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Revision 1

Integrated Disposal Facility Preoperational Monitoring Plan

Prepared for the U.S. Department of Energy
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CH2MHILL
Hanford Group, Inc.

P.O. Box 1500
Richland, Washington

Integrated Disposal Facility Preoperational Monitoring Plan

D.G. Horton, S.P. Reidel, Yi-Ju Chien/ R.M. Mitchell
Pacific Northwest National Laboratory/ Duratek Federal Services, Inc
Richland, WA 99352
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Abstract:
This plan presents a revised program to characterize and establish an environmental baseline for the IDF site. The original plan was developed in 2000 (RPP-6877, Rev. 0) for the Immobilized Low-Activity Disposal Site. Since then, planning for the site has progressed and its mission has been changed to become the IDF, to include disposal of low-level and mixed low-level waste.

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TERMS

AL	action level
ANOVA	analysis of variance
CA	composite analysis
CERCLA	*Comprehensive Environmental Response, Compensation and Liability Act of 1981*
CFR	*Code of Federal Regulations*
CRBG	Columbia River Basalt Group
CV	coefficients of variation
DOE	U.S. Department of Energy
DQO	data quality objectives
EMI	electromagnetic induction
EMS	electromagnetic induction surveys
EPA	U.S. Environmental Protection Agency
GEA	gamma energy analysis
GPR	ground-penetrating radar
HLW	high-level radioactive waste
IC	ion chromatography
ICP	inductively coupled plasma
IDF	Integrated Disposal Facility
ILAW	immobilized low-activity waste
LAW	low-activity waste
MS	mass spectrometry
OBL	operating background level
PA	performance assessment
PUREX	plutonium-uranium extraction
RCRA	Resource Conservation and Recovery Act of 1976
RCW	*Revised Code of Washington*
RHO	Rockwell Hanford Operations
SAP	Sampling and Analysis Plans
SST	single-shell tanks
TLD	thermoluminescent dosimeters
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
WHC	Westinghouse Hanford Company
WIDS	*Waste Information Data System*
WRS	Wilcoxon Rank Sum
WTP	Waste Treatment Plant
XRF	x-ray fluorescence

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1.0 INTRODUCTION

The U.S. Department of Energy's (DOE) Hanford Site has the most diverse and largest amount of radioactive tank waste in the United States. High-level radioactive waste (HLW) has been stored in large underground tanks since 1944. Approximately 232,000 m^3 (53.6 Mgal) of waste currently are stored in 177 tanks. This caustic waste consists of many different chemicals and radionuclides, and is in the form of liquids, slurries, salt cakes, and sludges. Estimates of the total tank waste inventory vary depending on the assumptions used to develop the estimate.

The radioactive waste came from plutonium and uranium recovery processing of approximately 100,000 Mtu of irradiated fuel, radionuclide recovery processing of tank waste, and miscellaneous sources (e.g., laboratories and reactor decontamination solutions). The neutralized waste contains sodium nitrate, sodium hydroxide, sodium aluminate, sodium phosphate, large amounts of organic materials in soluble solids, and approximately 260 MCi of radioactive waste. The waste is stored in 149 single-shell tanks (SST) and 28 double-shell tanks.

Most of the waste in Hanford Site tanks resulted from processing irradiated nuclear fuels and subsequent waste treatment. The major chemical separation processes included the bismuth phosphate process, the tri-butyl phosphate uranium recovery process, the reduction-oxidation process, the plutonium-uranium extraction (PUREX) process, Plutonium Finishing Plant operations, and B Plant waste fractionation, with smaller volumes generated from various development programs. Other uranium recovery and volume reduction programs resulted in ferrocyanide and other chemicals being added to selected tanks. Over the years these waste volumes have been transferred and mixed among individual tanks in some tanks farms, as well as between tank farms. Waste volumes have been reduced by using various evaporation and concentration methods and decanting dilute waste to the ground. (See WHC-SD-WM-TI-740, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Waste Tanks*, for a more detailed description of tank waste concentration variability.)

Today, the Site's missions are environmental restoration, energy-related research, and technology development. As part of its environmental restoration mission, DOE is proceeding with plans to permanently dispose of the waste stored on Site. These plans are based on Revision 6 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) and 62 FR 8693, "Record of Decision for the Tank Waste Remediation System, Hanford Site, Richland, Washington." These documents call for the waste to be retrieved from the Hanford Site's single- and double-shell tanks, then treated to separate the low-level fraction (now called the low-activity fraction) from the high-level and transuranic fractions. Both fractions then will be immobilized. The high-activity fraction would be vitrified and disposed of in a geologic repository off the Hanford Site. The low-activity fraction would be solidified and disposed of in the Integrated Disposal Facility (IDF) on the Hanford Site.

The Tri-Party Agreement (Ecology et al. 1989) was renegotiated in September 1993 (Ecology et al. 1994) and signed by all parties in January 1994. Vitrification and onsite disposal of low-activity tank waste are embodied in the strategy described in the Tri-Party Agreement.

Location of Facilities

The IDF will be located in the south-central portion of the 200 East Area (Figure 1-1).

1.1 SCOPE

This plan presents a revised program to characterize and establish an environmental baseline for the IDF site. The original plan was developed in 2000 (RPP-6877, Rev. 0) for the Immobilized Low-Activity Disposal Site. Since then, planning for the site has progressed and its mission has been changed to become the IDF. A record of decision (ROD) (69 FR 39449, "Revision to the Record of Decision for the Department of Energy's Waste Management Program: Treatment and Storage of Transuranic Waste") has been issued by the DOE. The ROD documents their decision to proceed with the preferred alternative described in DOE/EIS-0286F, *Final Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement Richland, Washington*. This preferred alternative includes the construction and operation of a lined, combined-use disposal facility(the IDF) in the Hanford Site's 200 East Area for the disposal of low-level waste (LLW) and mixed low-level waste (MLLW).

The major change in mission from the Immobilized Low-Activity Disposal Site to the IDF is including the disposal of solid mixed waste and low-activity waste in the facility's mission. This plan updates the characterization activities for the surface and near-surface vadose zone and the data collection activities supporting the development of the preoperational baseline for the IDF. This plan is being coordinated with the IDF performance assessment (PA) activity.

1.2 PURPOSE AND OBJECTIVE

The purpose of this plan is to define and update the data collection activities used to develop the preoperational environmental baseline for the IDF site. The characterization data necessary to develop the environmental baseline were determined using the data quality objectives (DQO) approach discussed in WHC-SD-WM-PLN-109, *Characterization Plan for the Proposed TWRS Treatment Complex*. The DQO process ensures that only necessary and relevant data are acquired.

This document provides a plan for the following activities:

- Characterizing the IDF site surface area and near-surface vadose zone to the level needed for the operational mission
- Screening the IDF site for shallow-buried material or near-surface contamination from past-practice activities.
- Developing an environmental baseline for the IDF site.

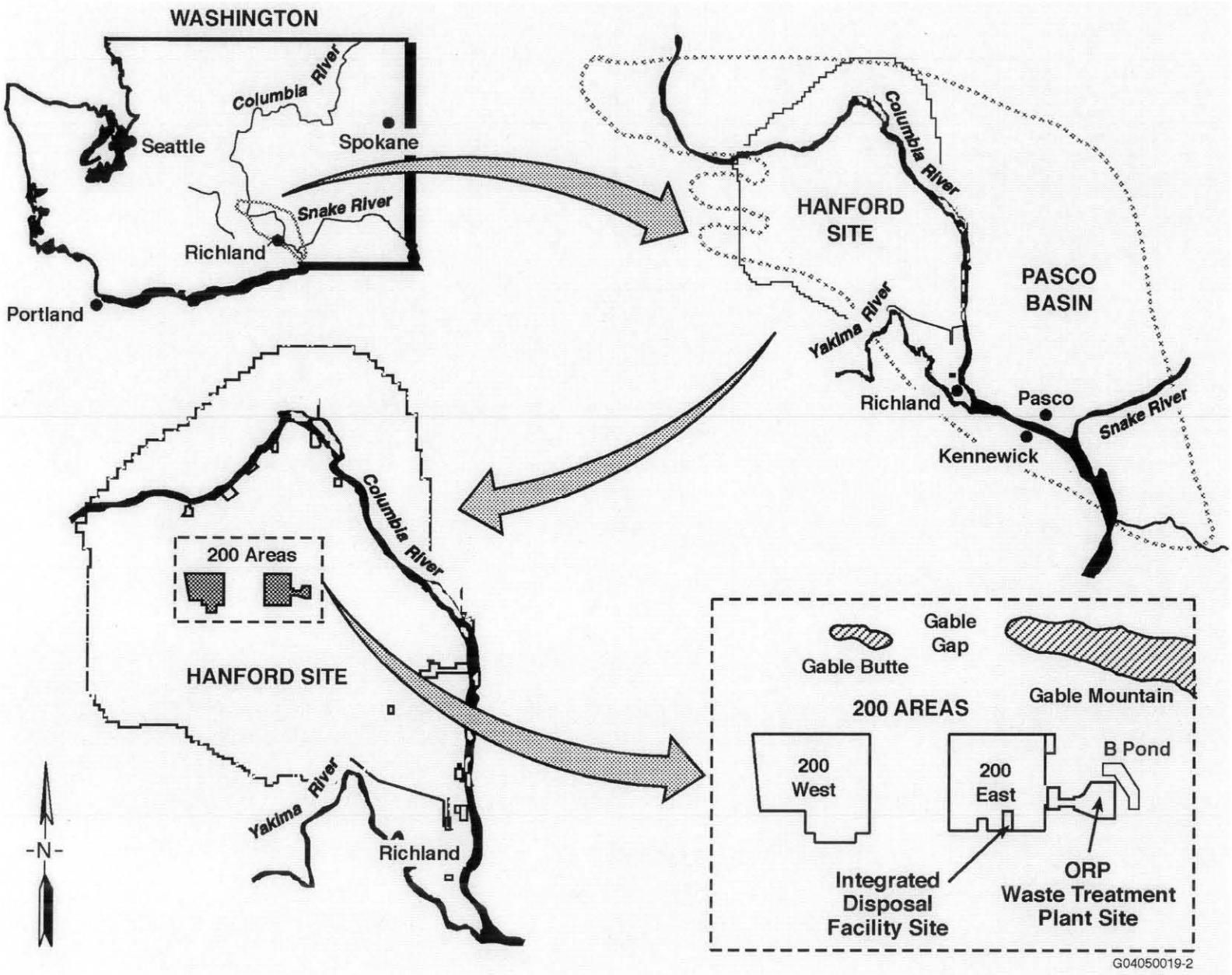

Figure 1-1. Location of Integrated Disposal Facility Site.

1.3 PLAN RATIONALE AND ORGANIZATION

Characterization plans are required to fully implement DOE/RL-89-12, *Hanford Site Groundwater Protection Management Program* and DOE O 435.1, *Radioactive Waste Management*. The groundwater protection management program is required by DOE Order 5400.1, *General Environmental Protection Program*.

DOE O 435.1, requires that a disposal authorization statement ("Disposal Authorization Statement for the Hanford Site Low-Level Waste Disposal Facilities," [DOE 1999]) be obtained before operating a new LAW disposal facility. With respect to disposal facilities, DOE O 435.1 (M) requires that

> "A preliminary monitoring plan for low-level waste disposal shall be prepared and submitted to Headquarters for review with the performance assessment and composite analysis. The monitoring plan shall be updated within one year following issuance of the disposal authorization statement to incorporate and implement conditions specified in the disposal authorization statement."

Baseline data are required to compare the operational environmental status with its preoperational status. The preoperational data will permit evaluation of the environmental impact of adjacent operational and waste disposal operations on the IDF site. Environmental components that will be needed for developing the baseline include atmospheric, radioecological (surface soils/flora, fauna, and external radiation), and vadose zone components.

As directed in DOE M 435.1-1, *Radioactive Waste Management Manual*, startup of a new facility has a specific environmental requirement for preoperational monitoring. "Preoperational monitoring of a new disposal site or the expansion of an existing disposal site to determine baseline conditions will be conducted as required by DOE M 435.1-1 as part of the Site Evaluation" (DOE M 435.1-1, Section IV.M.(1)). This activity needs to be performed for at least 1 year before constructing a disposal facility. Because many of the environmental data collected by monitoring programs are influenced by seasonal events, 1 year of data represents an absolute minimum for data collection for new disposal sites.

The Hanford Site has an extensive database from past site characterization activities. The most recent compilation of data is DOE/RW-0164, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*, a nine-volume set published by the DOE in 1988 for the former Basalt Waste Isolation Project, but more recent data are available from ongoing monitoring and characterization activities. Chapter 2 summarizes the extent of current environmental knowledge at the site and vicinity.

The logic behind the plans set forth in Chapter 4 is based on following the DQO process. The DQO for the site was completed in 1995 and is documented in WHC-SD-WM-PLN-109. This information is reproduced in Chapter 3 accompanied by a discussion of how it applies to this project. The rational for plans in Chapter 4 was discussed originally in WHC-SD-WM-PLN-109. Chapter 4 of this report has been revised to incorporate those of the original plans that still are applicable, plus new planning for the current design and operation of

the IDF site. The actual details of the data collection activities are set forth in Appendices A1, "Field Sampling and Analysis Plans (SAP)," and A2, "Quality Assurance Project Plans."

The preoperational monitoring program will provide for characterization of the environment before operations begin to document existing contamination levels at the proposed site that may be attributable to past waste management practices. This program consists of collecting data to evaluate the existing conditions of the site and the surrounding area. Chapter 4 covers the activities and the rationale behind them.

1.4 DISPOSAL AUTHORIZATION AND U.S. DEPARTMENT OF ENERGY RADIOACTIVE WASTE MANAGEMENT ORDER

DOE O 435.1 requires that a disposal authorization statement be obtained before constructing a new IDF. DOE G 435.1-1, *Implementation Guide for Use with DOE M 435.1-1*, the guide implementing DOE O 435.1, states that a disposal authorization statement shall be issued based on a review of the facility's PA and composite analysis (CA) or appropriate *Comprehensive Environmental Response, Compensation and Liability Act of 1980* (CERCLA) documentation. The disposal authorization shall specify the limits and conditions on construction, design, operations, and closure of the facility. Failure to obtain a disposal authorization statement shall result in disapproval to initiate construction of a new facility such as the IDF.

