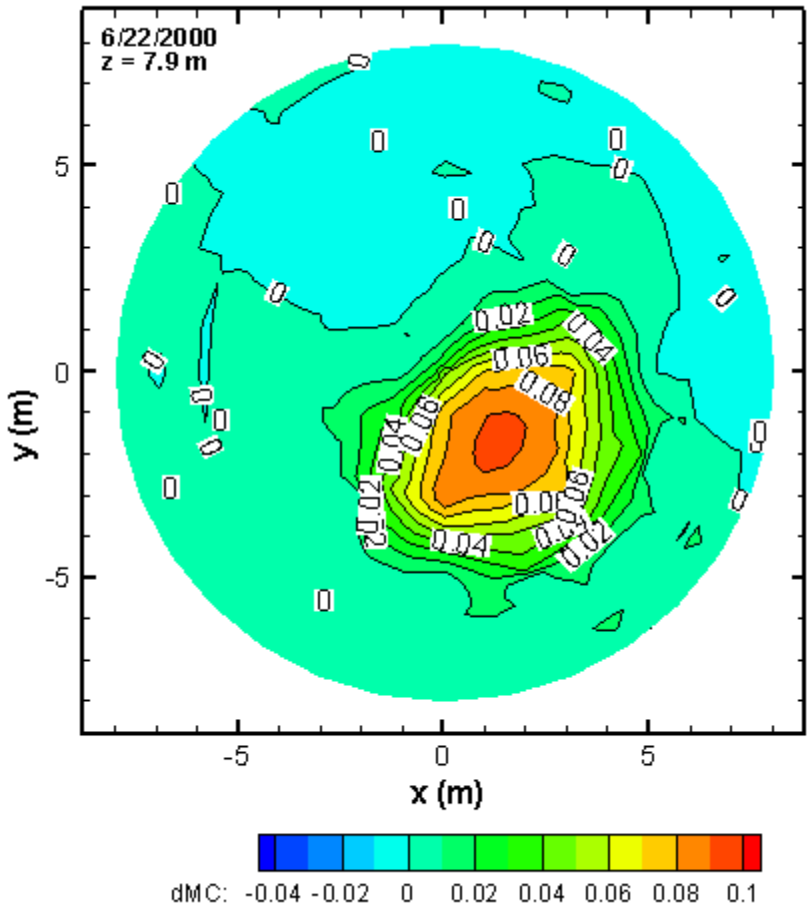
In summary, the potential impact of lateral flow in the ET cover is not likely to be a concern since the cover material and construction will result in a homogeneous cover.



Note: Recovered mass was determined from the zeroth moments.

Figure E-5. Comparison of the Injected and Recovered Mass of Water

Another component of lateral flow is the flow of off-site moisture, which may infiltrate the surface adjacent to the cover and flow laterally under the cover to the waste where it may become leachate. A simple two-dimensional simulation was conducted to demonstrate the impact of a surface barrier on travel times within a homogenous isotropic vadose zone (PNNL-18661). The simulation evaluated the lateral and vertical impact of a surface barrier on travel time of subsurface water through the vadose zone. Directly beneath the barrier, the travel times were more than 10,000 years. At the same depth less than 100 m (328 ft) beyond the edge of the barrier, the travel times to the water table were about 1,950 years. Although travel times were impacted most significantly below the center of the barrier, the barrier impact on travel time extended nearly 30 m (98 ft) beyond the edge of the barrier. In summary, the results illustrate (1) the surface barrier increases time of travel (i.e., retards travel), (2) the increase is a function of depth and a function of distance from the barrier edge, and (3) the barrier increases travel time in the vadose zone some distance beyond the barrier edge. The movement of the plume is shown to the southeast. This plot represents the change in soil water content (θ) from the initial condition (Figure E-6).



Notes: The movement of the plume was southeast. This plot represents the change in θ from the initial condition at the 7.9 m depth (vertical location of center of mass) of 15,978 kg of Salt-free Water at coordinates x=0,y=0.

Figure E-6. Change in Soil Water Content from the initial condition after the Injection

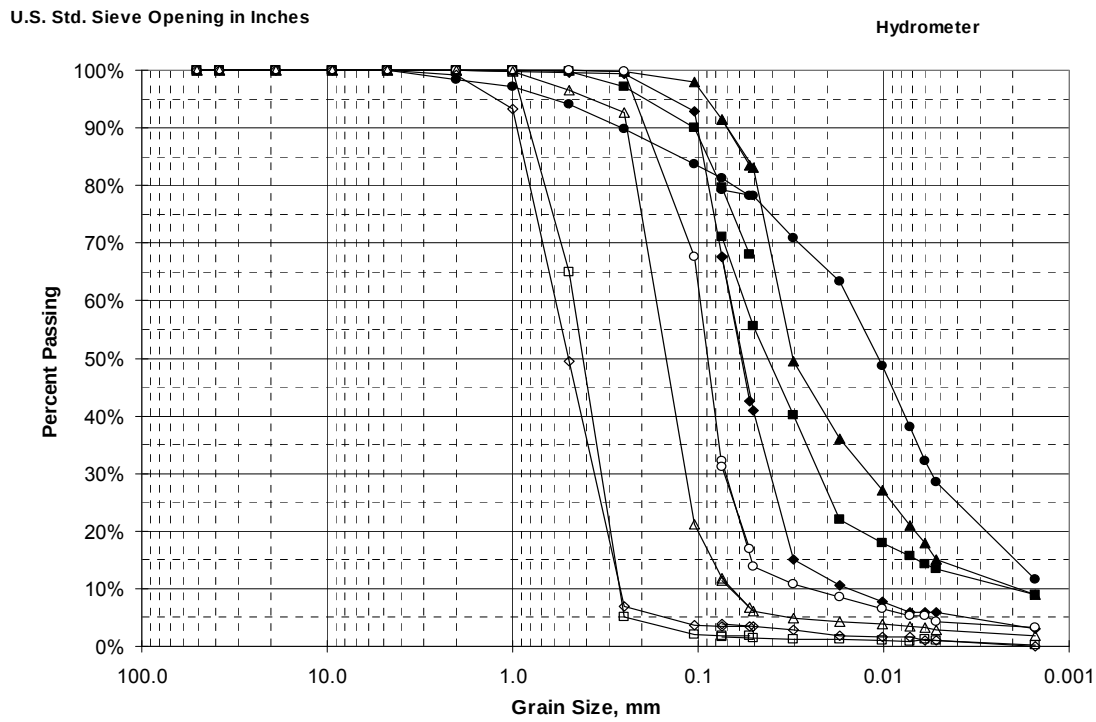
E12 Clastic Dikes

In typical depositional environments such as the area of the NRDWL/SWL, sediments are laid down in a predominantly horizontal fashion. Occasionally within these layers, sub-vertical cracks and horizontal seams are filled with sediments other than the host material. Bedding discordant (dikes) filled with multiple layers of sand, silt, clay, and minor debris typically less than 2 m (6.5 ft) wide are often shallow but have been observed up to 70 m (230 ft) deep (BHI01103). Vertical clastic dikes occur at many locations in the waste management areas at Hanford (BHI01103) and have been proposed as potential preferential pathways for vertical contaminant transport (PNNL-11810). The vertical orientation of the clastic dikes provides a possible avenue for vertical transport of contaminants that may be faster than transport through a horizontally layered sediment sequence. For example, at one field site flow rates were found to be more than 10 times faster in a clastic dike than flow through the enclosing horizontally-layered sediments (BHI01103). Bedding concordant (sills), usually thin in relation to their length, were commonly observed along the base of the lowermost fine-grained stratum and could enhance lateral flow.

Much of what is known about clastic dikes at Hanford is based on qualitative rather than quantitative observations. Bechtel Hanford, Inc. published the results of several small-scale field tests designed to measure the hydraulic conductivity of clastic dikes and their host sediments (BHI01103). They found hydraulic conductivities in the center of dikes to be about 10-3 cm/sec (3.9-1.1 in./sec), hydraulic conductivities across clay linings to vary from 10-4 to 10-5 cm/sec (3.9-1.6 to 3.9-2.0 in./sec), and hydraulic conductivities of Hanford formation host sediments to be about 10-3 cm/sec (3.9-1.1 in./sec).

In 2001, a study was undertaken to examine the small-scale hydrogeologic properties of clastic dikes, to address issues related to their geometry and internal structure, and to quantify their effect on vertical transport (Murray et al., 2007). The study was performed at a site off of Army Loop Road and included excavation of a clastic dike, taking detailed measurements, performing an infiltration test, and conducting flow modeling. A number of methods were used to measure geological and hydrogeological properties of the clastic dikes and enclosing matrix sediment of the Hanford formation. Techniques employed included air permeability, IR temperature imagery, grain-size analysis, and antecedent moisture content, x-ray diffraction (XRD) measurements of the mineralogy, GPR, neutron probe log, time-domain reflectometry (TDR), and tensiometers. Over 450 measurements were made on three tiers of the excavation, one-third in the dike and two-thirds in the matrix.

Figure E-7 shows a log-probability plot of particle diameter, d, as a function of cumulative mass percent less than d for several samples. The wide range of textures exemplifies the variability at the field site. Even though these samples were all from material that is from the sand-dominated upper Hanford formation, or appears to be derived from that material, there were many samples with size distributions reflecting a finer texture than the typical Hanford sand. Soil textures, derived from the ratio of sand, silt, and clay, ranged from coarse sands (AL-HT2-1) with over 95 percent sand for a sample taken from the matrix sediment surrounding the dike, to medium and fine sands (AL CDT2-2) in coarse segments of the clastic dike, to loam and silt loam (AL-CD-T2-7) with as much as 19 percent clay in the fine-grained portions of the clastic dike. This wide variation in particle size distribution within clastic dike material can be expected to influence water retention characteristics and permeability, and ultimately, the flow and transport properties under unsaturated conditions.



Note: Essentially five soil types were identified from the analyses-silt loam (e.g., IN-A1-5, ●), loam (e.g., AL-CD-T3-1, ■); sandy loam (e.g., AL-CD-T2-8, ♦); loamy sand (e.g., AL-CDT2-5, ○); and sand (e.g., Al-HT4-1, □).

Figure E-7. Comparison of Particle Size Distribution from <2 mm Fractions from the Army Loop Road Field Site

The results indicate the median air permeability of the dike is about an order of magnitude lower than the permeability in the host matrix. Therefore, even though dikes may penetrate to significant depths, the permeability is much lower than surrounding materials and would likely impede flow. The variability of the data from the dike is much higher than that of the matrix, with a coefficient of variation (i.e., ratio of standard deviation to the mean) of 1.2 in the dike vs. 0.6 in the matrix. The overall variability of air permeability in the dike-matrix system is about four orders of magnitude (Figure E-8). This is an important observation, because some methods used for upscaling permeability data assume the variability in the system is low, about an order of magnitude, which means it would be questionable to apply those methods to the clastic dike and its surrounding sediments.

Experimental data and numerical simulations suggest that enhanced vertical transport in a dike, relative to the matrix, would only occur for certain ranges of recharge (Murray et al., 2007). In general, these would be limited to recharge rates where the saturation of the finer materials resulted in a higher permeability in the dike than in the sand. However, even under these conditions, the permeability of the dike would be so small that the increase in flow would have negligible effects. There is potential for increased flow in the coarse inclusions of the dike as seen in the dye tracer experiment. However, these inclusions are typically discontinuous and would transport contaminants over relatively short distances. Even if clastic dikes did increase the vertical transport for moisture at certain conditions of saturation, the effect on transport would be limited to non-sorbing contaminants. The fine-grained nature of clastic dikes, with up to 19 percent clay sized material in the finer-grained portion of the Army Loop Road clastic dike, suggests that reactive contaminants would be effectively sorbed and would be unlikely to travel very deep in clastic dikes. Therefore, dikes would effectively cut off lateral flow and transport of these contaminants.

Therefore, the potential impact from clastic dikes on accelerating the transport of contaminants to the groundwater is very minor.

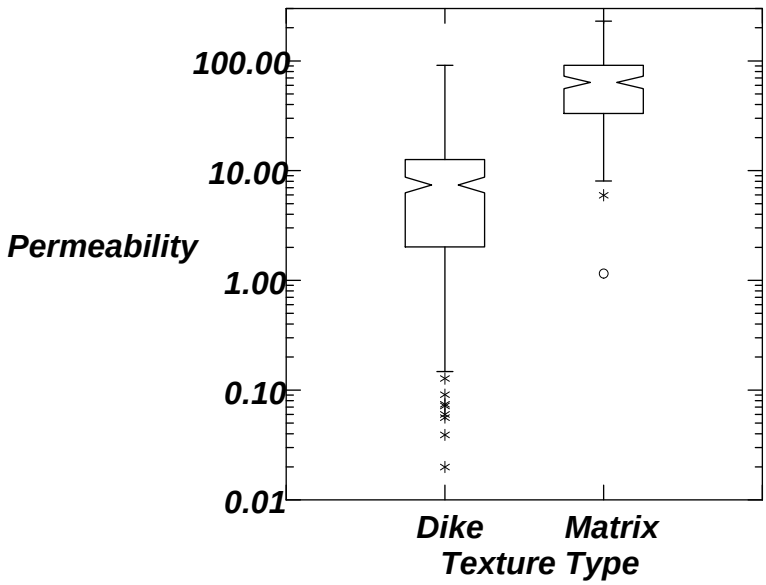
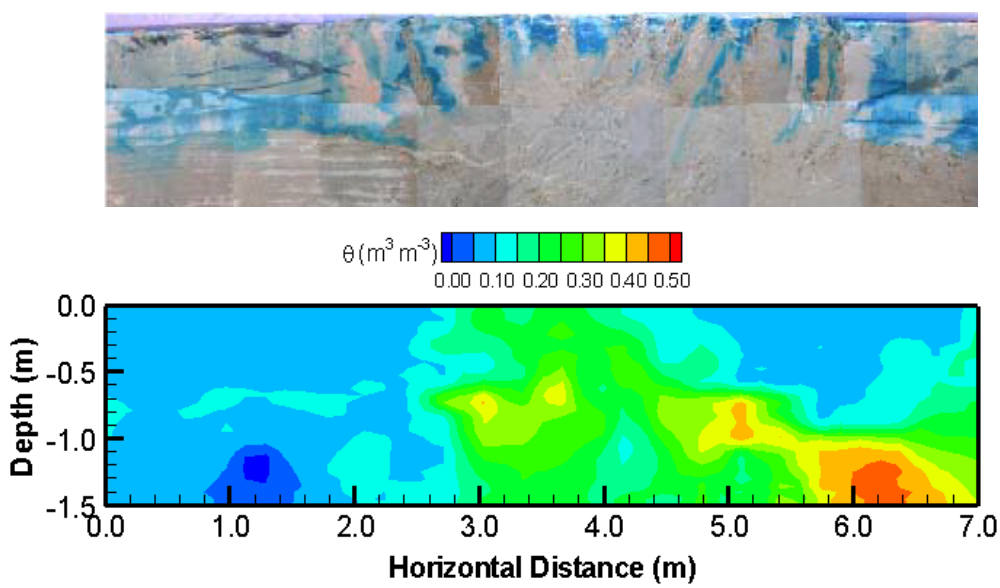


Figure E-8. Air Permeability Measurements from Army Loop Road Excavation



Note: Water content measurements for surface are shown in upper image.

Figure E-9. Top—Composite Image of Dye Penetration; Bottom—Contour Map of Clastic Dike Water Content Measurements for Surface are Shown in Top Image

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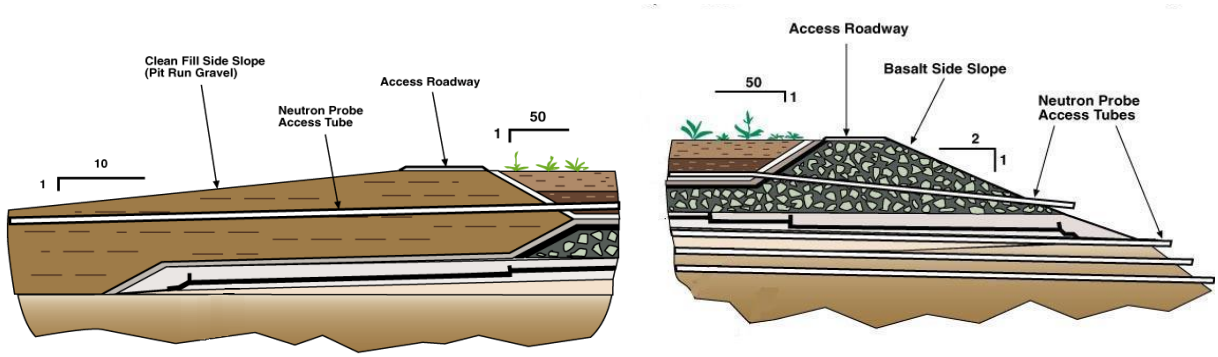
E13 Side Slopes

Above-grade barriers must include side slopes to protect the functional portion of the structure from erosion and collapse but they have received little attention in barrier studies. Although side slopes can occupy 30 to 70 percent of the foot print of above-grade covers, no consistent design or practice exists for their construction. As a result there is very little information on side-slope performance. Apart from studies performed at Hanford in the field lysimeter test facility to evaluate side-slope materials, the only data available on field-scale performance are from the Hanford Prototype Barrier. The prototype barrier is unique in its incorporation of two side-slope configurations for evaluation of stability and hydrologic performance (Figure E-10). The side slope on the east side of the barrier, which is constructed of 25 cm (9.8 in.) fractured basalt riprap, has a 2H:1V slope and occupies a smaller footprint. The side slope on the west side is constructed of pit run gravel with a 10:1 slope and occupies a larger footprint. Both side slopes are underlain by the asphalt layer and have drainage systems connected to the siphon monitors to record drainage.

As part of a CERCLA treatability test, the north half of the barrier side slopes was irrigated from November 1994 through October 1997 to document performance under the stress of elevated precipitation. During this test, the south half received only ambient precipitation.



A **B**

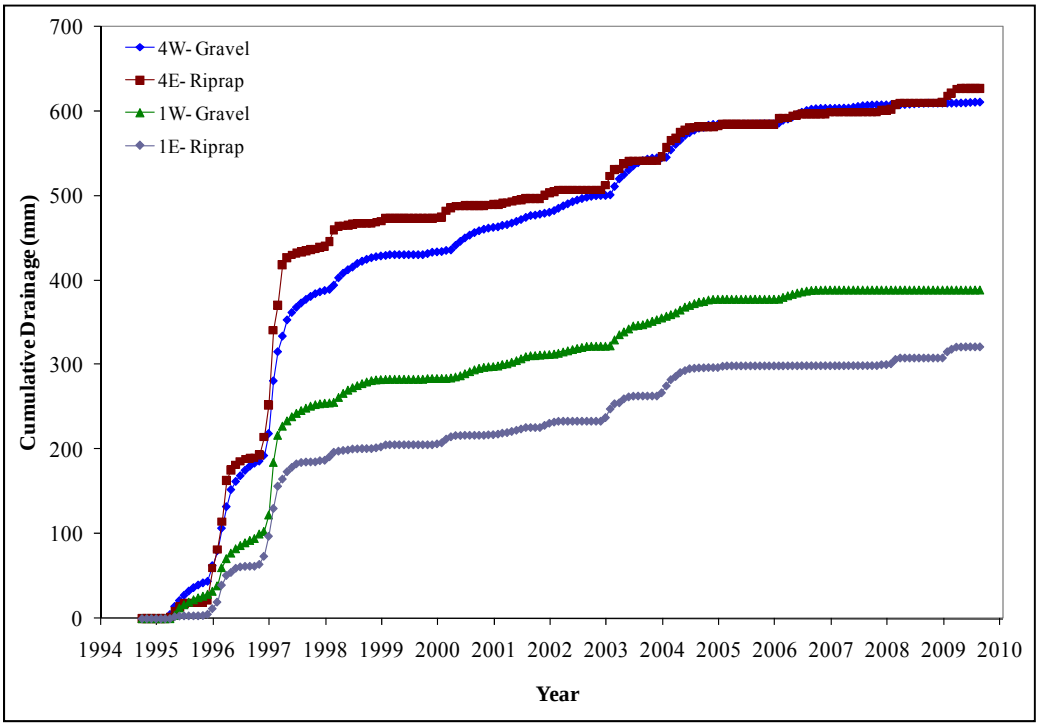
Note: (a) west side pit run gravel with a 10:1 slope, and (b) east site fractured basalt riprap with a 2:1 slope.