DOE G 435.1-1 specifies that a preliminary monitoring plan for a LLW disposal facility shall be prepared and submitted to DOE, Headquarters, for review with the PA and CA. This disposal authorization was granted in 1999. Revision 0 of the RPP-6877 was issued in 2000. The monitoring plan shall be updated within 1 year following issuance of the disposal authorization statement to incorporate and implement conditions specified in the disposal authorization statement. The current plan is the update that fulfills that requirement. The plans shall meet the following criteria:

- The site-specific PA and CA shall be used to determine the media, locations, radionuclides, and other substances monitored.
- The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters that may affect long-term performance.
- The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action before exceeding the performance objectives stated in DOE O 435.1.

DOE M 435.1-1 provides that following performance objectives applicable to the IDF site PA:

- "(1)(a) 25 mrem in a year total effective dose equivalent from all exposure pathways

- "(1)(b) 10 mrem in a year total effective dose equivalent via the air pathway
- "(1)(c) Release of radon shall not exceed 10 mrem in a year total effective dose equivalent
- "(2)(g) Include an assessment of impacts to water resources
- "(2)(h) The intruder analysis shall use performance measures for chronic and acute exposures, respectively, of 100 mrem in a year and 500 mrem in a year total effective dose equivalent
- "(2)(b) The point of compliance shall correspond to the point of highest projected dose or concentration beyond a 100 meter buffer zone surrounding a disposal waste
- "(2) Include calculations for a 1,000 year period after closure."

Because the IDF will require a *Resource Conservation and Recovery Act of 1976* (RCRA) Part B permit and concurrence from the U.S. Nuclear Regulatory Commission, Mann merged these requirements with the requirements from DOE O 435.1 into a unified set of performance objectives (Tables 1-1 and 1-2) for the disposal site (RPP-13263, *Performance Objectives for the Hanford Immobilized Low-Activity Waste (ILAW) Performance Assessment*, and DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment: 2001 Version*).

1.4.1 Composite Analysis

PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* was prepared in response to Recommendation 94-2 of the Defense Nuclear Safety Board to the Secretary of Energy (59 FR 47309). The recommendation noted the need for a risk assessment that addresses the environmental impacts of all radioactive waste disposal actions or leaks at a DOE site. The authors of the CA worked in conjunction with the authors of the IDF PA to ensure consistency of data and methods. The analysis considered the time period of 1,500 years beginning in 1944 and including the 1,000 years following Site closure, which is assumed to be 2050. The IDF PA, however, considered a time period of 10,000 years. Consistent with the IDF PA, the CA showed that groundwater impact from IDF disposal would occur after 1,500 years. The IDF PA, therefore, provides a more conservative approach to assessing the impact of waste disposal at the site on the environment and the performance objectives.

1.4.2 Monitoring Requirements of DOE O435.1

DOE O 435.1 requires a preliminary monitoring plan for a LLW disposal site. "The plan documents the monitoring performed in support of the PA and CA, and any preliminary changes or additions to the monitoring that reflect the results of the evaluations as submitted." The plan is to be cost effective and take into consideration the characteristics of the disposal site, the waste, and the disposal technology.

At present the waste characteristics have been embodied into the performance objectives discussed in HNF-EP-0826, *Performance Objectives for the Hanford ILAW Performance Assessment* (obsolete), revised in 2001 (DOE/ORP-2000-24) and reproduced in Tables 1-1, and 1-2. A considerable body of characterization information is available for the IDF site (see Chapter 2). Characterization activities have been started but not completed.

1.4.3 Elements of the Monitoring Plan

The following specific elements must be addressed in a monitoring plan.

1. "*The site-specific PA and CA shall be used to determine the media, locations, radionuclides and other substances monitored.*" The PA (DOE/RL-97-69, *Hanford Immobilized Low-Activity Tank Waste Performance Assessment*), DOE/ORP-2000-07, *White Paper Updating Conclusions of 1998 ILAW Performance Assessment*, and DOE/ORP-2000-24 address these specific criteria in detail. The media of concern are groundwater (protection) and air; the locations or point of compliance is the edge of the buffer zone, which is modeled as groundwater wells 100 m from the site; the specific radionuclides to be monitored are given in Table1-1 and other substances are given in Table 1-2.

2. "*The environmental monitoring program shall be designed to include measuring and evaluating releases, migration of radionuclides, disposal unit subsidence, and changes in disposal facility and disposal site parameters, which may affect long-term performance.*" Because of the uncertainties in groundwater flow directions, the final facility design, and incomplete characterization, only the preoperational monitoring plan can be prepared at this time. The operational monitoring plan can be written once the final design has been determined and characterization studies have been completed.

3. "*The environmental monitoring programs shall be capable of detecting changing trends in performance to allow application of any necessary corrective action prior to exceeding the performance objectives stated in the order.*" As stated in Element 2, a monitoring plan cannot be written until the final facility design has been determined and characterization activities have been completed.

Table 1-1. Radiological Performance Objectives
(from DOE/ORP-2000-24 and RPP-13263).

Protection of General Public and Workers[a,b]	
All-pathways dose from only this facility	25 mrem in a year[d,h]
All-pathways dose including other Hanford Site sources	100 mrem in a year[e,i]
Incremental Lifetime Cancer Risk	10^{-5}
Hazard Index	1
Protection of an Inadvertent Intruder[c,f]	
Acute exposure	500 mrem
Continuous exposure	100 mrem in a year

Table 1-1. Radiological Performance Objectives
(from DOE/ORP-2000-24 and RPP-13263).

Protection of Groundwater Resources[b,d,j]	
Alpha emitters	
^{226}Ra plus ^{228}Ra	5 pCi/L
All others (total)	15 pCi/L
Beta and photon emitters	4 mrem in a year
Protection of Surface Water Resources [b,g]	
Alpha emitters	
^{226}Ra plus ^{228}Ra	0.3 pCi/L
All others (total)	15 pCi/L
Beta and photon emitters	1 mrem in a year[k]
Protection of Air Resource[b,f,l]	
Radon (flux through surface)	20 pCi/m^2/s[l]
All other radionuclides	10 mrem in a year

[a]All doses are calculated as effective dose equivalents; all concentrations are in water taken from a well. Values given are in addition to any existing amounts or background.
[b]Evaluated for 1,000 and 10,000 years, but calculated to the time of peak or 10,000 years, whichever is longer.
[c]Evaluated for 500 years, but calculated to 1,000 years.
[d]Evaluated at the point of maximal exposure, but no closer than 100 m (328 ft) from the disposal facility.
[e]Evaluated at the 200 East Area fence (assumed future boundary of the Hanford Site).
[f]Evaluated at the disposal facility.
[g]Evaluated at the Columbia River, no mixing with the river is assumed.
[h]Main driver is DOE orders on Radioactive Waste Management.
[i]Main driver is DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*
[j]Main driver is 40 CFR 141, "National Primary Drinking Water Regulations."
[k]Main driver WAC 173-201A, "Washington State Surface Water Standards."
[l]Main Drivers are 40 CFR61H and 40 CFR61Q "National Emission Standards for Hazardous Air Pollutants."
DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment:2001 Version.*
RPP-13263, *Performance Objectives for the ILAW Performance Assessment.*

Table 1-2. Performance Goals for Inorganic Materials
(from DOE/ORP-2000-24).

Inorganics		
Chemical	**Groundwater**	**Surface Waters**
Ammonia (NH_3)	(a)	4.0 mg/L
Antimony (Sb)	0.006 mg/L	0.006 mg/L
Arsenic (As)	0.00005 mg/L	0.05 mg/L
Barium (Ba)	1.0 mg/L	2.0 mg/L
Beryllium (Be)	0.004 mg/L	0.004 mg/L
Cadmium (Cd)	0.005 mg/L	0.00077 mg/L
Chlorine (Cl)	250.0 mg/L	230.0 mg/L
Chromium (Cr)	0.05 mg/L	0.011 mg/L
Copper (Cu)	1.0 mg/L	0.0078 mg/L

Table 1-2. Performance Goals for Inorganic Materials (from DOE/ORP-2000-24).

Inorganics			
Chemical		**Groundwater**	**Surface Waters**
Cyanide (CN)		0.2 mg/L	0.0052 mg/L
Fluoride (F^-)		4.0 mg/L	4.0 mg/L
Iron (Fe)		0.3 mg/L	
Lead (Pb)		0.05 mg/L	0.0015 mg/L
Manganese (Mn)		0.05 mg/L	
Mercury (Hg)		0.002 mg/L	0.000012 mg/L
Nickel (Ni)		(a)	0.115 mg/L
Nitrate as N (NO_2)		10.0 mg/L	10.0 mg/L
Nitrite as N (NO_3)		1.0 mg/L	1.0 mg/L
Nitrite plus Nitrate		10.0 mg/L	10.0 mg/L
Selenium (Se)		0.01 mg/L	0.005 mg/L
Silver (Ag)		0.05 mg/L	(a)
Sulfate (SO_4)		250.0 mg/L	(a)
Thallium (TI)		0.002 mg/L	(a)
Zinc (Zn)		5.0 mg/L	0.072 mg/L
Organics			
CAS #	**Constituent (a)**	**Groundwater**	**Surface Waters**
56-23-5	Carbon tetrachloride	0.0003 mg/L	0.005 mg/L
67-66-3	Chloroform	0.007 mg/L	(a)
71-43-2	Benzene	0.001 mg/L	0.005 mg/L
71-55-6	1, 1, 1-trichloroethane	0.003 mg/L	0.2 mg/L
75-09-2	Dichloromethane (methylene chloride)	0.005 mg/L	0.005 mg/L
79-00-5	1, 1, 2-trichloroethane	0.005 mg/L	0.005 mg/L
79-01-6	1, 1, 2-trichloroethylene	0.005 mg/L	0.005 mg/L
95-47-6	o-Xylene	0.7 mg/L	0.7 mg/L
100-41-4	Ethyl benzene	0.1 mg/L	0.1 mg/L
106-46-7	1,4-dichlorobenzene	0.004 mg/L	0.075 mg/L
108-88-3	Toluene	1.0 mg/L	1.0 mg/L
127-18-4	1,1,2,2-tetrachloroethene	0.005 mg/L	0.005 mg/L

(a) No entry in a cell indicates that no limit was found.

DOE/ORP-2000-24, *Hanford Immobilized Low-Activity Waste Performance Assessment:2001 Version.*

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2.0 HANFORD SITE PHYSICAL AND ENVIRONMENTAL DESCRIPTION AND BACKGROUND INFORMATION

The Hanford Site was established in 1944 as a U.S. Government nuclear materials production facility. During its history, the Site's missions have included nuclear reactor operation, storage and reprocessing of spent nuclear fuel, and management of the waste resulting from processing operations. Present activities primarily involve waste management and Site restoration. The inactive fuel reprocessing facilities and the radioactive waste management facilities are located in the 200 East Area and 200 West Area (Separations Area).

Chapter 2 summarizes the physical and environmental conditions of the Hanford Site. This summary is based on an extensive database obtained from characterization studies, waste management activities, and nuclear projects over the past 50 years. These reports and databases are too numerous to list in this overview.

2.1 GEOGRAPHY

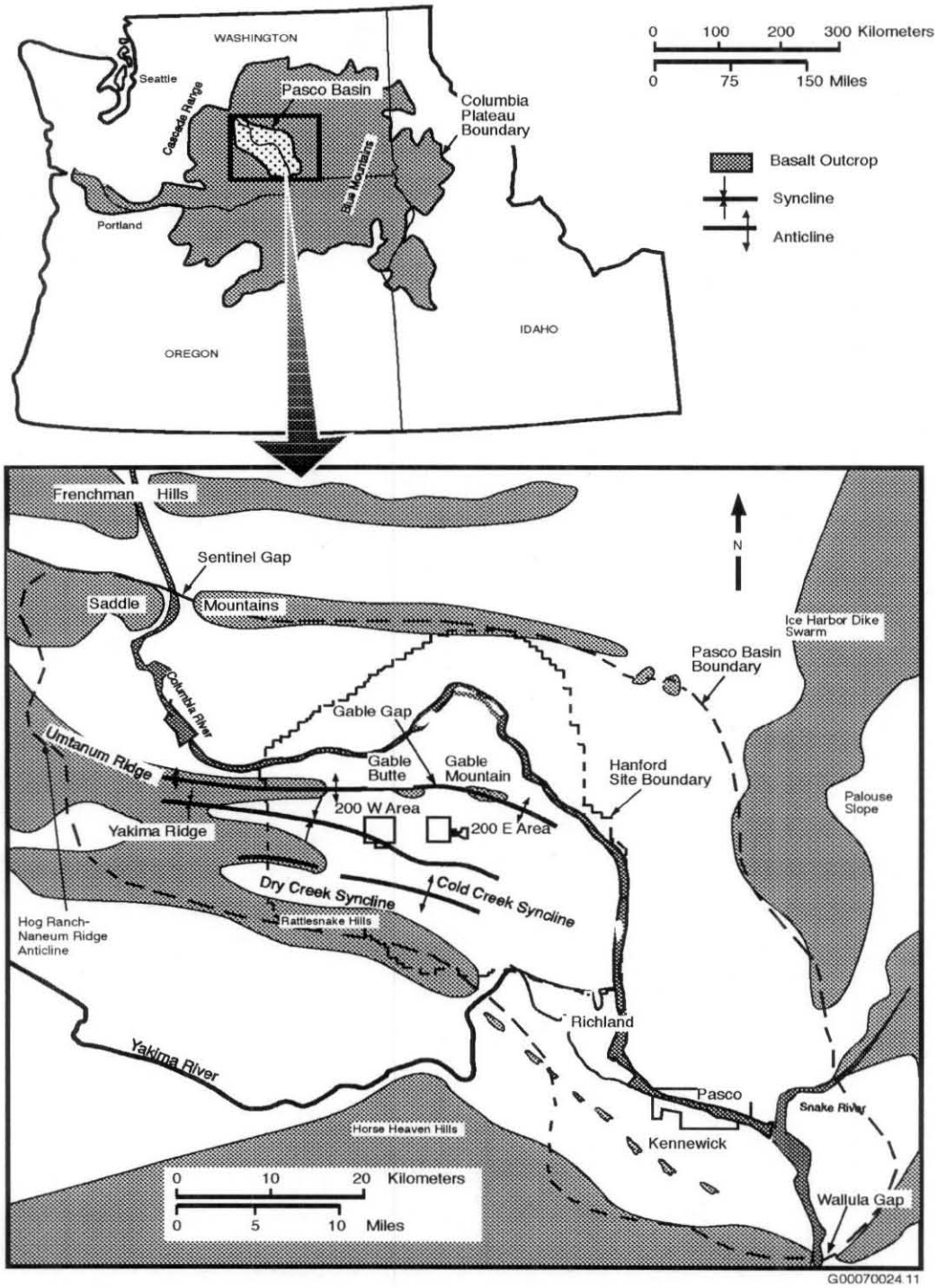
The Hanford Site covers a 1450 km^2 (560-mi^2) area, as shown in Figure 1-1, extending into Benton, Franklin, Grant, and Adams counties. Use of the Site is institutionally controlled by DOE for national security and health and safety reasons. In 1997, the DOE transferred management of the Fitzner/Eberhardt Arid Lands Ecology Reserve, a 665 km^2 (257-mi^2) area in the western part of the Site, to the U.S. Fish and Wildlife Service. The U.S. Fish and Wildlife Service also manages the Wahluke Slope Area and the Saddle Mountains National Wildlife Refuge, north of the Columbia River.