Figure E-10. Cross Section of the Two Side-Slope Configurations

Figure E-11 shows a plot of the cumulative drainage from the side slopes. Any water passing through rock layers is intercepted by the asphalt layer and diverted to the collection system where it is recorded and treated as drainage in the water balance.

Results indicate a seasonal dependence with significant differences between precipitation treatments (north and south), and side-slope configuration (riprap and gravel) from year to year and a strong correlation between drainage rates and winter precipitation. During the treatability test, the irrigated riprap slope (4E) typically drained less than the gravel (4W), except in the winter when most of the precipitation falls and ET processes are at the lowest. Despite low drainage rates in the summer, cumulative drainage from the riprap generally exceeded that from the gravel for the duration of the treatability test. By the end of August 2009, the north gravel slope (4W) had drained 611.1 mm (24 in.) or 17.8 percent of the intercepted precipitation whereas the north riprap slope (4E) had drained 627.29 mm (24.7 in.) or 18.3 percent of the intercepted precipitation. Interpretation of side-slope drainage from the north slopes is complicated by the use of irrigation during the treatability test. However, these effects are absent on the south side slopes. On the southern plots, drainage from the gravel slope (1W) consistently

exceeded that from the riprap (1E). These differences have persisted throughout the monitoring period and by the end of August 2009, cumulative drainage from the non-irrigated gravel was 388.5 mm (15.3 in.), or 14.1 percent of total precipitation, whereas the south riprap slope (1E) had drained 321.2 mm (12.6 in.), or 11.6 percent of intercepted precipitation. This represents a difference of 67 mm (2.6 in.), but this difference appears to be declining over time, from over 90 mm (3.5 in) in the early stage of monitoring to 80 mm (3.1 in.) in 2009. The discrepancy in drainage between two side-slope configurations exposed to the same climatic conditions is due to the effects of advective drying. Wind pumping with air of low relative humidity causes evaporation of moisture from the riprap surfaces, thereby reducing drainage from the riprap slopes, which, coupled with the smaller footprint, makes this a more efficient design.



Note: 1996/1997 were high irrigation years resulting in higher drainage rates.

Figure E-11. Cumulative Amounts of Water Diverted by the Asphalt (Drainage)

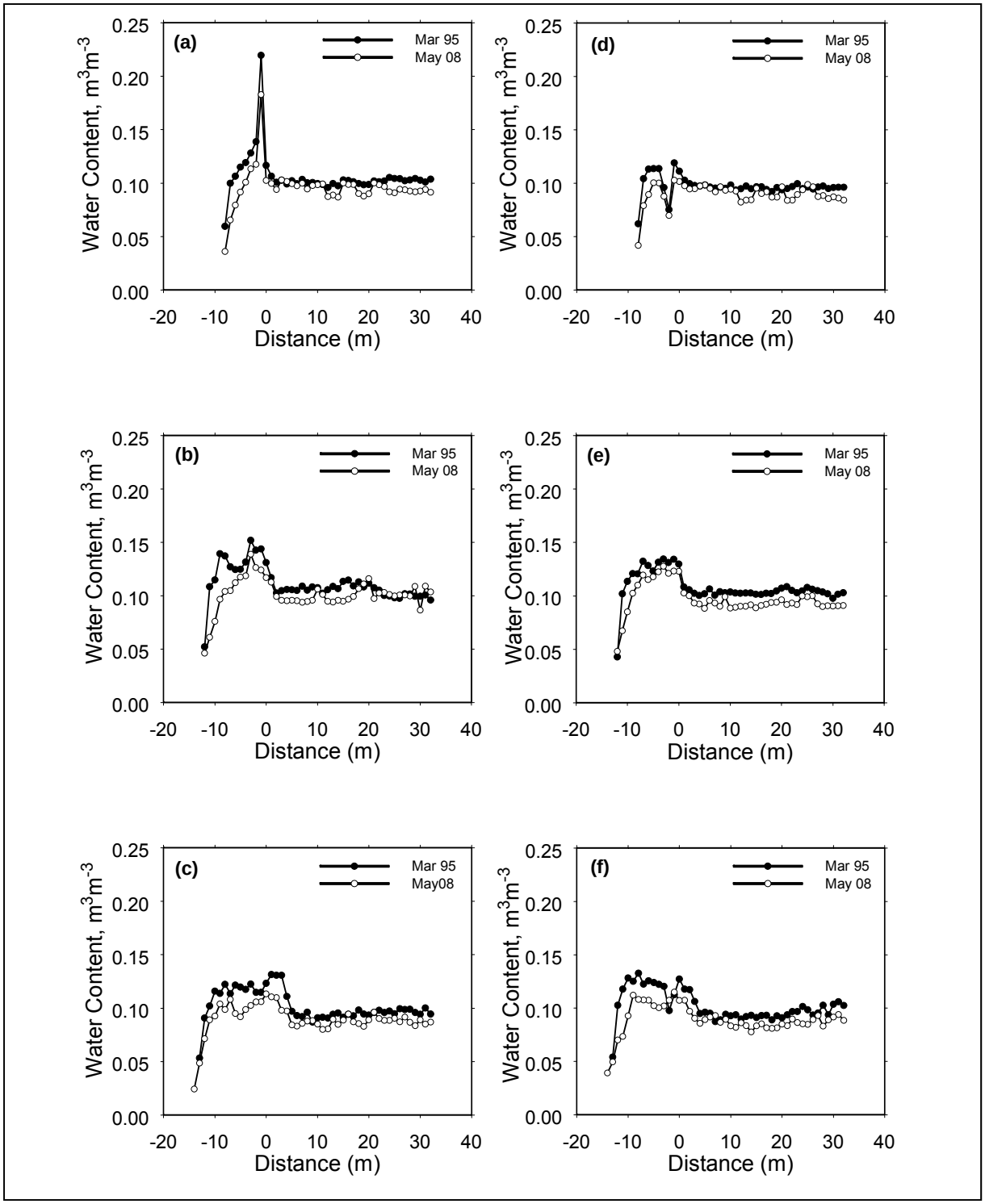
The proposed ET cover design prescribes 5H:1V side slopes. The side-slope effects described above indicate a smaller footprint is a more efficient design. The proposed 5H:1V slope was selected as a compromise between a smaller footprint and minimizing the slope to reduce the potential of side-slope erosion.

E14 Edge Effects

Underflow or interflow is the defined as inflow or outflow of water under the containment system and is important to barrier design and placement of adjacent barriers. There are few published accounts of underflow measurements on engineered covers. Even on the prototype Hanford barrier, such measurements are restricted to a small portion of the barrier as most of the asphalt layer is curbed to allow measurement percolation. Nonetheless, evidence of underflow has been inferred from measurements of soil-water content under the asphalt layer in horizontal neutron access tubes as well as thousands of observations by soil scientists at natural analog sites of capillary barriers throughout the world.

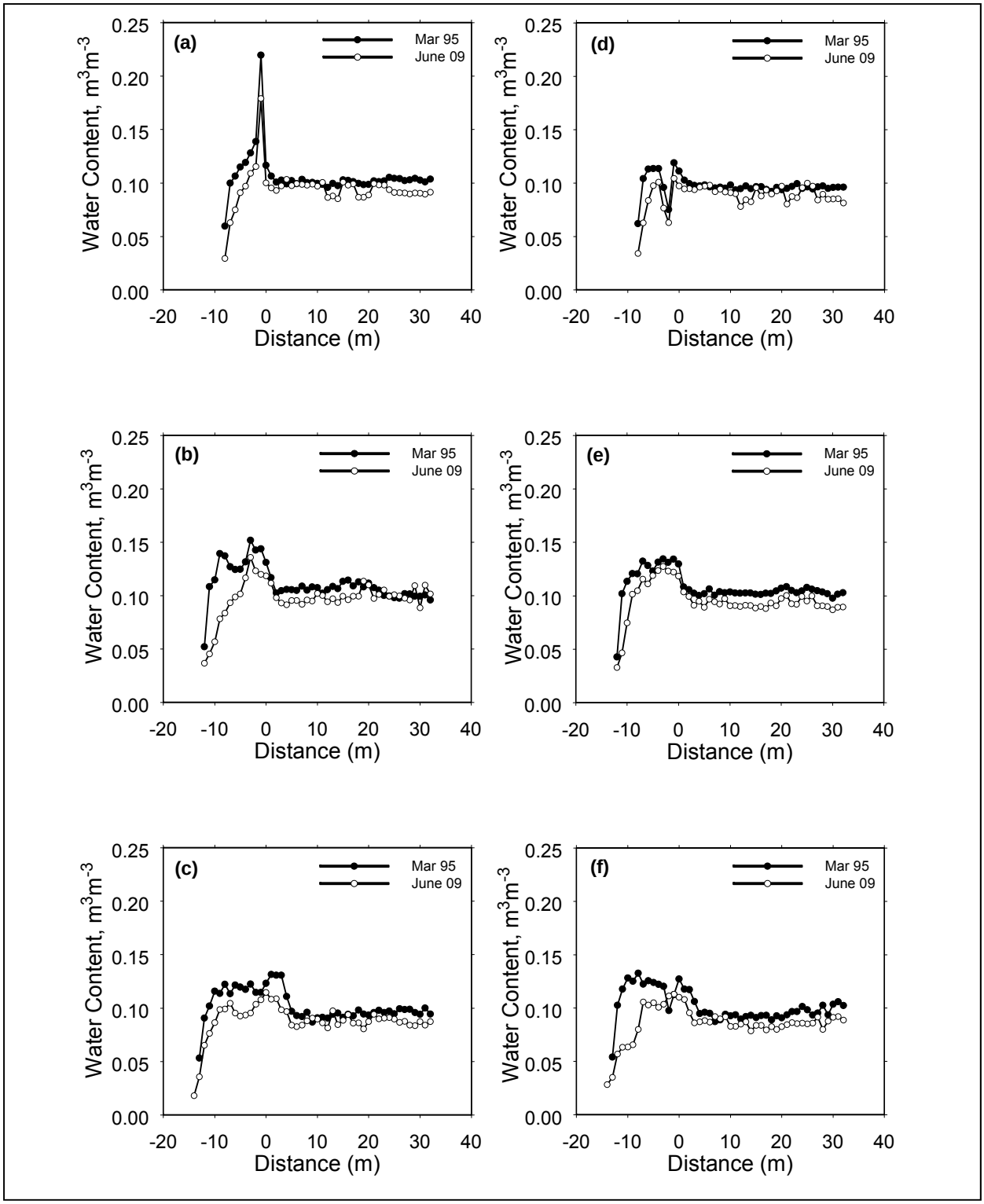
Figures E-12 and E-13 compare the spatial distribution of volumetric water content, θ, measured horizontally under the asphalt layer shortly after construction on March 28, 1995, with the distribution in June 2008 and July 2009.

After 13 years, the spatial trends in θ remain quite similar with only small increases in moisture near the edge of the asphalt layer in the winter. Typically, the wetting front migrates about 1 m under the asphalt before evapotranspiration curtails any further migration. While the extent of the annual migration of the wetting front appears small, underflow remains a major factor for consideration in the design of final covers. Overall, the soil beneath the asphalt layer has dried out over the last 15 years. These data show that a potential exists for underflow along the edges, although the true extent cannot be determined from the data because of the presence of curbs on the asphalt layer to allow measurement of percolation. The extent, however, can be easily simulated with a calibrated multidimensional numerical model such as the Subsurface Transport Over Multiple Phases (STOMP) simulator.



Note: (a) BA 1 at 1m, (b) BA 3 at 2 m, (c) BA 5 at 3 m, (d) BA 2 at 1 m, (e) BA 4 at 2 m, and (f) BA 6 at 3 m.

Figure E-12. Spatial Variation in Soil-Water Content Under the Asphalt Layer (with No Side Curb to Divert Runoff) on March 28, 1995 and May 23, 2008: Horizontal Neutron Tubes



Note: (a) BA 1 at 1m, (b) BA 3 at 2 m, (c) BA 5 at 3 m, (d) BA 2 at 1 m, (e) BA 4 at 2 m, and (f) BA 6 at 3 m.

Figure E-13. Spatial Variation in Soil-Water Content Under the Asphalt Layer (Uncurbed Section) on March 28, 1995 and June 30, 2009: Horizontal Neutron Tubes Piston Flow

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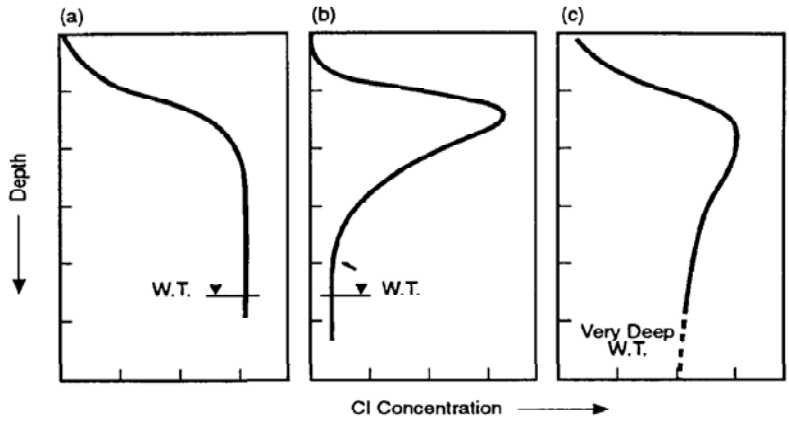
E15 Piston Flow

According to the piston flow model, incoming water replaces the water initially present in the soil, or, equivalently, pushes it ahead of the wetting front like a piston. Over the last 20 to 30 years, isotopic and geochemical tracer methods have been developed to understand the processes of groundwater recharge. These methods can be used to provide some insight into the importance of piston flow. In their pioneering contributions to the development of environmental tracer methods, Zimmerman et al. (1967) postulated that, in the case of homogenous soil, without many cracks and fissures, the bulk of water movement from the unsaturated zone to the saturated zone takes place via piston flow. This concept provided a convenient method of evaluation of recharge processes and recharge estimates using the thermonuclear tritium peak of 1963–1964 in precipitation, which could be easily identified in the unsaturated zone. A common assumption in the environmental tracer methods used to infer recharge in arid environments is that of one-dimensional vertical downward flow of water and solutes (i.e., piston flow). A question remains as to importance of piston flow in groundwater recharge processes.

Evidence of piston flow can be inferred from solute tracer profiles (Allison et al., 1994). In the simplest case of piston flow of water in the unsaturated zone, the chloride (Cl) concentration in soil water should increase through the root zone to a constant value (Figure E-13), provided the water table is deep or has the same concentration as the soil water, a depth-concentration profile such as shown in Figure E-14 should result. However, many of the depth profiles of Cl concentration in soil water show a more complex shape than that shown in Figure E-14-a. Some idealized examples of these more complex shapes are given for comparison in Figure E-14-b and E-14-c. As reported by Prych (1998), solute tracer profiles from many sites at Hanford show relatively low peak concentrations of environmental tracers and sometimes multiple peaks that are inconsistent with the assumptions of piston flow (Figure E-14). Mixing processes must be active in the subsurface to account for the lost tritium mass and the dispersed nature of the concentration profiles. Such mixing can occur via vertical preferential flow, which would require well developed soil structure and/or vertical macropores. However, these are typically limited to the top 3 m (9.8 ft) or so as both are controlled by plant rooting depth in Hanford Soils. Mixing can also occur via subsurface lateral flow. Subsurface lateral flow has been observed in both controlled experiments in vadose zone (Sisson and Lu site, Army Loop Road Dike) and accidental releases from tanks at Hanford (e.g., BX102). McCord et al. (1997) evaluated the impact of geologic heterogeneity, a pre-requisite for lateral flow, on recharge estimation with environmental tracers with a numerical model. They found that that recharge rates inferred from environmental tracer methods, based on the assumption of piston flow, is highly variable in space. Recharge rates inferred from these methods often overestimate recharge rates and should be considered accurate only to within an order of magnitude.

Figure E-15 displays vertical profiles of observed chlorine-36 to total-chloride ratio, chloride concentration in soil, anthropogenic chlorine-36 concentration in soil and estimated age of soil water at holes T02 at Benson Springs and TO3 at McGee Ranch (Prych 1998). Most of the depth profiles of soil water tracer profiles at Hanford show more complex shapes than expected from piston flow. These complex shapes have been attributed to a variety of mixing processes occurring in the vadose zone, including geologic heterogeneity and lateral flow. Furthermore, recharge rates inferred from environmental tracer methods that assume piston flow is highly variable in space and typically overestimate recharge rates by an order of magnitude or more.



Note: (a) piston flow with extraction of water by roots; (b) extraction of water by roots, but with either preferred flow of water through and below the root zone, or diffusive loss of Cl to the water table (W.T.); and (c) a profile reflecting past (paleo-) recharge conditions (Allison et al., 1994).

Figure E-14. Schematic Depth Profiles of the Cl Concentration of Soil Water

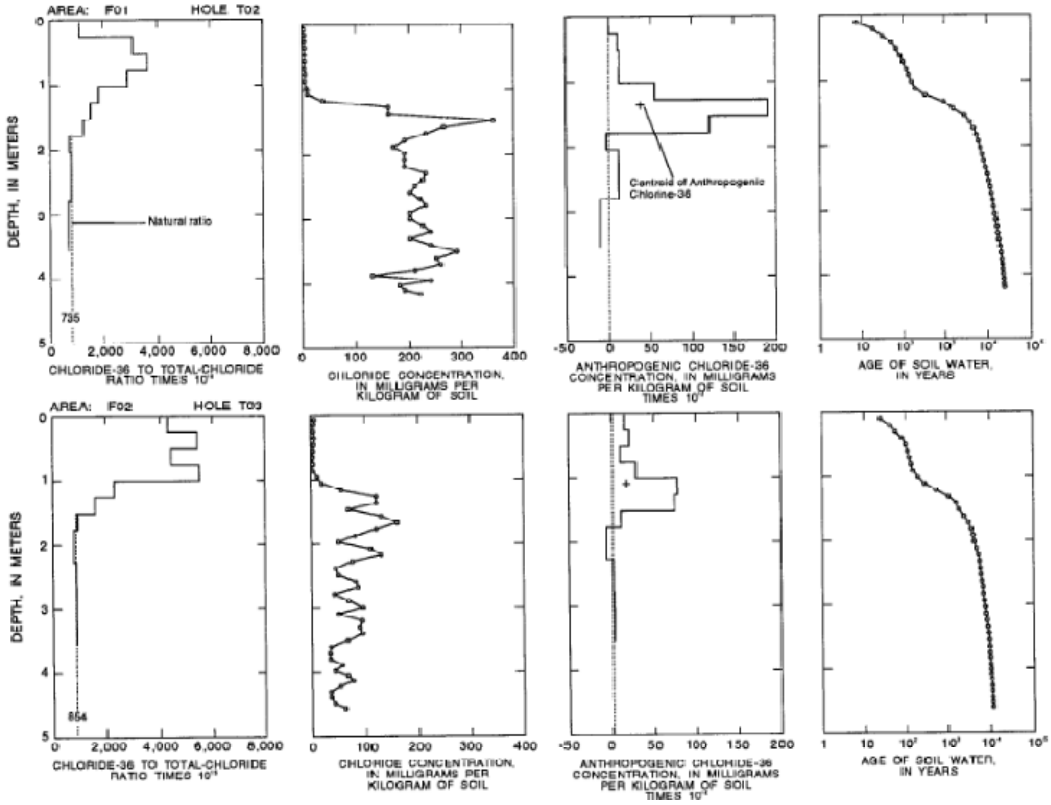


Figure E-15. Vertical Profiles of Observed Chlorine

E16 Potential Impacts Due to Burning

It is important to understand the effect of burning vegetation on an ET cover when evaluating the feasibility of such barriers at the Hanford Site. To be feasible, the ET cover must continue to be effective after a fire including cases where no post-burn maintenance is performed. Fortunately, several studies recently completed at Hanford document the effects of fire on barrier performance. The summary below is excerpted from "Short and Long-Term Fire Impacts on Hanford Barrier Performance," *WM 2009 Symposium*, March 1-5, Phoenix, Arizona" (Ward et al., 2010).