In Proclamation 7319 dated June 9, 2000, President Clinton established the Hanford Reach National Monument at the Hanford Site (Clinton 2000). This designation is consistent with 64 FR 61615, "Record of Decision: Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS)." The 200 Areas are designated as an "industrial-exclusive" use area.

The Columbia River enters the Hanford Site at the northwest corner and crosses over to form part of the Site's eastern boundary as it flows southward. The Yakima River flows from west to east, forms part of the southern boundary of the Site, and empties into the Columbia River at Richland. The Site is bordered on the north by the Saddle Mountains and on the west by the Rattlesnake Hills (Figure 2-1). Dominant natural features include the Columbia River, anticlinal ridges of basalt in and along the Hanford Site boundary, and sand dunes located near the Columbia River. The elevation along the Columbia River is about 105 m (345 ft) in the southern part of the Site and 120 m (390 ft) in the northern part. The surrounding basaltic ridges rise to elevations as high as 1100 m (3,600 ft).

The most broadly distributed varieties of vegetation are sagebrush, cheatgrass, bluebunch wheatgrass, and other plant species common to central Washington State.

Figure 2-1. Major Geographic Features of the Hanford Site.



2.2 CLIMATE

The climate of the Pasco Basin can be classified as midlatitude semiarid or midlatitude desert, depending on the climatological classification scheme used. Summers are warm and dry with abundant sunshine. Large diurnal temperature variation results from intense solar heating during the day and radiational cooling at night. Daytime high temperatures in June, July, and August periodically exceed 38 °C (100 °F). Winters are cool with occasional precipitation. Outbreaks of cold air associated with modified continental Arctic air masses can reach the area and cause temperatures to drop below -18 °C (0 °F). Overcast skies and fog occur periodically during the winter.

2.2.1 Temperature

At the Hanford Site, the annual average temperature is 12 °C (53 °F). July is typically the warmest month with an average maximum temperature of 33 °C (91 °F), an average minimum temperature of 16 °C (61 °F), and an average temperature of 25 °C (76 °F). January tends to be the coolest month with an average maximum temperature of 4 °C (38 °F), an average minimum temperature of -4 °C (24 °F), and an average temperature of 0 °C (32 °F). The highest temperature ever recorded on the Site was 45 °C (113 °F) on August 4, 1961. The lowest temperature ever recorded was -30 °C (-22 °F) on January 26, 1962.

2.2.2 Precipitation

The annual average precipitation value at the Hanford Meteorological Station is 16.8 cm (6.6 in.), with the wettest year (1950) having 29.1 cm (11.45 in.) and the driest (1976) having 7.6 cm (2.99 in.). On average, 54 percent of normal annual precipitation falls during November through February. December is the wettest month, receiving, on average, 2.6 cm (1.03 in.), and July is the driest month receiving, on average, only 0.46 cm (0.18 in.). The wettest month on record is June 1950 with 7.4 cm (2.92 in.); September 1991, August 1988, and August 1955 recorded no precipitation. An average of 125 days per year have a trace (less than 0.013 cm [0.005 in.]) or more of precipitation. The average number of days per month with a trace or more of precipitation ranges from 16 days in January to 5 days in July. Only 24 days a year receive totals of 0.25 cm (0.1 in.) or more. During the 54-year period of record (1945 through 1999), only 4 days have had 2.5 cm (1 in.) or more of precipitation (PNNL-13117, *Hanford Site Climatological Data Summary 1999 With Historical Data*).

Total annual snowfall, which includes all frozen precipitation, varies from a low of 0.76 cm (0.3 in.) to 142 cm (56.1 in.). The average annual snowfall is 38 cm (15 in.). The record snow depth during any single month at the Hanford Meteorology Station (200 West Area) is 55.9 cm (22 in.) in December 1996, but the record snow depth on the Hanford Site is 61 cm (24 in.) in February 1916.

2.2.3 Dust and Blowing Dust

Dust and blowing dust (locally resuspended) occur frequently, with blowing dust the most commonly observed. Dust and blowing dust are recorded at the Hanford Meteorological Station when horizontal visibility is reduced to 9.65 km (6 mi) or less. Dust is carried into the area from distant sources and may or may not occur during strong winds. Dust has been observed with wind speeds ranging from 1.8 m/s (4 mi/h) to 13.4 m/s (30 mi/h). Blowing dust occurs when dust is resuspended locally with strong winds. Wind speeds during blowing dust range from 8.5 m/s (19 mi/h) to 35.8 m/s (80 mi/h). The average number of days per year with dust or blowing dust is five. The greatest number of such days in any year is 20, while the fewest is 0. The greatest number of days with dust or blowing dust in any month was nine in May 1980, just after the Mt. St. Helens eruption. Dust and blowing dust occur most frequently between March and May and again in September and occur least frequently during November and December.

2.2.4 200 East Area Climate Data

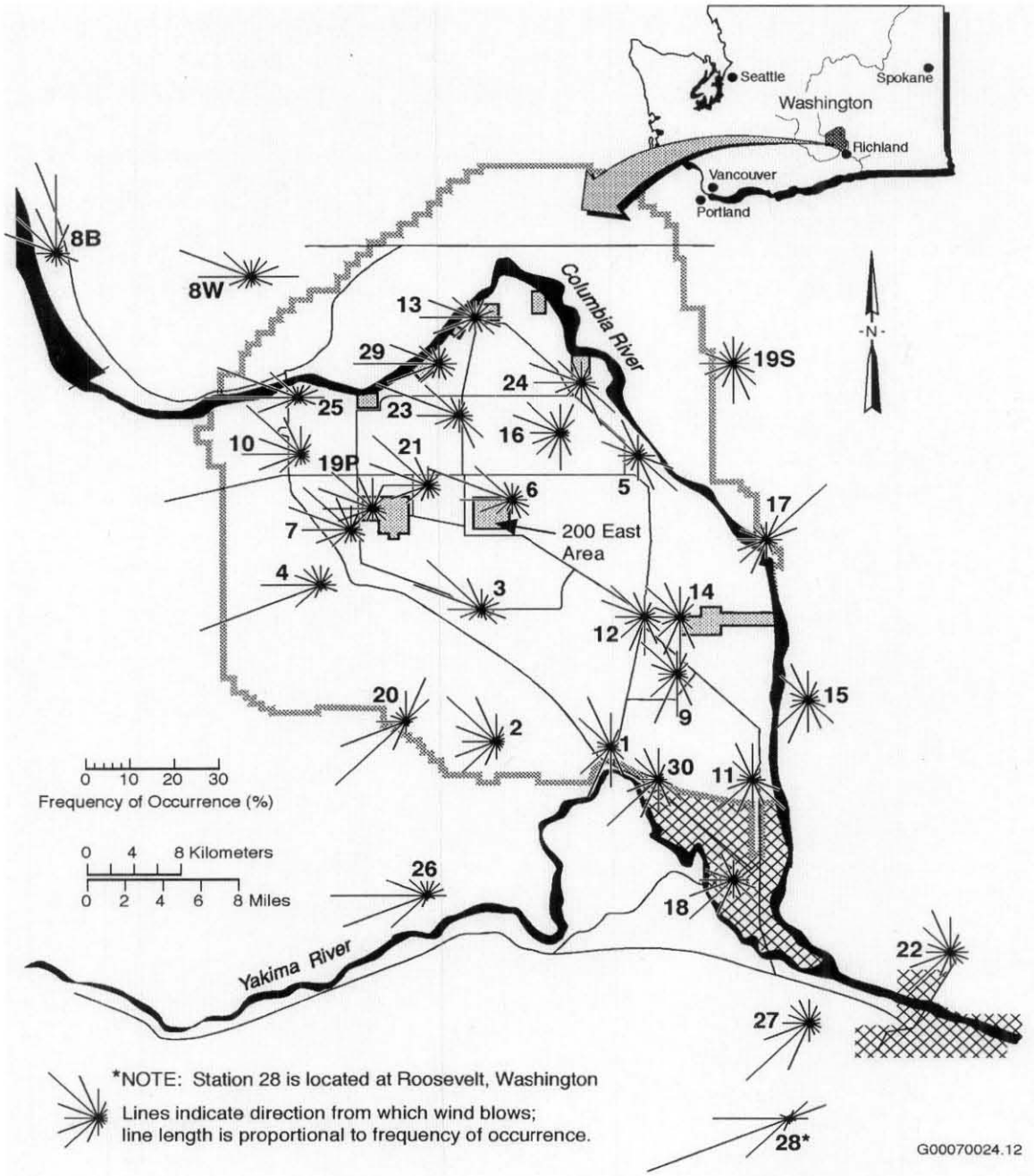
Data collected from the 200 East Area meteorological tower are the closest data for characterizing the dispersion climatology of the 200 East Area. The joint frequency distribution of hourly averaged wind data from the 200 East Area meteorological tower for the 17-year period January 1982 to December 1999 are provided in PNNL-13117. Figure 2-2 provides a graphical representation of the joint frequency distribution data for the Hanford Site in the form of wind roses. The wind rose data indicate that winds from the west-northwest occur most frequently (nearly 20 percent of the time). That is, the emissions are transported toward the east-southeast sector. Winds out of the northwest and west also occur with a relatively high frequency (12 percent of the time). At times of unstable wind direction, wind from the west-northwest and northwest sectors occurs more frequently than from the other directions. Winds are more frequently from the west-northwest during stable conditions.

2.3 GEOLOGY

2.3.1 Geologic Setting of the Hanford Site

The Hanford Site lies within the Columbia Plateau, which consists of a thick sequence of tholeiitic basalt flows called the Columbia River Basalt Group (CRBG). These flows have been folded and faulted over the past 17 million years, creating broad structural and topographic basins separated by asymmetric anticlinal ridges. Sediments up to 518 m (1,700 ft) thick have accumulated in some of these basins. Basalt flows of the CRBG are exposed along the anticlinal ridges, where they have been uplifted as much as 1097 m (3,600 ft) above the surrounding area. Overlying the CRBG in the synclinal basins are sediments of the late Miocene, Pliocene, and Pleistocene ages. The Hanford Site lies within one of the larger basins, the Pasco Basin. The Pasco Basin is bounded on the north by the Saddle Mountains and on the south by Rattlesnake Mountain and the Rattlesnake Hills (Figure 2-3). Yakima Ridge and Umtanum Ridge trend into the basin and subdivide it into a series of anticlinal ridges and synclinal basins. The largest syncline, the Cold Creek syncline, lies between Umtanum Ridge and Yakima Ridge and is the principal structure within the DOE waste management areas and the IDF (Figure 2-3). The geology of the Hanford Site is described in detail in Volume 1 of DOE/RW-0164.

Figure 2-2. Hanford Meteorological Monitoring Network Wind Roses at the 10 m Level, 1982 through 1999 (from PNNL-13117).