During September 2008, a controlled burn was conducted on the north side of the Hanford Barrier to test the cover's effectiveness after a fire. Although there were significant changes in soil properties due to the burn, these changes did not show any significant evidence of compromising the effectiveness of the ET cover. Tests confirmed the soil that was covered in ash due to the burn became hydrophobic. This resulted in greater water repellency on the burned side during the winter but decreased the rate of water loss in the barrier during the spring. However, this did not greatly affect overall barrier performance because these changes essentially balanced each other. It is worth noting that the amount of water stored never exceeded one-third of the barrier's capacity, despite an unusually wet winter after the burn. After 1 year, the reversion to pre-burn moisture was widely varied: some plots completely reverted and others did not.

One week after the burn, tests showed significant changes in soil composition that were mostly beneficial to revegetation. Nutrients important to plant growth either increased or had no significant change, but there was an increase in pH that could be considered detrimental to revegetation. After one year, many of the nutrient levels remained elevated with only a few falling back to pre-burn levels. Following the general trend of healthier soil, the pH levels dropped to levels beneficial to plant growth.

The changes in vegetation on the barrier surface were unexpected, but are believed to be temporary. After an expected drop in plant cover on the burned side, a remarkable increase in biodiversity occurred. This is explained by the reduction in the amount of sagebrush that was dominating the area of the barrier surface before the burn. After the dominant species was removed, other plants had more room to germinate. This increase in biodiversity creates a richer and more hardy ecosystem on top of the barrier, which is important for maintaining water evapotranspiration rates. However, there are signs of sagebrush returning, so this increase in biodiversity may be temporary.

Almost every test performed on the burned section of the barrier shows that its effectiveness has been maintained and that the barrier is likely to revert to its pre-burn state in a matter of years without human intervention. However, a full reversion has not yet been made so there remains a chance that the barrier's effectiveness may have been compromised in the future in some still unknown way. Data gathered during the burn and subsequent series of tests strongly suggests that an ET cover will continue to be effective after a wildfire and will recover almost completely from the effects of the fire within 10 to 20 years.

E17 Potential Plant Uptake

The potential for plants on the ET cover to uptake contaminants is remote. Dangerous waste at NRDWL is buried at least 3 m (10 ft) deep and there will be another 1 m (39 in.) of cover placed as part of the cover. The vegetation planned as part of the ET cover has root systems that will not penetrate to the waste. Most root systems will be located within 1 to 1.5 m (3 to 5 ft) of the surface. In addition, as part of the operations and maintenance of the NRDWL/SWL, plants with deeper root systems that might be capable of penetrating the waste layer will be removed from the cap. In addition, the placement of the barrier will dry out deeper soils over time since infiltration will be dramatically reduced. Since roots tend to grow toward moisture, roots are less likely to penetrate depths if there is a lack of moisture present at depth.

Since the ET cover (composed of silt loam over the course sand operational cover) will form a capillary barrier, it is unlikely that water and, therefore, plants will ever penetrate past the capillary interface.

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E18 Biointrusion

Routine cover integrity inspections will document any major disruption to the cover caused by animals burrowing or wallowing on the surface (digging large depressions) that might breach or otherwise impact the performance of the final cover. Significant breaches or depressions will require an evaluation to determine the root cause, evaluate the long-term environmental impacts, and provide a corrective solution, as needed. Results from bio-intrusion studies from the Hanford Barrier and other sites suggest that the problem can be mitigated by appropriate design features and monitoring during postclosure.

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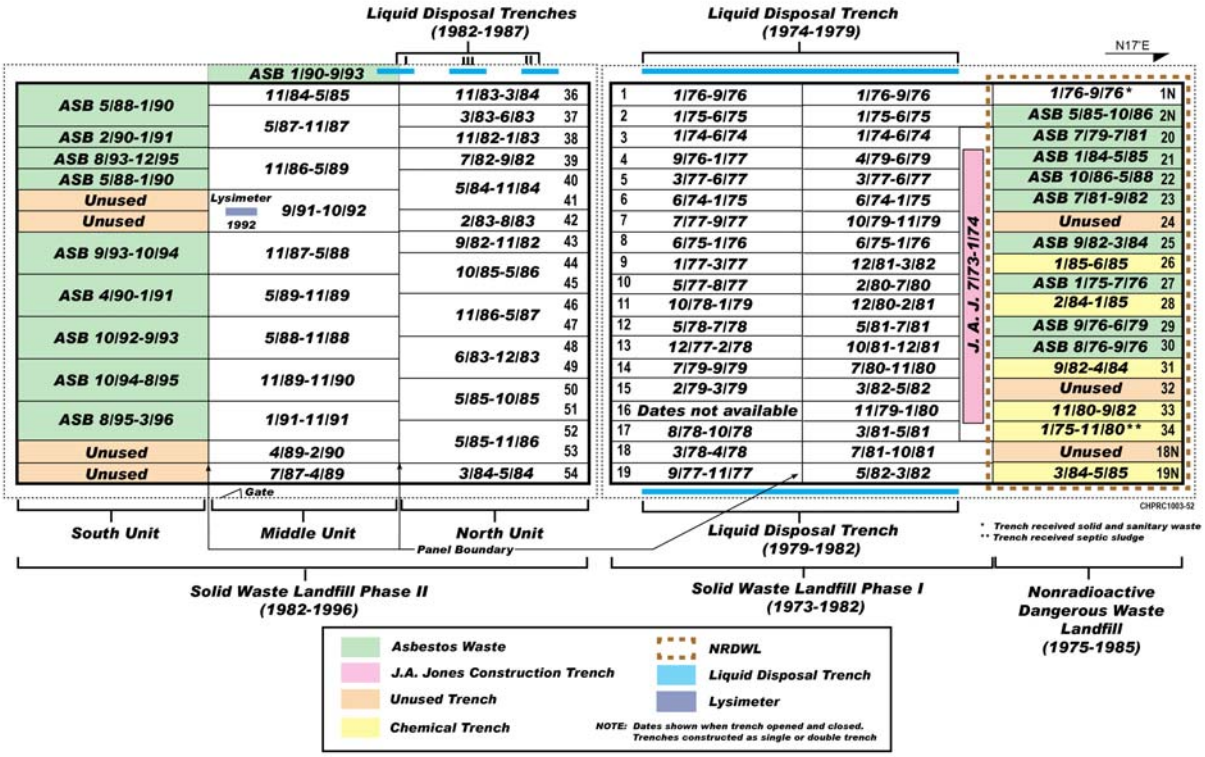
E19 SWL Lysimeter

In 1992, a basin lysimeter was installed beneath the southern end of double trench 41 and 42 in the SWL (see Figure E-16), which was closed in October 1992. The lysimeter is large compared with conventional lysimeters and has a collection area of 88 m^2 (946 ft^2).



Note: See location in Phase II, Middle Trench 41 and 42.

Figure E-16. NRDWL/SWL Schematic with Lysimeter

A discharge pipe drains the leachate from the lysimeter basin to a sump where leachate generated by water infiltrating through the overlying waste trench is collected. The leachate quality and quantity are analyzed to evaluate the impact that leachate would have on groundwater quality.

The constituents selected for analysis in the leachate are based on the constituent list for groundwater monitoring (contained in WAC 173-304-490) and suspected contaminants of concern known to be contained within the SWL waste inventory. Leachate constituents include conductivity, pH, chloride, nitrite, nitrate, ammonia, sulfate, dissolved iron, dissolved zinc, dissolved manganese, chemical oxygen demand, and total organic carbon. In addition, select metals and organic constituents are routinely monitored, based on historic monitoring of both the leachate and groundwater. Table E-2 provides results of monitoring for reporting year 2006 to 2007. Monitoring results for additional years can be found in the Hanford Site SWL annual monitoring reports, "*Hanford Site Solid Waste Landfill Annual Monitoring Report: July 2007 through June 2008*" (09-AMCP-0010, 2008).