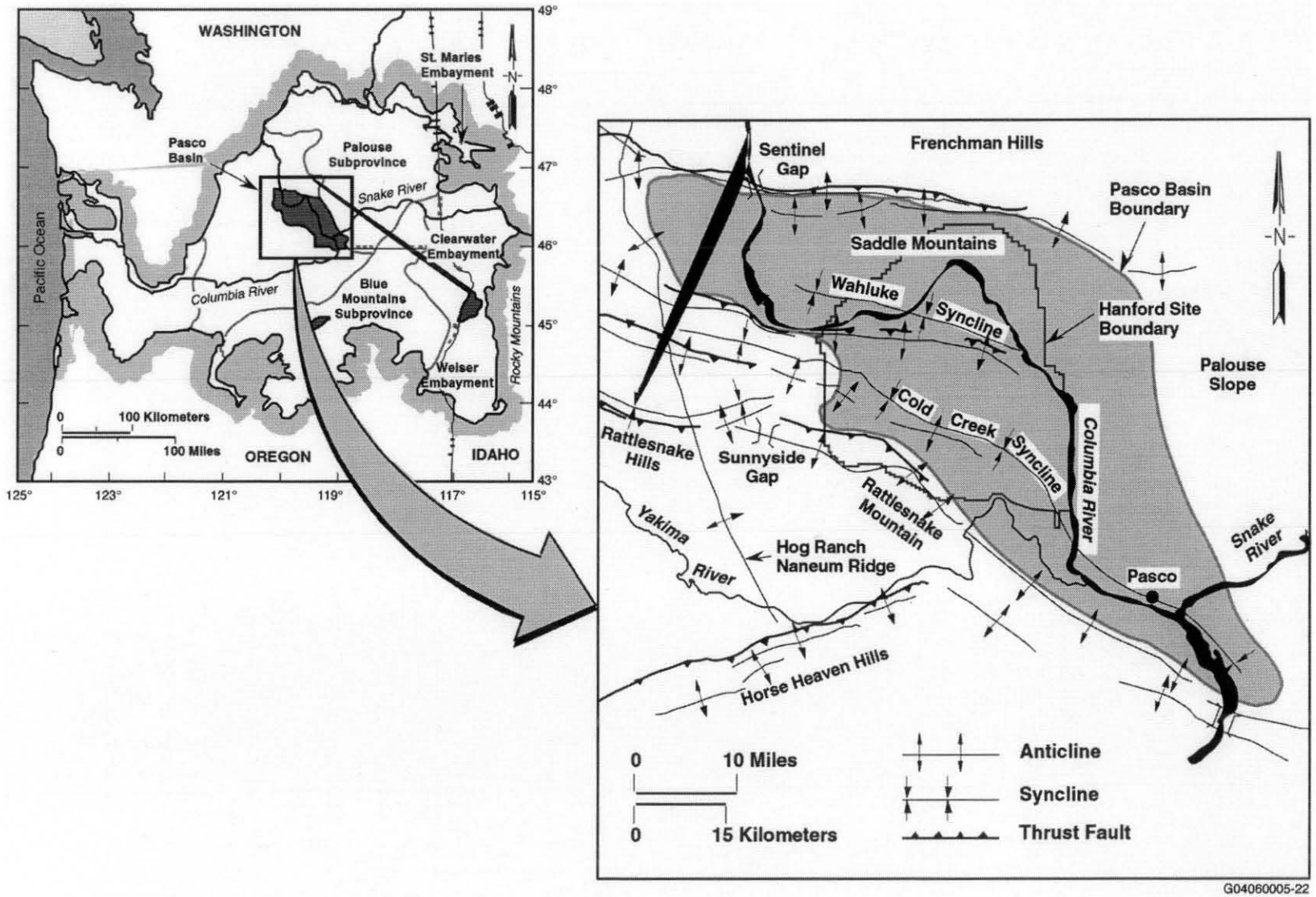
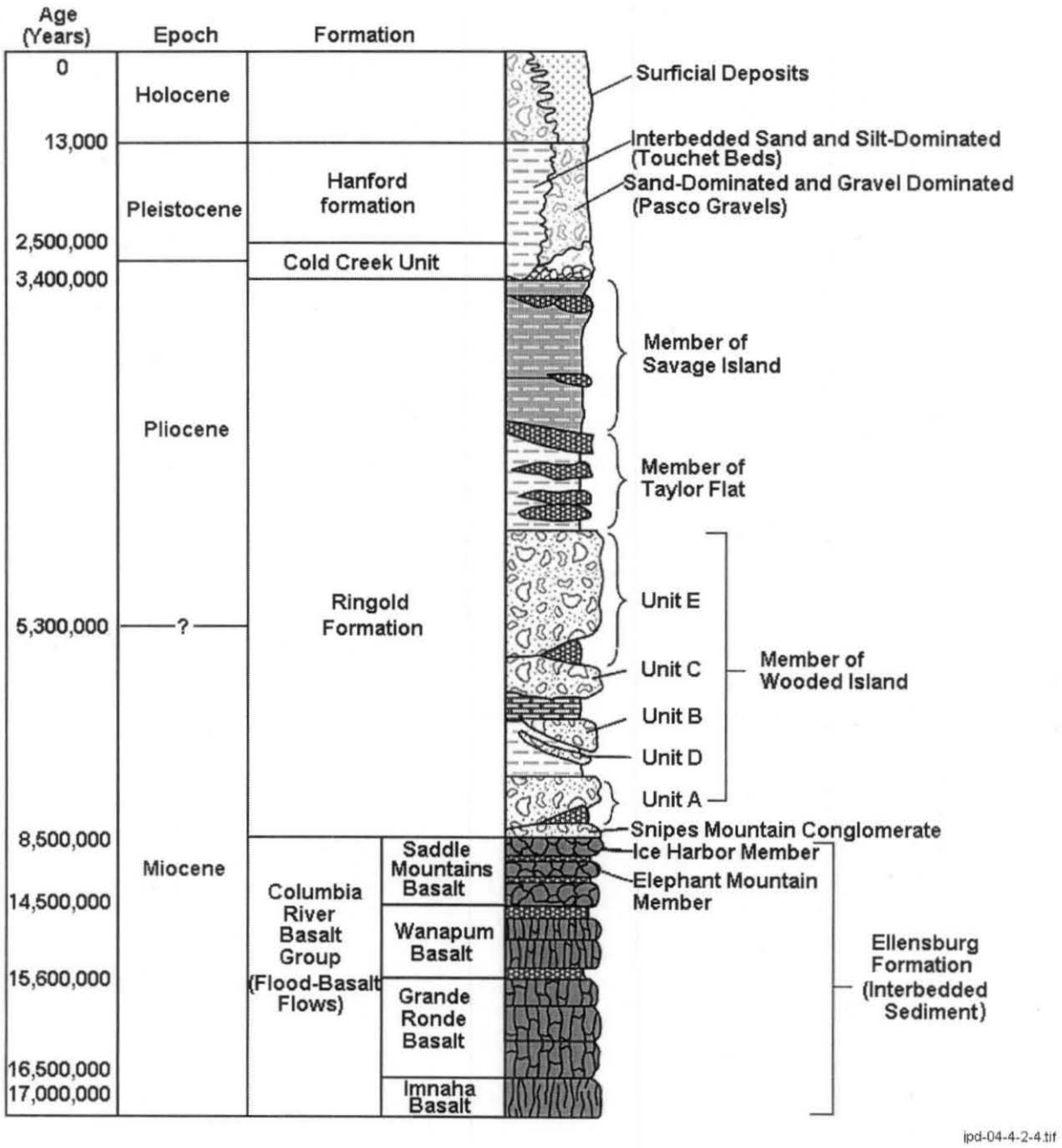


Figure 2-3. Generalized Geological Features of the Hanford Site.

Figure 2-4 shows the main stratigraphic units at the Site; in ascending order, they are the CRBG (Miocene), the Ringold Formation (Miocene-Pliocene), the Cold Creek unit, and the Hanford formation (Pleistocene). A regionally discontinuous veneer of recent alluvium, colluvium, and/or eolian sediments overlies the principal stratigraphic units. Figure 2-5 is a geologic map highlighting the 200 Areas.

Figure 2-4. Generalized Stratigraphy of the Hanford Site.



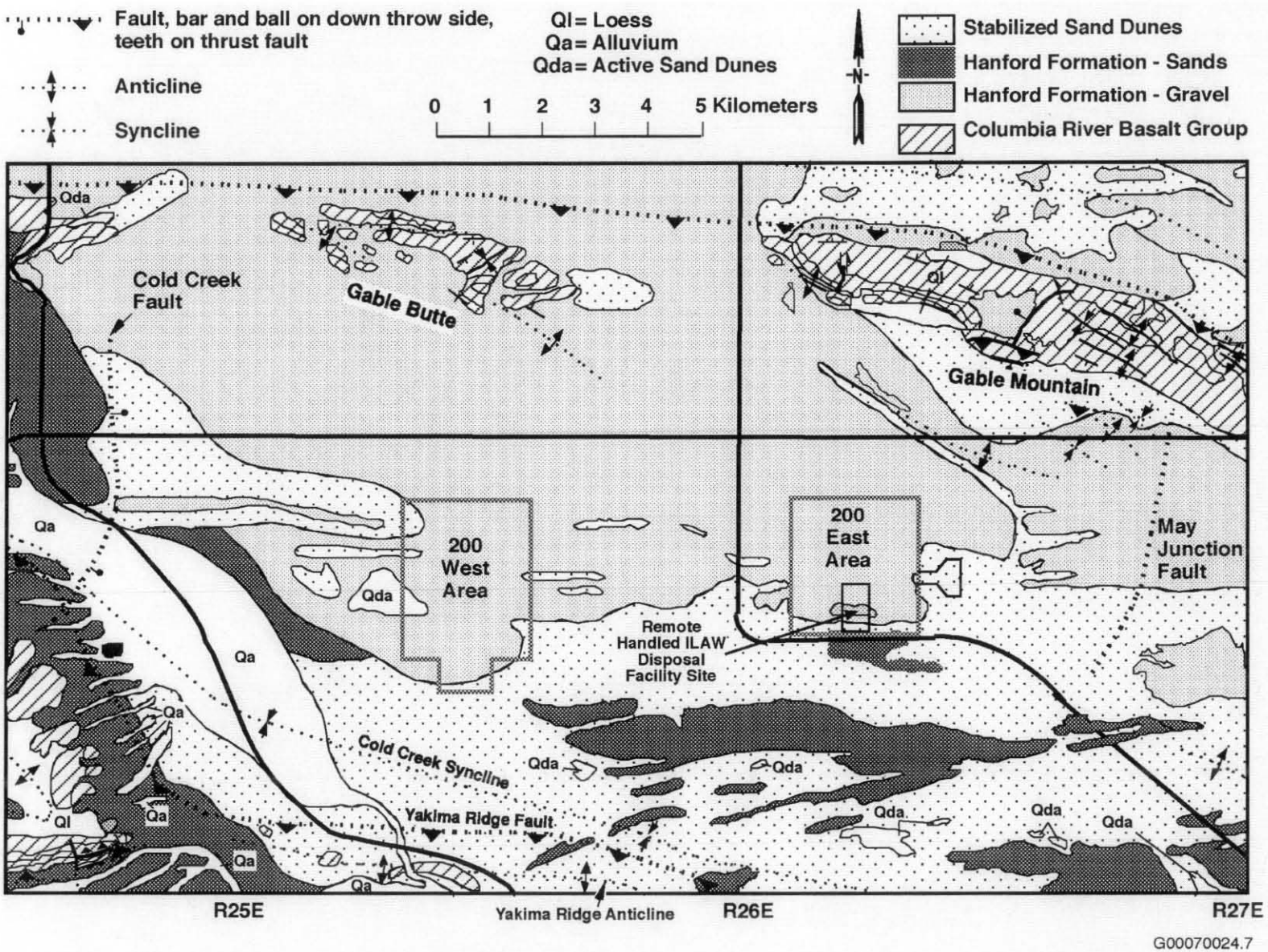


Figure 2-5. Geologic Map of the 200 East and West Areas and Vicinity.

2.3.1.1 Ringold Formation

The Ringold Formation consists of fluvial and lacustrine sediments deposited by the ancestral Columbia and Clearwater-Salmon river systems between about 3.4 and 8.5 Ma. *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-Central Washington and North-Central Oregon* (Lindsey 1996) described the Ringold Formation in terms of three informal members: the member of Wooded Island, the member of Taylor Flat, and the member of Savage Island. Of these, only the member of Wooded Island is present beneath the 200 East Area.

The member of Wooded Island consists of five separate units dominated by fluvial gravels (conglomerate). The gravels are designated (from bottom to top) as units A, B/D, C, and E. The gravel units are separated by fine-grained deposits typical of overbank and lacustrine environments. The lowermost of the fine-grained sequences is designated the lower mud unit. Only gravel units A and E are present beneath the 200 East Area and the Ringold Formation is entirely absent beneath the north and northeast parts of the 200 East Area (WHC-SD-EN-TI-012, *Geologic Setting of the 200 East Area: An Update*, and "Geohydrologic Setting of the Hanford Site, South-Central Washington" [Lindsey et al. 1994]).

Ringold Formation conglomerate is a variably indurated clast- and matrix-supported, pebble to cobble gravel with a fine- to coarse-sand matrix (Lindsey 1996). The most common lithologies are basalt, quartzite, and intermediate to felsic volcanics. Interbedded lenses of silt and sand are common. Cemented zones within the gravels are discontinuous and of variable thickness. In outcrop, the gravels are massive, planar bedded, or cross bedded. Lying above the Ringold gravels are silts and sands of the upper Ringold, member of Taylor Flats, which is not present beneath the 200 East Area.

The Neocene-age Ringold Formation is composed of weakly to moderately consolidated and compacted fluvial coarse-grained gravels and sands as well as fine-grained muds associated with lacustrine and fluvial overbank environments. These strata record a history of alluvial-lacustrine sedimentation and pedogenic activity associated with the ancestral Columbia River system ("Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State – A Summary" [Fecht et al. 1987], Lindsey 1996; *Late Cenozoic Structure and Stratigraphy of South Central Washington* [Reidel et al. 1994]). Ringold Formation deposits overlie basalt and are overlain by late Pliocene- and Pleistocene-aged deposits (Cold Creek unit).

The Ringold Formation was deposited from braided stream channel systems of the Columbia and Salmon-Clearwater Rivers with the two rivers joining in the area of the present White Bluffs. The deposits at the Hanford Site represent an eastward shift of the Columbia River from the west side of the Site to its present location. The Columbia River first flowed across the west side of the Site and up Dry Creek, crossing over the Rattlesnake Hills at Sunnyside Gap. Later the river shifted to a course that took it through Gable Gap and south across the present 200 East Area and the IDF site.

2.3.1.2 Cold Creek Unit. The Cold Creek unit occurs only in the north central part of the 200 East Area (HNF-5507, *Subsurface Conditions Description of the B-BX-BY Waste Management Area*). There, the Cold Creek unit consists of Columbia and Salmon-Clearwater

River mainstream facies and a silt facies. The mainstream facies is difficult to distinguish from the underlying conglomerates of the Ringold Formation and the overlying Hanford formation flood gravels, especially where it is in contact with those formations, because it shares similar characteristics with both. Generally, the mainstream facies of the Cold Creek unit consists of largely nonbasaltic gravel clasts and felsic sand matrix (characteristics shared with the Ringold Formation gravels). The Cold Creek mainstream facies is loose, unconsolidated, transmissive, and unweathered in nature (characteristics shared with the Hanford formation gravels). The Cold Creek unit has not been identified in the southern part of the 200 East Area in the location of the IDF site.

2.3.1.3 Hanford Formation

The Hanford formation is the informal name for the deposits of the cataclysmic floods of the Pleistocene epoch (2 Ma to 13 ka). Glacial Lake Missoula formed in the Clark Fork River Valley behind continental glaciers that spread south as far as the present Columbia Plateau. Glacial Lake Missoula was impounded behind an ice dam that may have given way as many as 40 times, allowing the impounded water to spread across eastern Washington and form the Channeled Scablands. These flood waters collected in the Pasco Basin and formed Lake Lewis, which slowly drained through the small water gap in the Horse Heaven Hills called Wallula Gap. Evidence has been found for at least four major cataclysmic flood sequences in and around the Hanford Site.

The Hanford formation consists of pebble to boulder gravel, fine- to coarse-grained sand, and silt to clayey silt. These deposits are divided into three facies: gravel-dominated facies, sand-dominated facies, and silt-dominated facies (WHC-MR-0391, *Field Trip Guide to the Hanford Site*; WHC-SD-EN-TI-012; and Lindsey et al. 1994). These facies are referred to as coarse-grained deposits, plane-laminated sand facies, and rhymite facies, respectively, in "Quaternary Geology of the Columbia Plateau," (Baker et al. 1987) and RHO-BW-SA-563A, *Quaternary Stratigraphy of the Pasco Basin Area, South-Central Washington*. The Hanford formation is present throughout the Hanford Site and is up to 65 m thick in places (WHC-SD-ER-TI-0003, *Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports*).

- **Gravel-Dominated Facies.** This facies generally consists of very poorly sorted coarse-grained basaltic sand and granule to boulder gravel. These deposits display an open framework texture, massive bedding, plane to low-angle bedding, and large-scale planar cross bedding in outcrop. Comparatively thin, fining-upward sand and silt beds occur between some gravel beds. Gravel clasts are predominantly basalt with lesser amounts of Ringold Formation clasts, granite, quartzite, and gneiss (WHC-SD-EN-TI-012). The gravel-dominated facies was deposited by high-energy floodwaters in or immediately adjacent to the main cataclysmic flood channelways.

- **Sand-Dominated Facies.** This facies consists of fine- to coarse-grained sand and granule gravel. The sands typically have a high basalt content and are referred to commonly as black, gray, or salt-and-pepper sands (WHC-SD-EN-TI-012). Individual beds, ranging from about 1 m to several meters thick, typically contain pebble to granule gravel at their base and plane-laminated sand through the main

portion of the bed. The plane-laminated sand may grade upward into a thinner sequence of fine sand or silt at the top. The silt content of the sand varies, but where it is low, a well-sorted open framework texture is common. In outcrop, this facies commonly displays plane lamination and bedding and less commonly displays channel-fill sequences (WHC-SD-EN-TI-012). The sand-dominated facies was deposited adjacent to main flood channelways during the waning stages of flooding. This facies is transitional between the gravel-dominated facies and the silt-dominated facies.

- **Silt-Dominated Facies.** This facies consists of rhymically bedded, plane-laminated and ripple cross-laminated silt and fine- to coarse-grained sand. Beds are typically a few centimeters to several tens of centimeters thick and commonly display normally graded bedding (WHC-SD-EN-TI-012). Sediments of this facies were deposited under slackwater conditions along the margins of flooded valleys and in back-flooded areas (DOE/RW-0164).

2.3.1.4 Holocene Surficial Deposits

Holocene surficial deposits consisting of silt, sand, and gravel form a thin (<5 m [16-ft]) veneer across much of the Hanford Site. In the 200 West Area and the southern part of the 200 East Area, these deposits consist mainly of laterally discontinuous sheets of wind-blown silt and fine-grained sand.

2.3.2 Geology of the IDF Site

The IDF site lies in the south-central part of the 200 East Area. The geology and hydrology of this area have been the subject of several studies and reports (RHO-ST-23, *Geology of the Separation Areas Hanford Site, South Central Washington*; WHC-SD-EN-TI-012, Lindsey et al. 1994; Lindsey 1996; and PNNL-11957, *Immobilized Low-Activity Waste Site Borehole 299-E17-21*). Most recently, in PNNL-14586, *Geologic Data Package for 2005 Integrated Disposal Facility Waste Performance Assessment*, Reidel compiled existing geologic information from the area in support of the ILAW 2005 Performance Assessment.

The 200 East Area lies on the Cold Creek bar, a geomorphic remnant of the cataclysmic floods of the Pleistocene era. As the floodwaters raced across the lowlands of the Pasco Basin and Hanford Site, they lost energy and began leaving behind deposits of sand and gravel.
The 200 Area Plateau is one of the most prominent deposits. The plateau lies just south of one of the major channelways across the Hanford Site that form the topographic lowland south of Gable Mountain.

A geologic cross-section across the IDF site is shown in Figure 2-6. Borehole data provide the principal source of geologic, hydrologic, and groundwater information for the 200 East Area and the IDF site. Numerous boreholes (both vadose zone boreholes and groundwater monitoring wells) have been drilled in the 200 East Area for groundwater monitoring and waste management studies. Figure 2-7 shows the location of groundwater wells in the vicinity of the IDF site. However, data are limited within the IDF site primarily because no previous

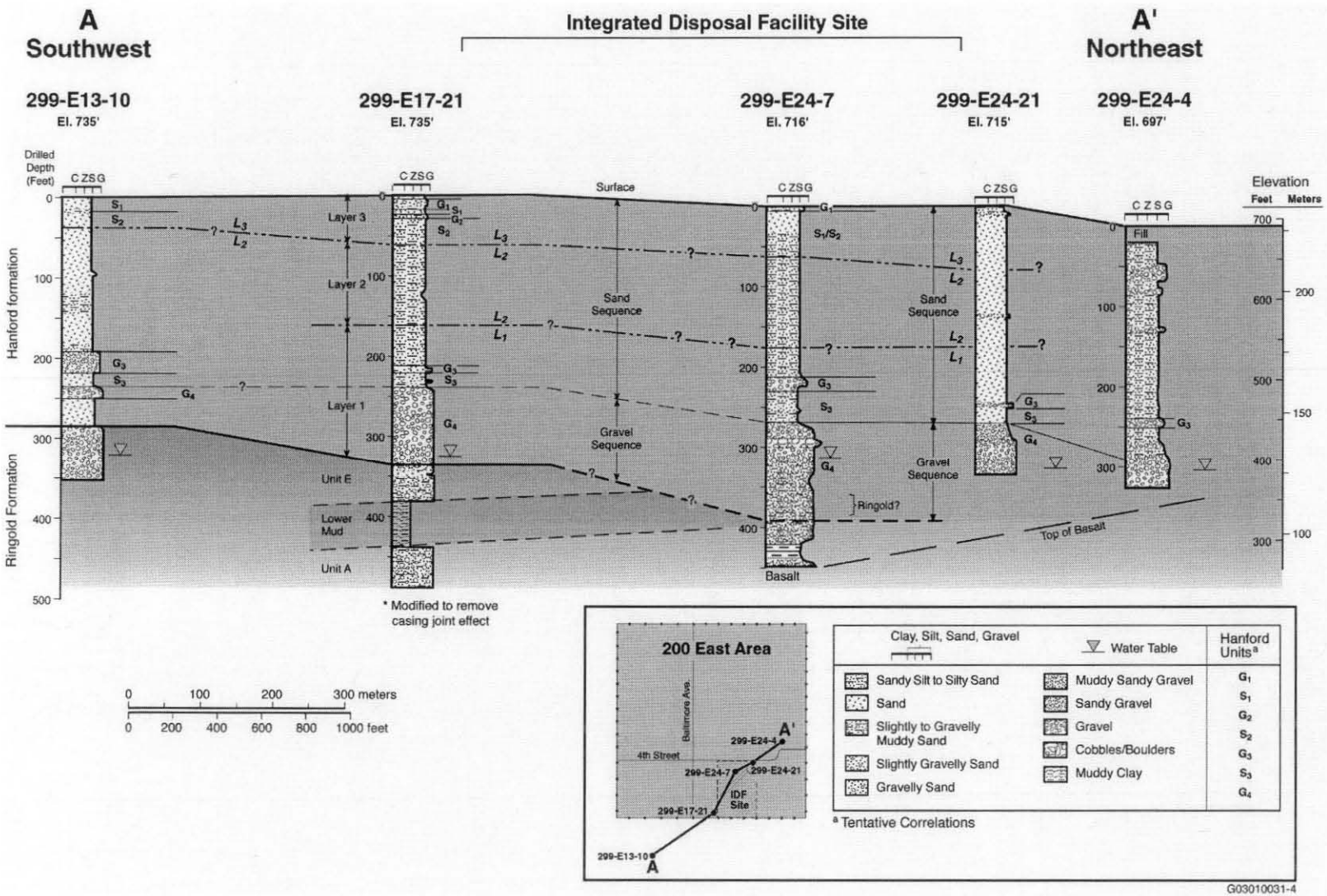
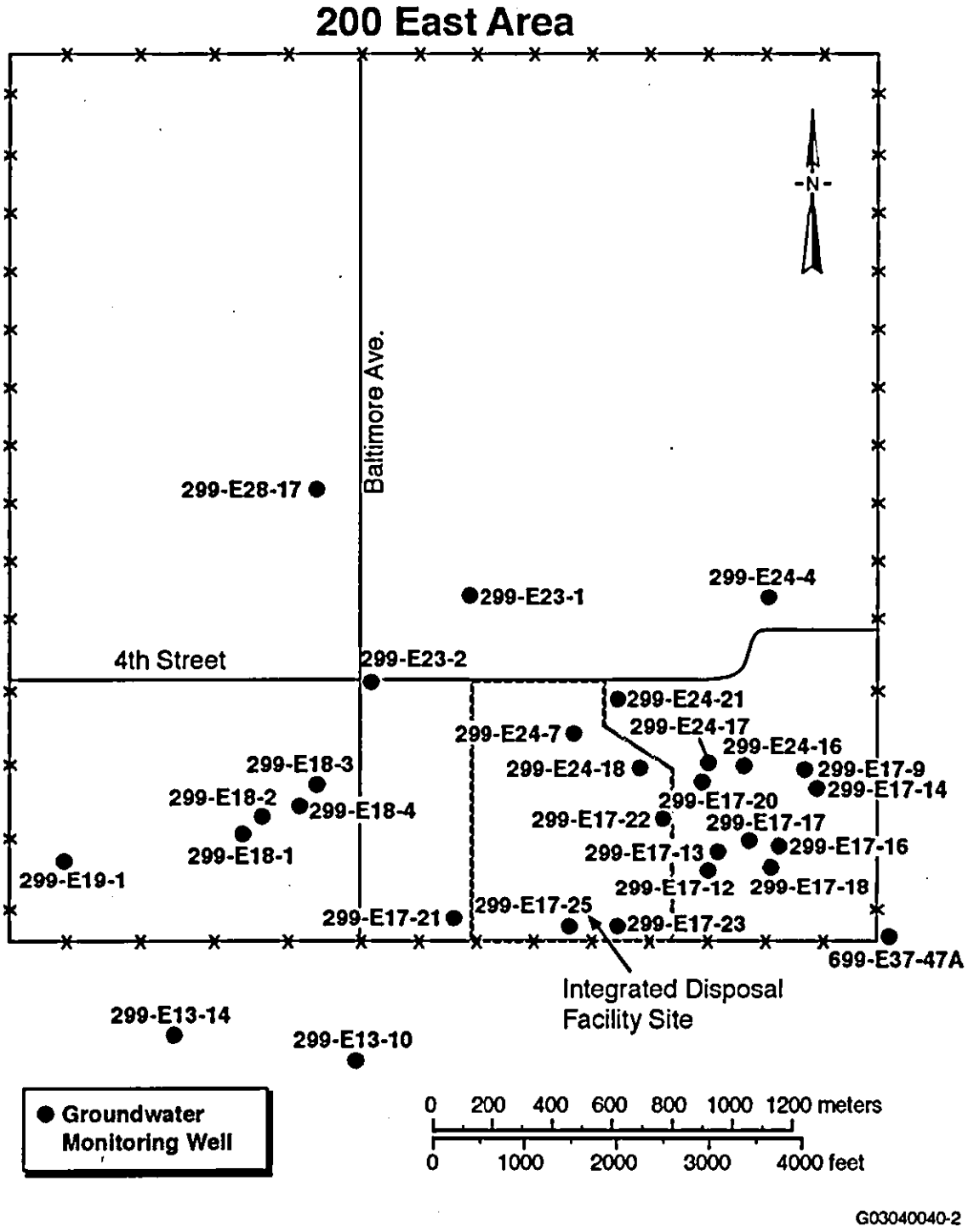


Figure 2-6. Cross Section Through the Integrated Disposal Facility Site and Vicinity. (See Figure 2-7 for Location of Cross Section.)

Figure 2-7. Location of Boreholes at and Near the Integrated Disposal Facility Site.



construction or waste disposal activities have occurred there. Although most boreholes in the 200 East Area were drilled using the cable-tool method and either a hard tool or drive barrel to advance the hole, some were drilled by rotary and wire-line coring methods. Geologic logs based on these boreholes are constructed by examining chips and cuttings, which limits information on all but the broadest of the stratigraphic units. Chip samples, typically taken at 1.5 m (5-ft) intervals, are routinely archived at the Hanford Geotechnical Sample Library.

Structural Framework. The IDF site is located south of the Gable Mountain segment of the Umtanum Ridge anticline and about 3 km (2 mi) north of the axis of the Cold Creek syncline (Figure 2-1), which controls the structural grain of the basalt bedrock and the Ringold Formation. The basalt surface and Ringold Formation trend roughly southeast-northwest parallel to the major geologic structures of the site. As a result, the Ringold Formation and the underlying CRBG dip gently to the south off the Umtanum Ridge anticline into the Cold Creek syncline. Geologic mapping at the Hanford Site and examination of borehole cuttings in the area have not identified any faults in the vicinity of the IDF site (DOE/RW-0164). The closest faults are along the Umtanum Ridge-Gable Mountain structure north of the site and the May Junction fault east of the site (Figure 2-5).

2.3.2.1 Stratigraphy

The post-basalt stratigraphy for the IDF site is shown in Figure 2-6. Approximately 137 m to 167 m (450 to 550 ft) of suprabasalt sediments overlie the basalt bedrock at the site.