Table E-2. Recent Leachate Monitoring Results

Parameter	Results by Quarter				GWQC	MCL
	3rd 2006	4th 2006	1st 2007	2nd 2007		
Indicator Parameters						
Specific Conductance (µS/cm)	1,680	1,860	1,920	2,000	N/A	700 µS/cm
Field pH	7.35	6.74	6.89	7.32	6.5-8.5	N/A
Total Organic Carbon (mg/L)	701	100	76.5	275	N/A	N/A
Chloride (mg/L)	210	191	192	199	250	25.0
Ammonia as N (mg/L)	0.330	0.340	0.292	NT	N/A	N/A
Sulfate (mg/L)	5.66	7.67	6.32	7.77	250	25
Dissolved Iron (µg/L)	87.9	9,850	8,870	6,400	300	300
Dissolved Zinc (µg/L)	187	40.5	109	155	5,000	5,000
Dissolved Manganese (µg/L)	1,580	1,590	1,540	1,295	50	50
Chemical Oxygen Demand (mg/L)	222	220	208	204	N/A	N/A
Site-Specific Parameters						
Arsenic (µ/L)	29.3	NT	NT	20.1	0.05	0.010
Carbon Tetrachloride (µg/L)	<1.0	NT	NT	<1.0	0.3	5
Chloroform (µg/L)	<1.0	NT	NT	<1.0	7.0	N/A
1,4-Dichlorobenzene (µg/L)	6.5	NT	NT	4.15	4	N/A
1,1-Dichloroethane (µg/L)	<1.0	NT	NT	<1.0	1.0	N/A
Methylene Chloride (µg/L)	<1.0	NT	NT	1.25	5	N/A
Tetrachloroethene (µg/L)	<1.0	NT	NT	<1.0	N/A	N/A
Trichloroethene (µg/L)	<1.0	NT	NT	<1.0	N/A	N/A
1,1,1-Trichloroethane (µg/L)	<1.0	NT	NT	<1.0	200	200
1,4-Dioxane (µg/L)	<25.0	NT	NT	<20.0	7	N/A
Total Dissolved Solids (mg/L)	1,460	NT	NT	1,380	500	500
Total Organic Halides (µg/L)	NT	NT	NT	846	N/A	N/A
Barium (µg/L)	519	NT	NT	452	1,000	2,000
Cadmium (µg/L)	<0.100	NT	NT	<0.100	10	5
Copper (µg/L)	1.60	NT	NT	1.03	1,000	N/A
Fluoride (mg/L)	<0.145	<0.0315	<0.321	0.207	4	4
Nickel (µg/L)	110	NT	NT	92.9	N/A	100
Selenium (µg/L)	2.58	NT	NT	2.15	10	50

GWQC = groundwater quality criteria (WAC 173-200)
IDL = instrument detection level (WAC 173-200)
MCL = maximum contaminant levels
MDL = method detection level
µg/L = micrograms per liter
mg/L = milligrams per liter
N/A = not applicable
NT = not tested

E19.1 Primary Leachate Constituents

The analysis of leachate samples collected between 1996 and 2007 indicates that the leachate constituents in the SWL Lysimeter are typical of sanitary landfills. Only one chlorinated organic compound (1,4-dichlorobenzene) has been detected on a routine basis with concentrations above the WAC 173-200 groundwater quality criteria. Some of the indicator parameters (metals and organics) have been detected above groundwater quality criteria. These include conductivity, total dissolved solids, arsenic, manganese, and 1,4-dioxane; however, monitoring of these same constituents in the underlying groundwater has not revealed any elevated trends towards the groundwater quality criteria at the facility compliance point.

Several organic contaminants were detected in the early rounds of sampling in 1996 and 1997; however, levels have since dropped. Total dissolved solids, arsenic, manganese, 1,4-dioxane, and 1,4-dichlorobenzene are equal to or exceed the groundwater quality criteria established in WAC 246-290. In addition, conductivity, manganese, and nickel exceed the drinking water standards. While informative of leachate quality, this leachate is collected just below the waste material, some 35 m (114.8 ft) above the groundwater and does not correlate to groundwater conditions. For example, 1,4-dioxane, which was reported in the leachate, has not been detected in groundwater.

E19.2 Leachate Generation and Drainage Trends

Leachate has been collected from the basin lysimeter since July 1996. The average annual precipitation at the Hanford Site is 170 mm (6.8 in.); therefore, approximately 27 percent of the precipitation has drained through the existing operational soil cover based on collections since 1996. (This data will be included in the final closure plan.) The high leachate volume seen from 1997 through 1999 might be a result of the high precipitation recorded from years 1995 and 1996, being the two wettest years recorded at the Hanford Site over a 95-year period. Each of those two years produced almost double the average precipitation (e.g., 313 mm [12.3 in.] and 310 mm [12.2 in.] respectfully). The report, *Hanford Site Groundwater Monitoring for Fiscal Year 2008* states, "during the July 2003 through June 2004 and July 2004 through June 2005 reporting periods, the generation rates increased significantly to ~19 liters/day. This increase mainly was attributed to above average rainfall recorded at the Hanford Site." Figure E-17 depicts a summary of the leachate volume collected from the lysimeter.

Leachate generation records from 1996 to 2009 provide an indication of historical drainage patterns at the SWL. Drainage can be attributed to a specific combination of soils, vegetation, and climate. Soil type and soil-cover thickness affects the soil-water holding capacity and subsequent drainage to the subsurface. Coarse soils (e.g., gravelly sands with low water-holding capacities) drain readily, leaving little water at the surface to evaporate. Coarse soils can drain up to 50 percent or more of the annual precipitation and up to 70 percent or more of the winter precipitation under the Hanford Site climatic conditions (Gee et al., 1992, "Variations in Recharge at the Hanford Site"; PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*). The interim cover at the SWL consists of stockpiled soil from SWL excavations (BHI-01063). The native soil at the SWL has over 95 percent sand content and is considered a coarse soil.

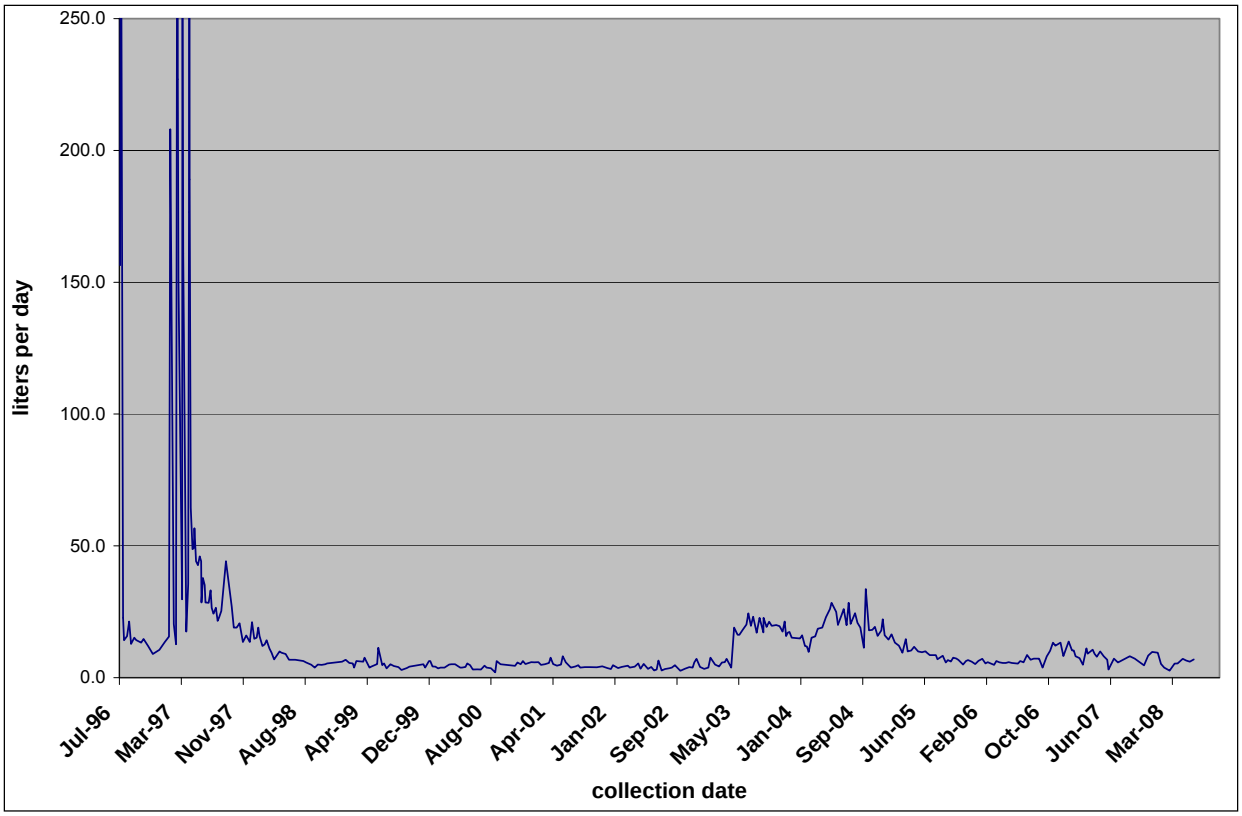


Figure E-17. Leachate Generation Rates

Leachate collected from the SWL basin lysimeter over the past ten years is typical of drainage expected from a sparsely vegetated area with coarse sand under the Hanford Site climatic conditions. Observed changes in drainage rates are attributed primarily to variations in winter precipitation and vegetative cover. Winter precipitation at the Hanford Site controls the drainage at any given site, because winter rains and snowmelt occur when atmospheric conditions (e.g., lower solar radiation and air temperatures, higher humidity) minimize surface evaporation. Precipitation from late spring and summer rains are readily lost to the atmosphere because of high evaporative demand (high temperatures, high solar radiation, high plant transpiration, and low humidity).

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Appendix F

Leachate Generation Volumes

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Tables

Table F-1. Leachate Volumes F-1

1

F1 Introduction

The following table provides leachate volumes for the lysimeter at the Solid Waste Landfill by date of collection, cumulative volumes since initial collection, and volumes per day based on elapsed time between collection dates. The lysimeter is positioned beneath the double trench 41 and 42 and has a collection surface of 88 m^2 (950 ft^2).

Based on the leachate volumes collected as noted in Table F-1 (48,834 L collected over 4,324 days), the average calculated drainage for the entire collection period noted is 47 mm/yr (1.84 in./yr). This value correlates well with an average drainage of 51 mm/yr (2.00 in./yr at the Solid Waste Landfill presented by Gee et al., 2005a, "Measurement and Prediction of Deep Drainage from Bare Sediments at a Semiarid Site." This value is also comparable in magnitude with the recharge rate of 44 mm/yr (1.72 in./yr) identified as the best estimate value for bare unvegetated soil (PNNL-14725, *Geographic and Operational Site Parameters List [GOSPL] for Hanford Assessments*; DOE/RL-2006-35, *Hanford Facility Dangerous Waste Permit Application, Encapsulation and Storage Facility*, Appendix A), and is about 25 percent lower than the average recharge rate of 63 mm/yr (2.47 in./yr) determined from lysimeter data representing infiltrations for medium-grained sand kept free of vegetation for a period of over 20 years (DOE/RL-2007-35; Gee et al, 2005a; Gee et al., 2005b, "Chloride Mass Balance: Cautions in Predicting Increased Recharge Rates").