Basalt Bedrock. Previous studies (RHO-BWI-ST-14, *Subsurface Geology of the Cold Creek Syncline*, "Wanapum and Saddle Mountains Basalts of the Cold Creek Syncline Area;" *Geologic Map of the Priest Rapids 1:100,000 Quadrangle, Washington* [Reidel and Fecht 1994a]; and *Geologic Map of the Richland 1:100,000 Quadrangle, Washington* [Reidel and Fecht 1994b]) have shown that the youngest lava flows of the CRBG at the 200 East Area are those of the 10.5-million-year-old Elephant Mountain Member. This member underlies the entire 200 East Area and surrounding area and forms the base of the suprabasalt aquifer. No erosional windows are known or suspected to occur in the area of the IDF site.

Ringold Formation. Few boreholes penetrate the entire Ringold Formation at the IDF site, so data are limited. The Ringold Formation reaches a maximum thickness of 95 m (285 ft) on the west side of the site and thins eastward. It consists of three units of Lindsey's (1996) member of Wooded Island. The member of Taylor Flat was identified in borehole 699-37-47A in the southeastern corner of the 200 East Area (PNNL-11515, *Borehole Data Package for Well 699-37-47A, PUREX Plant Cribs, FY 1996*), but is not present beneath the disposal site. The deepest unit encountered is the lower gravel, unit A. Lying above unit A is the lower mud and overlying the lower mud is an upper gravel, unit E. The upper Ringold (sand and silt of the member of Taylor Flat) is not present at the IDF site. Unit A and unit E are equivalent to mapping unit PLMcg, Pliocene-Miocene continental conglomerates, of Reidel and Fecht (1994a and 1994b). The lower mud is equivalent to mapping unit PLMc, Pliocene-Miocene continental sand, silt, and clay beds, of Reidel and Fecht (1994a and 1994b).

Only three boreholes penetrated unit A in the vicinity of the IDF site. Unit A is 19 m (61 ft) thick on the west side of the site and thins to the northeast. Unit A is a well-cemented sandy

gravel consisting of both felsic and basaltic clasts and is interpreted as Lindsey's (1996) fluvial gravel facies. Occasional yellow to white interbedded sand and silt with silt and clay lenses is evident. Green-colored, reduced-iron stain is present on some grains and pebbles. Although the entire unit appears to be cemented, the zone produced abundant high-quality water in borehole 299-E17-21 (PNNL-11957).

Nineteen meters (61 ft) of the lower mud were encountered in boreholes at the IDF site (PNNL-11957). The uppermost 1 m (3 ft) or so consists of a yellow sandy to silty mud. The silty mud grades downward into about 10 m (33 ft) of blue mud with zones of silt to slightly silty mud. The blue mud, in turn, grades down into 7 m (23 ft) of brown silty mud with organic-rich zones and occasional wood fragments. The lower mud is absent in the center of the site (boreholes 299-E23-1 and 299-E24-7 on Figure 2-7).

Unit E is described as a sandy gravel to gravelly sand. It is interpreted to consist of as much as 15 m (49 ft) of sandy gravel to gravely sand with scattered large pebbles and cobbles up to 25 cm (10 in.) in size. The gravel consists of both felsic and basaltic rocks, which are well rounded with a sand matrix supporting the cobbles and pebbles. Cementation of this unit ranges between slight and moderate. The upper contact of unit E is not easily identified at the IDF site. In the western part of the study area, unconsolidated gravels of the Hanford formation directly overlie the Ringold Formation unit E gravels, making exact placement difficult. The dominance of basalt in the Hanford formation and the absence of cementation are the key criteria used to distinguish the formations here (PNNL-11957). In the central and northeast part of the study area, unit E is interpreted as having been completely eroded. Unconsolidated gravels and sands typical of the Hanford formation replace them.

Member of Taylor Flat. The member of Taylor Flat is not present at the IDF site but has been identified in the southeast corner of the 200 East Area in borehole 699-37-47A (PNNL-11515). These sediments apparently pinch out before reaching the site.

Unconformity at the Top of the Ringold Formation. The surface of the Ringold Formation is irregular in the IDF site area. A northwest-southeast trending erosional channel, or trough, is centered along the northeast portion of the site. The trough is deepest near borehole 299-E24-7 in the northern part of the site. This trough is interpreted to be a small part of a much larger trough under the 200 East Area resulting from scouring by the Missoula floods (PNNL-12257, *Geologic Data Package for 2001 Immobilized Low-Activity Waste Performance Assessment*; PNNL-12261, *Revised Hydrology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*, and PNNL-14586).

Hanford Formation. The Hanford formation is as much as 116 m (381 ft) thick in and around the IDF site. It thickens in the erosional channel cut into the Ringold Formation and thins to the southwest along the margin of the trough. It may thin to the northeast of the trough, but this supposition is based on only one data point.

At the IDF site, the Hanford formation consists mainly of sand-dominated facies with lesser amounts of silt-dominated and gravel-dominated facies. Here the Hanford formation has been described as poorly sorted pebble to boulder gravel and fine- to coarse-grained sand, with lesser amounts of interstitial and interbedded silt and clay. In previous studies of the site, the Hanford

formation was described as consisting of three units: an upper and lower gravelly facies and a sandy facies between the two gravelly units. The upper gravel-dominated facies appears to be thin or absent in the immediate area of the IDF site (PNNL-12257 and PNNL-14586).

The lowermost 27 m (88 ft) of the Hanford formation encountered in borehole 299-E17-21 consists of the gravel-dominated facies. This was previously interpreted as a sandy gravel sequence based on geologic logs from the nearest wells. Drill core and cuttings from boreholes 299-E17-21, 299-E17-22, 299-E17-23, and 299-E24-21 indicate that the unit is clast-supported pebble to cobble gravel with minor amounts of sand in the matrix. The cobbles and pebbles are almost exclusively basalt with no cementation. In outcrop, these deposits display massive bedding, plane to low-angle bedding and large-scale planar cross-bedding, but such features typically cannot be observed in borehole cores. This unit pinches out west of the site and thickens to the northeast. It is interpreted to be Missoula Flood gravels deposited in the erosional channel carved into the underlying Ringold Formation.

The basal gravel sequence is equivalent to unit H3 of Lindsey et al. (1994) and may be equivalent to mapping unit Qfg_1, Missoula Outburst Flood gravel deposits, of Reidel and Fecht (1994a and 1994b). Those units are 720 ka and have a reversed magnetic polarity.

The upper portion of the Hanford formation consists of at least 73 m (240 ft) of fine- to coarse-grained sand with minor amounts of silt and clay and some gravelly sands. This sequence is equivalent to unit H2 of Lindsey et al. (1994), and may be equivalent to the following mapping units of Reidel and Fecht (1994a and 1994b): Qfs_1, Qfs_2, and Qfs_3, Missoula Outburst Flood deposits consisting of sand, silt, and clay.

Three paleosols (soils) were identified in core and drill cuttings from borehole 299-E17-21. These three horizons represent significant time intervals when soil development took place and are interpreted to be the tops of three Missoula flood deposits. PNNL-11957 identified the layers defined by the paleosols as follows: Layer 1 as that part of the Hanford formation extending from the paleosol horizon at 49 m (161 ft) to the top of the basalt gravel at 75 m (246 ft); Layer 2 extends from the top of the second paleosol horizon at 18 m (59 ft) to the top of the first paleosol at 49 m (161 ft); and Layer 3 extends from the top of the third paleosol horizon at 1.5 m (5-ft) depth to the second paleosol horizon at 18 m (59 ft).

Layer 1 is 26 m (85 ft) thick in the southwest corner of the IDF site. A zone of sand and silt cemented by calcium carbonate ($CaCO_3$), forming a poorly developed caliche layer, marks the paleosol. Only the upper several inches are well cemented, but cementing and $CaCO_3$ extend to a depth of about 3.3 m (10 ft) below the top. $CaCO_3$, as fragments and grain coatings, occurs to a depth of at least 66 m (217 ft).

The lower 6 m (20 ft) of Layer 1 consist of interbedded sands and gravels. The basal gravel sequence underlying Layer 1 appears to grade upward into a sequence of interbedded sands and gravels. At least three upward fining zones of gravels to sands occur in Layer 1. These zones are equivalent to unit H2A of Lindsey et al. (1994).

Planar-laminar sands with minor silt lenses dominate the upper 16 m (52 ft) of Layer 1. This sequence consists of fining upward sands, well-compacted, slightly $CaCO_3$-cemented sands,

and well-laminated sands. As noted earlier, $CaCO_3$ associated with development of the paleosol extends well down into this layer.

Layer 1 is part of unit H2 defined in Lindsey et al. (1994), and may be equivalent to mapping unit Qfs_1 defined in Reidel and Fecht (1994a and 1994b). Mapping unit Qfs_1 is Missoula Outburst Flood deposits that are 720 ka and have reversed magnetic polarity. Layer 1 has been identified in the region of the study area only in borehole 299-E17-21. Either data from surrounding boreholes are of too poor quality to identify this layer or the layer is not present.

The upper 27 m (89 ft) of Layer 2 is principally fine- to medium-grained sand with minor amounts of interstitial silt. Flakes of $CaCO_3$ and $CaCO_3$-cemented sand grains are disseminated throughout the sands. Several fining-upward zones occur along with well-compacted zones of sand and silt with faint laminations. In addition, the paleosol that forms the top of this layer appears to be responsible for lateral spreading of contaminants under waste disposal sites to the east of the IDF site.

Layer 2 also is part of unit H2 defined in Lindsey et al. (1994), and is equivalent to mapping unit Qfs_2 defined in Reidel and Fecht (1994a and 1994b). Layer 2 consists of the Missoula Outburst Flood deposits that are older than 13 ka and younger than 720 ka. Mapping unit Qfs_2 has a normal magnetic polarity.

Layer 3 is 16 m (53 ft) thick in the southwest part of the IDF site. The paleosol is a 0.3 m (1.1-ft) thick, oxidized and leached zone of fine-grained sand and silt with some pebbles with a 10 cm (4-in.) caliche zone (sand and silt cemented by $CaCO_3$). Several distinct gravelly sands are present within several feet of the paleosol at the top of this layer.

The lower 8 m to 10 m (25 to 30 ft) of Layer 3 consist principally of sand with interstitial silt and minor silt lenses. Several minor silt lenses are locally present but are discontinuous. Gravely sand marks a transition to finer grained sand with more silt at a depth of approximately 8 m (25 ft).

Layer 3 is interpreted to consist of the upper gravelly sequence and the upper part of the sandy sequence defined in previous studies. It is part of unit H2 defined in Lindsey et al. (1994) and is equivalent to mapping unit Qfs_3 defined in Reidel and Fecht (1994a and 1994b). Qfs_3 is Missoula Outburst Flood deposits consisting of sand, silt, and clay that are about 13 ka or younger. An ash layer from the 13 ka eruption of Mt. St. Helens (Set S Ash) typically is found near the top of this unit in many places throughout the Pasco Basin. The ash has not been recognized in any of the boreholes near the IDF site.

Holocene Deposits. Holocene, eolian deposits cover the southern part of the IDF site. The southern part of the site is capped by a stabilized sand dune. The eolian unit is composed of fine- to coarse-grained sands with abundant silt, as layers and as material mixed with the sand. The caliche coating on the bottom of pebbles and cobbles in drill core through this unit is typical of Holocene caliche development in the Columbia Basin. This unit is equivalent to mapping unit Qd, Holocene Dune Sand, defined in Reidel and Fecht (1994a and 1994b).

Clastic Dikes. Clastic dikes have not been observed at the IDF site. However, they have been observed in excavations surrounding the site (e.g., US Ecology, the former grout area, the

BC cribs area, the Central Landfill, and the Environmental Restoration Disposal Facility [BHI-01103, *Clastic Injection Dikes of the Pasco Basin and Vicinity*]). In undisturbed areas, such as the IDF site, clastic dikes typically are not observed because they are covered by wind-blown sediments. The common occurrence of clastic dikes in the surrounding areas suggests that they probably are present in the subsurface at the site.

2.4 HYDROGEOLOGY

Hanford Site hydrogeology is discussed in several studies (RHO-BWI-ST-5, *Hydrologic Studies Within the Columbia Plateau, Washington: An Integration of Current Knowledge*; RHO-ST-42, *Hydrology of the Separations Area*; DOE/RL-93-88, *An Assessment of Aquifer Intercommunication in the B-Pond - Gable Mountain Area of the Hanford Site Facilities for 1993*; DOE/RW-0164; WHC-SD-ER-TI-0003; and PNNL-13080, *Hanford Site Groundwater Monitoring: Setting, Sources and Methods*). The water table beneath the Hanford Site and surrounding area is shown in Figure 2-8. The following sections summarize Hanford Site hydrogeology.