Hanford Site meteorological data (available at: http://hms.pnl.gov/totprcp.htm) states that the average annual precipitation is 170 mm/yr (6.68 in./yr). Therefore, the calculated infiltration rate of 47 mm/yr (1.84 in./yr) indicates approximately 27 percent of the precipitation has reached the lysimeter since collection started in 1996. This magnitude of value is also consistent with the "default annual infiltration" value of 25 percent specified in WAC 173-340-747(5)(f)(ii)(A), "Deriving Soil Concentrations for Ground Water Protection," for sites east of the Cascade Mountains.

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
7/15/1996	0	0	79	79	--
7/18/1996	3	3	469	549	156
7/19/1996	1	4	360	908	360
7/29/1996	10	14	227	1,136	22.7
8/2/1996	4	18	57	1,192	14.2
8/14/1996	12	30	189	1,382	15.8
8/22/1996	8	38	170	1,552	21.3
8/30/1996	8	46	102	1,654	12.8
9/12/1996	13	59	197	1,851	15.2
9/20/1996	8	67	114	1,965	14.3
10/10/1996	20	87	265	2,230	13.3
10/19/1996	9	96	132	2,362	14.7

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
11/7/1996	19	115	227	2,589	11.9
11/26/1996	19	134	170	2,759	8.9
12/23/1996	27	161	284	3,043	10.5
1/13/1997	21	182	284	3,327	13.5
1/30/1997	17	199	265	3,592	15.6
2/3/1997	4	203	511	4,103	128
2/5/1997	2	205	416	4,519	208
2/19/1997	14	219	284	4,803	20.3
2/28/1997	9	228	114	4,917	12.7
3/3/1997	3	231	795	5,712	265
3/5/1997	2	233	757	6,469	379
3/7/1997	2	235	454	6,923	227
3/10/1997	3	238	454	7,377	151
3/24/1997	14	252	416	7,793	29.7
3/26/1997	2	254	568	8,361	284
3/28/1997	2	256	322	8,683	161
4/10/1997	13	269	227	8,910	17.5
4/18/1997	8	277	284	9,194	35.5
4/21/1997	3	280	530	9,724	177
4/22/1997	1	281	473	10,197	473
4/23/1997	1	282	189	10,386	189
4/28/1997	5	287	322	10,708	64.4
5/5/1997	7	294	341	11,049	48.7
5/10/1997	5	299	246	11,295	49.2
5/13/1997	3	302	170	11,465	56.7
5/19/1997	6	308	265	11,730	44.2
5/27/1997	8	316	341	12,071	42.6
6/3/1997	7	323	322	12,393	46.0
6/9/1997	6	329	265	12,658	44.2
6/11/1997	2	331	57	12,715	28.5

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
6/16/1997	5	336	189	12,904	37.8
6/23/1997	7	343	246	13,150	35.1
6/27/1997	4	347	114	13,264	28.5
7/9/1997	12	359	341	13,605	28.4
7/17/1997	8	367	265	13,870	33.1
7/22/1997	5	372	132	14,002	26.4
7/29/1997	7	379	170	14,172	24.3
8/8/1997	10	389	265	14,437	26.5
8/15/1997	7	396	151	14,588	21.6
8/20/1997	5	401	114	14,702	22.8
8/29/1997	9	410	227	14,929	25.2
9/17/1997	19	419	397	15,326	44.2
10/3/1997[b]	16	435	264	15,591	16.5
10/10/1997	7	442	189	15,781	27.0
10/19/1997	9	451	170	15,951	18.9
10/31/1997	12	463	227	16,178	18.9
11/11/1997	11	474	227	16,405	20.6
11/25/1997	14	488	189	16,594	13.5
12/8/1997	13	501	208	16,803	16.0
12/22/1997	14	515	189	16,992	13.5
12/31/1997	9	524	189	17,181	21.0
1/9/1998	9	533	132	17,314	14.7
1/19/1998	10	543	151	17,465	15.1
1/25/1998	6	549	114	17,579	18.9
1/31/1998	6	555	95	17,673	15.8
2/11/1998	11	566	132	17,806	12.0
2/20/1998	9	575	114	17,919	12.6
2/28/1998	8	583	114	18,033	14.2
3/12/1998	12	595	132	18,165	11.0
3/20/1998	8	603	76	18,241	9.5

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
3/31/1998	11	614	76	18,317	6.9
4/21/1998	21	635	208	18,525	9.9
4/29/1998	8	643	76	18,600	9.5
5/16/1998	17	660	151	18,752	8.9
5/30/1998	14	674	95	18,847	6.8
6/24/1998	25	699	170	19,017	6.8
7/27/1998	33	732	208	19,225	6.3
8/6/1998	10	742	57	19,282	5.7
8/27/1998	21	763	102	19,384	4.9
9/10/1998	14	777	53	19,437	3.8
9/23/1998	13	790	64	19,501	4.9
10/8/1998	15	805	72	19,573	4.8
10/23/1998	15	820	76	19,649	5.0
10/30/1998	7	827	38	19,687	5.4
12/30/1998	61	888	371	20,058	6.1
1/13/1999	14	902	95	20,152	6.8
1/28/1999	15	917	83	20,236	5.6
2/11/1999	14	931	76	20,311	5.4
2/16/1999	5	936	19	20,330	3.8
2/25/1999	9	945	57	20,387	6.3
3/25/1999	28	973	170	20,557	6.1
3/30/1999	5	978	38	20,595	7.6
4/19/1999	20	998	76	20,671	3.8
4/28/1999	9	1,007	38	20,709	4.2
5/20/1999	22	1,029	114	20,822	5.2
5/25/1999	5	1,034	57	20,879	11.4
6/10/1999	16	1,050	76	20,955	4.7
6/17/1999	7	1,057	38	20,993	5.4
6/28/1999	11	1,068	38	21,030	3.4
7/13/1999	15	1,083	76	21,106	5.0

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
7/26/1999	13	1,096	57	21,163	4.4
8/14/1999	19	1,115	76	21,239	4.0
8/27/1999	13	1,128	38	21,276	2.9
9/17/1999	21	1,149	76	21,352	3.6
9/28/1999	11	1,160	45	21,398	4.1
11/23/1999	56	1,216	284	21,681	5.1
11/30/1999	7	1,223	26	21,708	3.8
12/15/1999	15	1,238	95	21,803	6.3
12/21/1999	6	1,244	38	21,840	6.3
12/30/1999	9	1,253	38	21,878	4.2
1/10/2000	11	1,264	45	21,924	4.1
1/21/2000	11	1,275	38	21,962	3.4
1/31/2000	10	1,285	38	21,999	3.8
2/8/2000	8	1,293	30	22,030	3.8
2/16/2000	8	1,301	30	22,060	3.8
3/6/2000	19	1,320	95	22,155	5
3/15/2000	9	1,329	45	22,200	5
3/30/2000	15	1,344	76	22,276	5
4/19/2000	20	1,364	76	22,351	3.8
4/27/2000	8	1,372	30	22,382	3.8
5/11/2000	14	1,386	57	22,438	4.1
5/18/2000	7	1,393	38	22,476	5.4
5/30/2000	12	1,405	57	22,533	4.7
6/9/2000	10	1,415	30	22,563	3
6/27/2000	18	1,433	57	22,620	3.2
7/12/2000	15	1,448	45	22,666	3
7/27/2000	15	1,463	68	22,734	4.5
8/4/2000	8	1,471	30	22,764	3.8
8/22/2000	18	1,489	64	22,828	3.6
9/8/2000	17	1,506	34	22,862	2

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
9/14/2000	6	1,512	38	22,900	6.3
9/29/2000	15	1,527	76	22,976	5
11/27/2000	59	1,586	265	23,241	4.5
12/7/2000	10	1,596	57	23,298	5.7
12/19/2000	12	1,608	61	23,358	5
12/28/2000	9	1,617	57	23,415	6.3
1/8/2001	11	1,628	57	23,472	5.2
1/15/2001	7	1,635	38	23,510	5.4
1/31/2001	16	1,651	95	23,604	5.9
2/13/2001	13	1,664	76	23,680	5.8
3/1/2001	16	1,680	95	23,775	5.9
3/12/2001	11	1,691	53	23,828	4.8
3/27/2001	15	1,706	76	23,903	5
4/13/2001	17	1,723	95	23,998	5.6
4/19/2001	6	1,729	45	24,043	7.6
4/30/2001	11	1,740	57	24,100	5.2
5/15/2001	15	1,755	68	24,168	4.5
5/31/2001	16	1,771	79	24,248	5
6/7/2001	7	1,778	57	24,304	8.1
6/20/2001	13	1,791	76	24,380	5.8
7/10/2001	20	1,811	76	24,456	3.8
7/28/2001	18	1,829	76	24,532	4.2
8/9/2001	12	1,841	57	24,588	4.7
8/17/2001	8	1,849	30	24,619	3.8
9/5/2001	19	1,868	76	24,694	4
9/24/2001	19	1,887	76	24,770	4
10/23/2001	29	1,916	114	24,884	3.9
11/14/2001	22	1,938	95	24,978	4.3
12/5/2001	21	1,959	76	25,054	3.6
12/19/2001	14	1,973	45	25,099	3.2