2.4.1 Hanford Site Hydrogeologic Setting

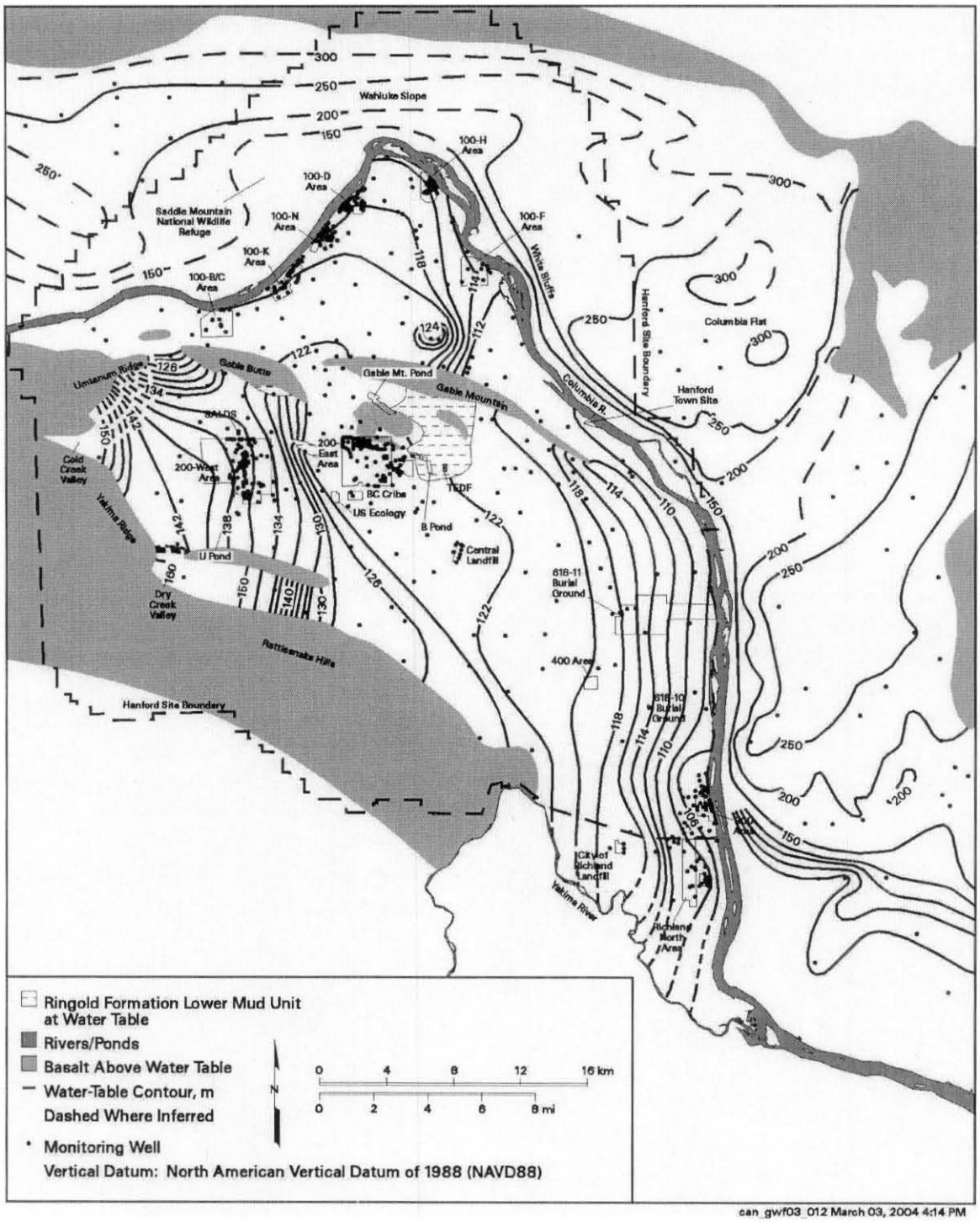
Primary surface-water features associated with the Hanford Site are the Columbia River and its major tributaries, the Yakima and Snake Rivers. West Lake, about 4 ha (10 acres) in size and less than 1 m (3 ft) deep, is the only natural lake within the Hanford Site (DOE/RW-0164). Wastewater ponds, cribs, and ditches associated with nuclear fuel processing and waste disposal activities are numerous, but are no longer used.

Recharge rates are suggested to range from near 0 to more than 100 mm/yr (4 in./yr), depending on surface conditions (PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*. Low recharge rates occur in fine-textured sediments where deep-rooted plants grow. The larger values are interpreted to occur in areas covered by coarse gravel with no vegetation, such as disturbed areas in the tank farms.

Approximately one-third of the Hanford Site is drained by the Yakima River system. Cold Creek and its tributary, Dry Creek, are ephemeral streams in the Yakima River drainage system. Both streams drain areas along the western part of the Yakima River. Surface flow in Cold Creek and Dry Creek, which may occur during spring runoff or after heavier-than-normal precipitation, infiltrates and disappears into the surface sediments.

The hydrogeology of the Pasco Basin is characterized by a multiaquifer system consisting of four hydrogeologic units that correspond to the upper three formations of the CRBG and the sediments overlying the basalts. The basalt aquifers consist of the CRBG flood basalts and relatively minor amounts of intercalated fluvial and volcaniclastic sediments of the Ellensburg Formation. Confined zones in the basalt aquifers are present in the sedimentary interbeds and/or interflow zones that occur between dense basalt flows. The main water-bearing portions of the interflow zones are networks of interconnecting vesicles and fractures of the flow tops and flow bottoms (DOE/RW-0164).

Figure 2-8. Hanford Site and Outlying Areas Water Table Map, 2003
(from PNNL-13116, *Hanford Site Groundwater Monitoring for Fiscal Year 1999).*



The suprabasalt aquifers are the uppermost regionally extensive aquifers beneath the Hanford Site. Groundwater within this aquifer system is contained within the glaciofluvial sands and gravels of the Hanford formation and the fluvial-lacustrine sediments of the Ringold Formation. The base of the unconfined aquifer generally is regarded as the basalt surface and, where this is the case, the suprabasalt aquifer consists entirely of the uppermost unconfined aquifer. Where the Ringold Formation is present in the suprabasalt aquifer, the silt and clay horizon of the formation's hydrogeologic unit 8 (lower mud unit) forms a confining layer that separates the suprabasalt aquifer into the uppermost unconfined aquifer and the underlying Ringold confined aquifer.

2.4.2 Uppermost Aquifer System

The uppermost aquifer system is unconfined regionally beneath the Hanford Site and lies at depths ranging from less than 0.3 m (1 ft) below ground surface near West Lake and the Columbia and Yakima Rivers to greater than 107 m (350 ft) in the central portion of the Cold Creek syncline. Groundwater in the aquifer system occurs within the glaciofluvial sands and gravels of the Hanford formation and the fluvial/lacustrine sediments of the Ringold Formation.

A water table contour map of the uppermost aquifer for the Hanford Site is shown in Figure 2-8. The position of the water table in the western portion of the Site generally is within Ringold unit E gravels. The water table in the eastern portion of the Site generally is within the Hanford formation. Hydraulic conductivities for the glaciofluvial Hanford formation (601 m/day to 3048 m/day [2,000 to 10,000 ft/day]) are much greater than those of the poorly sorted, frequently cemented, gravel facies of the Ringold Formation (186 m/day to 930 m/day [610 to 3,050 ft/day]) (RHO-ST-42).

The base of the uppermost aquifer system is defined as the top of the uppermost basalt flow. However, fine-grained paleosols, overbank, and lacustrine deposits in the Ringold Formation locally form confining layers in Ringold fluvial gravels underlying gravel unit E. The uppermost aquifer system is bounded laterally by anticlinal basalt ridges.

Sources of natural recharge to the uppermost aquifer system are rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia Rivers. Discharge from the uppermost aquifer is primarily to the Columbia River (RHO-ST-42 and DOE/RW-0164).

In the past, artificial recharge to the uppermost aquifer occurred principally from Hanford Site contractors' wastewater disposal practices at surface facilities within the 200 East and 200 West Areas. Two large recharge mounds developed beneath the 200 West and 200 East Areas at U Pond and B Pond, respectively. Under U Pond, which was decommissioned in 1985, the water table had risen more than 26 m (85 ft) after 40 years of operation. The mound under B Pond had risen more than 9 m (30 ft) (RHO-ST-42). These facilities were associated with wastewater disposal from fuel- and waste-processing activities and had received treated liquid effluents of varying chemical characteristics. All nonpermitted liquid discharges ceased at the Hanford Site in 1995. With decreased discharges to the groundwater, the water table at these artificial mounds is returning to pre-Hanford Site-operations levels. Currently, liquid is

discharged to the ground surface only at the Treated Effluent Disposal Facility (TEDF) east of the 200 East Area and at the State-Approved Land Disposal System north of the 200 West Area.

2.4.3 Hydrogeology of the Integrated Disposal Facility Site

The unconfined aquifer under the IDF site occurs in the fluvial gravels of the Ringold Formation and flood deposits of the Hanford formation. The thickness of the aquifer ranges from about 70 m (230 ft) at the southwest corner of the site to about 30 m (100 ft) under the northeast corner of the site. The Elephant Mountain Member of the CRBG forms the base of the unconfined aquifer except in the southwestern-most part of the site where the Ringold Formation lower mud unit is present.

The unsaturated zone beneath the land surface at the IDF site is approximately 100 m (300 ft) thick and lies within the Hanford formation. The water level in borehole 299-E24-7, in the northeast part of the site, indicates that the water table is in the lower gravel sequence of the Hanford formation and at an elevation of approximately 122.8 m (400 ft) above sea level. This lies within the Columbia River/Missoula Flood channel. The water table is relatively flat beneath the IDF site. In the southwest corner of the site, the water table is at 121.9 m (403 ft) above sea level. Thus, there is less than 1 m (3.3 ft) of head across the site.

2.5 GROUNDWATER QUALITY

Plume maps for the major groundwater contaminants beneath the 200 East Area and the IDF site were discussed in WHC-SD-WM-PLN-109. The most current update of that information is in the 1999 annual groundwater monitoring report (PNNL-13116). The contaminants beneath the site include tritium, ^{129}I, and nitrate (Figure 2-9). Groundwater monitoring for the IDF will be conducted under a separate groundwater monitoring plan.

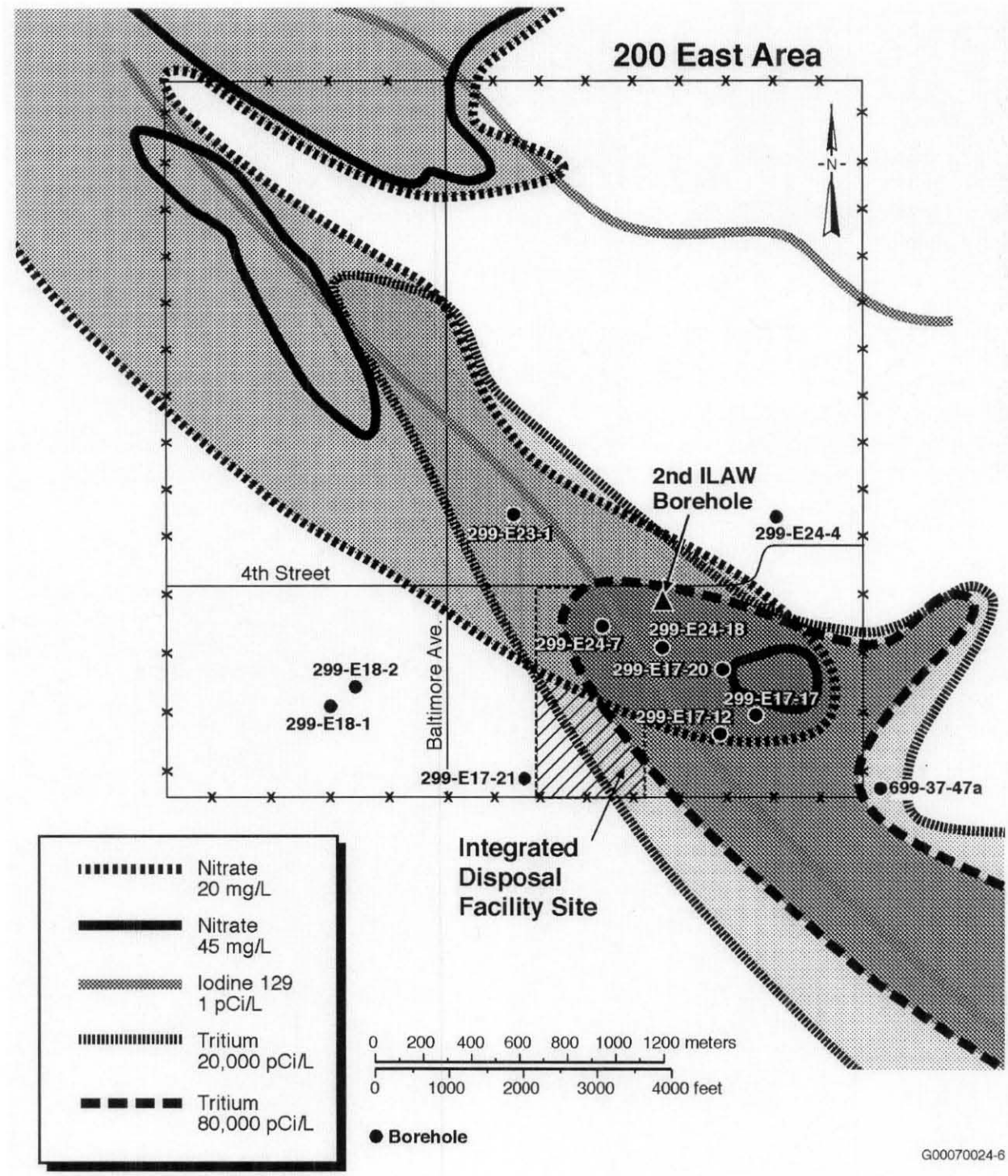
2.6 SOIL QUALITY

The Hanford Site contains 15 different soil types (BNWL-243, *Soil Survey - Hanford Project in Benton County, Washington*). The surface soils of the IDF site are sand to silty and sandy loam. The site does not contain any prime or unique agricultural land.

2.6.1 Surface Contamination

This section summarizes chemical and radionuclide contamination in the soils and vadose zone at the IDF site.

Figure 2-9. Contaminant Plume Map for the 200 East Area.



2.6.1.1 Chemicals

Because no major construction or waste disposal activities have occurred at the IDF site, little is known about the soil chemistry and soil contamination within the site. Also because no construction or waste disposal activities have occurred, the site is expected to be free of contamination and to resemble the general Hanford Site background in composition.

Background chemical data on organic and inorganic Hanford Site soil sites were determined in a survey done in 1994 and documented in DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*. Analyses were obtained from samples collected at 14 locations around the Hanford Site; four of these were around the periphery of the 200 East Area. That study found no volatile or semivolatile organic chemicals, pesticides, or polychlorinated biphenyls in any of the samples. However, none of the samples was specific to the IDF site.