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
12/27/2001	8	1,981	38	25,137	4.7
1/17/2002	21	2,002	76	25,213	3.6
1/31/2002	14	2,016	57	25,270	4.1
2/25/2002	25	2,041	114	25,383	4.5
3/5/2002	8	2,049	30	25,413	3.8
3/25/2002	20	2,069	83	25,497	4.2
4/8/2002	14	2,083	76	25,572	5.4
4/17/2002	9	2,092	30	25,603	3.4
4/30/2002	13	2,105	68	25,671	5.2
5/17/2002	17	2,122	57	25,728	3.3
5/31/2002	14	2,136	57	25,784	4.1
6/11/2002	11	2,147	30	25,815	2.8
6/21/2002	10	2,157	30	25,845	3
6/28/2002	7	2,164	45	25,890	6.5
7/12/2002	14	2,178	38	25,928	2.7
7/25/2002	13	2,191	42	25,970	3.2
8/12/2002	18	2,209	64	26,034	3.6
8/22/2002	10	2,219	38	26,072	3.8
9/3/2002	12	2,231	57	26,129	4.7
9/25/2002	22	2,253	57	26,186	2.6
10/14/2002	19	2,272	64	26,250	3.4
10/31/2002	17	2,289	68	26,318	4
11/14/2002	14	2,303	53	26,371	3.8
11/20/2002	6	2,309	34	26,405	5.7
11/29/2002	9	2,318	64	26,470	7.1
12/13/2002	14	2,332	57	26,526	4.1
12/30/2002	17	2,349	57	26,583	3.3
1/16/2003	17	2,366	64	26,647	3.8
1/24/2003	8	2,374	61	26,708	7.6
2/12/2003	19	2,393	95	26,803	5

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
2/28/2003	16	2,409	68	26,871	4.3
3/12/2003	12	2,421	68	26,939	5.7
3/23/2003	11	2,432	64	27,003	5.8
3/31/2003	8	2,440	57	27,060	7.1
4/18/2003	18	2,458	68	27,128	3.8
4/30/2003	12	2,470	227	27,355	18.9
5/14/2003	14	2,484	227	27,582	16.2
5/21/2003	7	2,491	114	27,696	16.2
6/3/2003	13	2,504	235	27,931	18.1
6/19/2003	16	2,520	322	28,252	20.1
6/26/2003	7	2,527	170	28,423	24.3
7/7/2003	11	2,538	216	28,638	19.6
7/16/2003	9	2,547	208	28,846	23.1
7/30/2003	14	2,561	238	29,085	17
8/11/2003	12	2,573	273	29,357	22.7
8/26/2003	15	2,588	257	29,615	17.2
8/27/2003	1	2,589	23	29,638	22.7
9/8/2003	12	2,601	231	29,868	19.2
9/18/2003	10	2,611	212	30,080	21.2
9/29/2003	11	2,622	216	30,296	19.6
10/17/2003	18	2,640	360	30,656	20
10/30/2003	13	2,653	254	30,909	19.5
11/12/2003	13	2,666	227	31,136	17.5
11/20/2003	8	2,674	170	31,307	21.3
11/26/2003	6	2,680	95	31,401	15.8
12/2/2003	6	2,686	102	31,504	17
12/9/2003	7	2,693	121	31,625	17.3
12/18/2003	9	2,702	136	31,761	15.1
1/20/2004[c]	33	2,735	428	32,189	13
1/21/2004[c]	1	2,736	76	32,264	75.7

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
1/29/2004	8	2,744	129	32,393	16.1
2/10/2004	12	2,756	144	32,537	12
2/18/2004	8	2,764	95	32,631	11.8
2/25/2004	7	2,771	68	32,700	9.7
3/8/2004	12	2,783	182	32,881	15.1
3/22/2004	14	2,797	220	33,101	15.7
4/2/2004	11	2,808	204	33,305	18.6
4/20/2004	18	2,826	341	33,646	18.9
5/5/2004	15	2,841	344	33,990	23
5/21/2004	16	2,857	416	34,407	26
5/27/2004	6	2,863	170	34,577	28.4
6/15/2004	19	2,882	473	35,050	24.9
6/22/2004	7	2,889	140	35,190	20
7/7/2004	15	2,904	360	35,550	24
7/15/2004	8	2,912	208	35,758	26
7/27/2004	12	2,924	238	35,996	19.9
8/4/2004	8	2,932	227	36,223	28.4
8/12/2004	8	2,940	163	36,386	20.3
8/30/2004	18	2,958	439	36,825	24.4
9/9/2004	10	2,968	208	37,033	20.8
9/20/2004	11	2,979	208	37,242	18.9
10/5/2004	15	2,994	170	37,412	11.4
10/13/2004	8	3,002	269	37,681	33.6
10/25/2004	12	3,014	216	37,896	18
11/8/2004	14	3,028	254	38,150	18.1
11/18/2004	10	3,038	193	38,343	19.3
11/29/2004	11	3,049	174	38,517	15.8
12/14/2004	15	3,064	269	38,786	17.9
12/20/2004	6	3,070	132	38,918	22.1
12/28/2004	8	3,078	129	39,047	16.1

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
1/12/2005	15	3,093	216	39,263	14.4
1/24/2005	12	3,105	197	39,460	16.4
2/7/2005	14	3,119	185	39,645	13.2
2/23/2005	16	3,135	193	39,838	12.1
3/9/2005	14	3,149	132	39,971	9.5
3/23/2005	14	3,163	204	40,175	14.6
3/31/2005	8	3,171	79	40,254	9.9
4/14/2005	14	3,185	144	40,398	10.3
4/26/2005	12	3,197	140	40,538	11.7
5/12/2005	16	3,213	159	40,697	9.9
5/27/2005	15	3,228	144	40,841	9.6
6/10/2005	14	3,242	140	40,981	10
6/16/2005	6	3,248	57	41,038	9.5
6/28/2005	12	3,260	102	41,140	8.5
7/22/2005	24	3,284	204	41,345	8.5
7/28/2005	6	3,290	42	41,386	6.9
8/19/2005	22	3,312	182	41,568	8.3
8/31/2005	12	3,324	68	41,636	5.7
9/8/2005	8	3,332	53	41,689	6.6
9/21/2005	13	3,345	79	41,768	6.1
9/30/2005	9	3,354	68	41,837	7.6
10/12/2005	12	3,366	87	41,924	7.3
10/21/2005	9	3,375	61	41,984	6.7
11/9/2005	19	3,394	95	42,079	5
11/21/2005	12	3,406	76	42,155	6.3
11/29/2005	8	3,414	53	42,208	6.6
12/14/2005	15	3,429	91	42,298	6.1
12/28/2005	14	3,443	72	42,370	5.1
1/10/2006	13	3,456	83	42,454	6.4
1/26/2006	16	3,472	114	42,567	7.1

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
2/7/2006	12	3,484	64	42,631	5.4
2/16/2006	9	3,493	53	42,684	5.9
2/27/2006	11	3,504	61	42,745	5.5
3/14/2006	15	3,519	72	42,817	4.8
3/23/2006	9	3,528	57	42,874	6.3
4/5/2006	13	3,541	76	42,949	5.8
4/18/2006	13	3,554	72	43,021	5.5
5/1/2006	13	3,567	72	43,093	5.5
5/12/2006	11	3,578	64	43,158	5.8
5/25/2006	13	3,591	72	43,229	5.5
6/19/2006	25	3,616	132	43,362	5.3
6/28/2006	9	3,625	57	43,419	6.3
7/11/2006	13	3,638	76	43,494	5.8
7/25/2006	14	3,652	121	43,616	8.7
8/9/2006	15	3,667	102	43,718	6.8
8/21/2006	11	3,678	79	43,797	7.2
9/12/2006	22	3,700	159	43,956	7.2
9/26/2006	14	3,714	53	44,009	3.8
10/13/2006	17	3,731	136	44,145	8
10/26/2006	13	3,744	132	44,278	10.2
11/7/2006	12	3,756	159	44,437	13.2
11/17/2006	10	3,766	121	44,558	12.1
12/7/2006	20	3,786	265	44,823	13.2
12/19/2006	12	3,798	98	44,921	8.2
1/9/2007	21	3,819	288	45,209	13.7
1/23/2007	14	3,833	144	45,353	10.3
1/30/2007	7	3,840	72	45,425	10.3
2/6/2007	7	3,847	57	45,482	8.1
2/22/2007	16	3,863	117	45,599	7.3
3/8/2007	14	3,877	68	45,667	4.9

Table F-1. Leachate Volumes

Collection Date	Elapsed Time (days)	Total Time (days)	Liters[a]	Cumulative Liters[a]	Liters per Day
3/22/2007	14	3,891	155	45,822	11.1
3/27/2007	5	3,896	45	45,868	9.1
4/16/2007	20	3,916	212	46,080	10.6
4/24/2007	8	3,924	72	46,152	9
5/3/2007	9	3,933	72	46,223	8
5/16/2007	13	3,946	129	46,352	9.9
5/31/2007	15	3,961	121	46,473	8.1
6/14/2007	14	3,975	95	46,568	6.8
6/19/2007	5	3,980	15	46,583	3
7/11/2007	22	4,002	159	46,742	7.2
7/27/2007	16	4,018	91	46,833	5.7
9/13/2007	48	4,066	390	47,223	8.1
10/3/2007	20	4,086	144	47,366	7.2
11/9/2000	37	4,123	170	47,537	4.6
11/26/2007	17	4,140	142	47,679	8.3
12/12/2007	16	4,156	156	47,835	9.7
1/4/2008	23	4,179	218	48,052	9.5
1/17/2008	13	4,192	68	48,120	5.2
1/30/2008	13	4,205	49	48,170	3.8
2/21/2008	22	4,227	59	48,228	2.7
3/12/2008	19	4,246	100	48,329	5.3
3/24/2008	13	4,259	70	48,399	5.4
4/14/2008	21	4,280	150	48,548	7.1
4/28/2008	14	4,294	91	48,639	6.5
5/12/2008	14	4,308	85	48,724	6.1
5/28/2008	16	4,324	110	48,834	6.9

a. Numbers rounded to nearest whole number.

b. Volume includes 132 liters collected prior to this date not accounted for elsewhere.

c. A single sampling event occurring over two days treated as a single collection of 504 liters.

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