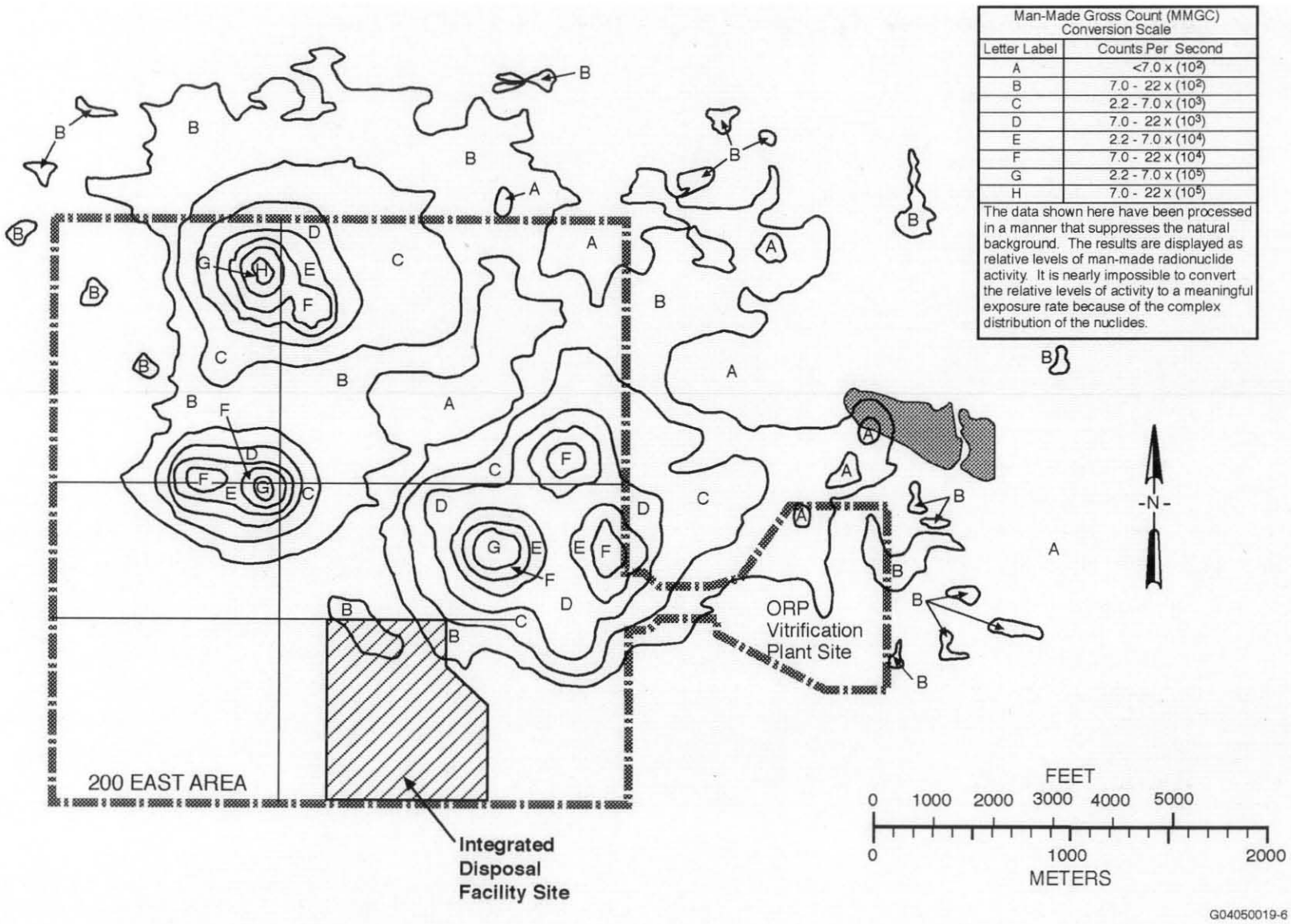
Chapter 4 and Appendix A1 of this plan describe the soil sampling survey for chemicals that will be done at the IDF site.

2.6.1.2 Radionuclides

Aerial radiological surveys (surface and near-surface gamma radiation) have been conducted at various times over the Hanford Site. The most recent gamma-ray survey (EGG-10617-1062, *An Aerial Radiological Survey of the Hanford Site and Surrounding Area Richland, Washington*) detected between 700 and 2,200 c/min in the northern part of the IDF site (Figure 2-10). The specific gamma emitter detected was probably ^{137}Cs, but may include some ^{60}Co as well.

From 1978 to 1987, the DOE's prime contractor at the Hanford Site monitored the soil at one 10 m^2 site near the center of the IDF site. The results for ^{137}Cs, ^{90}Sr, and ^{239}Pu are shown in Table 2-1. After 1988, the nearest soil sampling site to the IDF site was near the northeast corner of the 218-E-1 Burial Ground. Table 2-2 shows the results from the 1999 sampling and analysis from that site. Except for the 1980 value for ^{90}Sr, all analytical results are close to, but less than, the Hanford Site background radiation level (DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*).

Figure 2-10. Aerial Radiation Survey Conducted July-August 1988 (from EGG-10617-1062).



Man-Made Gross Count (MMGC) Conversion Scale	
Letter Label	Counts Per Second
A	<7.0 x (10^2)
B	7.0 - 22 x (10^2)
C	2.2 - 7.0 x (10^3)
D	7.0 - 22 x (10^3)
E	2.2 - 7.0 x (10^4)
F	7.0 - 22 x (10^4)
G	2.2 - 7.0 x (10^5)
H	7.0 - 22 x (10^5)

The data shown here have been processed in a manner that suppresses the natural background. The results are displayed as relative levels of man-made radionuclide activity. It is nearly impossible to convert the relative levels of activity to a meaningful exposure rate because of the complex distribution of the nuclides.

Table 2-1. Cesium-137, ^{90}Sr, and ^{239}Pu Concentrations in Soil at the Integrated Disposal Facility Site, 1978 through 1987 (pCi/g) (from WHC-EP-0145).

Date	^{137}Cs	^{90}Sr	$^{239/240}Pu$
1978	1.0 ± 0.12	0.28 ± 0.02	0.04 ± 0.018
1979	0.3 ± 0.053	0.32 ± 0.027	0.0071 ± 0.0036
1980	0.37 ± 0.063	12 ± 1.4	0.033 ±0.0073
1981	0.71 ± 0.094	0.26 ± 0.029	Not analyzed
1982	0.33 ± 0.06	0.18 ± 0.05	0.0097 ± 0.0037
1983	0.43 ± 0.064	0.73 ± 0.077	0.0076 ± 0.0019
1984	Not sampled	Not sampled	Not sampled
1985	0.94 ± 0.099	0.69 ± 0.13	0.031 ± 0.0041
1986	Not sampled	Not sampled	Not sampled
1987	0.60 ± 0.073	0.23 ± 0.058	0.021 ± 0.0026
Hanford Site Background[1]	2.04	0.364	0.0521

95/95 UCL based on log normal distributions given in DOE/RL-96-12, Rev. 0, Table 5.1.

DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Rev. 0.

WHC-EP-0145, *Westinghouse Hanford Company Environmental Surveillance Annual Report - 200/600 Areas, Calendar Year 1989*

UCL = upper confidence limit.

Table 2-2. Soil Sample Results from 1999 monitoring at the 218-E-1 Burial Ground (pCi/g) (from PNNL-13230).

Analyte	Result ± Error (%)	Hanford Site Background
^{134}Cs	0.024 + 33.0	Not available
^{137}Cs	0.51 + 13.0	2.04
^{234}U	0.2 + 38.0	1.44
^{238}U	0.25 + 37.0	1.39
$^{239/240}Pu$	0.025 + 77.0	0.0521
^{60}Co	Not detected	0.01222
^{90}Sr	Not detected	0.364
^{125}Sb	Not detected	Not available

95/95 UCL based on log normal distributions given in DOE/RL-96-12, Rev. 0, Table 5.1.

DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Rev. 0.

PNNL-13230, *Hanford Site Environmental Report for Calendar Year 1999.*

UCL = upper confidence limit.

The aerial survey was not sensitive enough to detect low-level spot contamination on the ground. Spot contamination can occur from deposition of feces and urine from predators that consume contaminated prey (e.g., rodents) captured outside the site. The spot contamination also can be caused by decomposition of contaminated tumbleweeds originating from upwind contaminated sites such as the BC cribs. Aerial deposition of radionuclides blown from waste sites or deposited during waste management activities also can result in localized surface contamination. Translocated contamination from plants will be less likely in the future because a security fence now surrounds the 200 East Area. Fence lines commonly collect tumbleweeds and are routinely checked with gamma survey instruments. The fence also may limit site access for predators or other large animals (deer or elk). Chapter 4 and Appendix A of this plan describe the soil sampling survey that will be done at the IDF site for radionuclides.

2.6.2 Vadose Zone Contamination

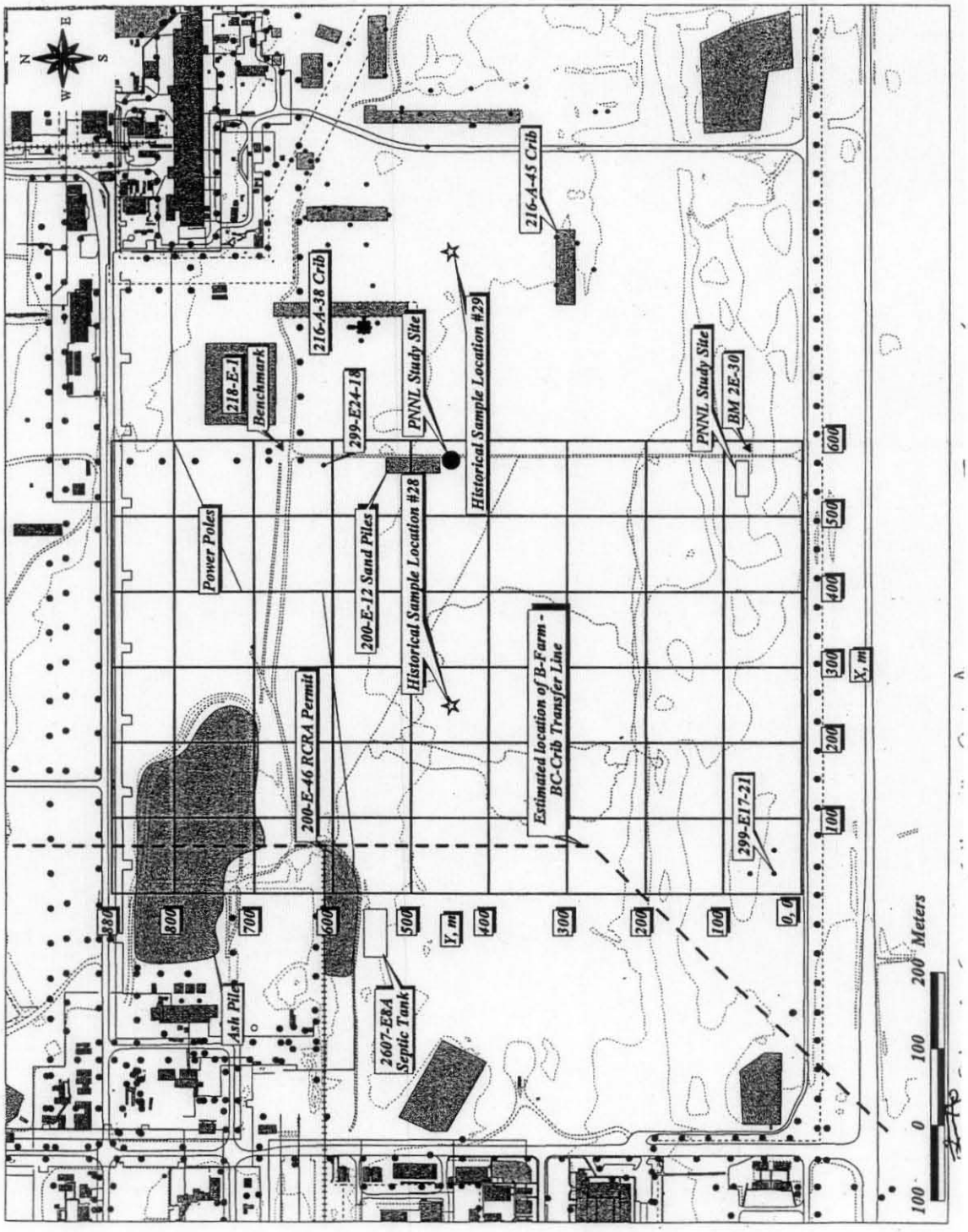
Four areas near the IDF site may have influenced the vadose zone beneath the study area. These are the 218-E-1 Burial Ground and an associated unplanned release, the coal ash pile in the northwest part of the site, past-practice liquid waste disposal facilities east of the site, and a transfer line along the northern part of the west boundary of the study site. (See Figure 2-11 for locations of nearby waste sites.)

The 218-E-1 Burial Ground is a dry waste burial ground located about 20 m (65 ft) east of the northern part of the study site. It consists of fifteen 60 m (200-ft)-long trenches ranging from 4.9 m to 6.1 m (16 to 20 ft) wide. During the burial ground's active period (between 1945 and 1953) it received about 3,030 m^3 (107,000 ft^3) of both mixed fusion products and transuranic dry waste (DOE/RL-92-04, *PUREX Source Aggregate Area Management Study Report*). In 1974, the trenches were filled with cinders from the 200 East Powerhouse then covered with gravel. In 1981 the surface was covered with clean overburden and revegetated. It is unlikely that the burial ground has affected the study site because of the dry nature of the buried waste, but samples were collected during drilling of groundwater monitoring well 299-E17-22, located between the burial ground and the study site, to ensure that no subsurface contamination has entered the site from the burial ground at a depth that will be encountered during excavation of the trenches. (See Chapter 4 and Appendix A.)

The 218-E-1 Burial Ground has one unplanned release, UPR-200-E-53. In 1978 up to 150 mR/hr of beta/gamma were measured during a burial operation when contamination was spread by uncovering previously buried waste (DOE/RL-92-04). This dry waste is extremely unlikely to have affected the vadose zone beneath the IDF site.

The 200 East Powerhouse ash pit and ash disposal pile are an inactive waste management unit in the northwestern part of the IDF site. The ash pits are located south of 4th Street and about 30 m (100 ft) east of the powerhouse. The ash pit received ash from the 200 East Area Powerhouse between 1943 and 1997 when the powerhouse ceased operation (DOE/RL-92-05, *B-Plant Source Aggregate Area Management Study Report*). Ash slurry was dried in the pit then placed on the ash disposal pile.

Figure 2-11. The 200 East Area Powerhouse Ash Disposal Pile, the BY Tank Farm-to-BC Controlled Area Transfer Line, and Past-Practice Waste Disposal Sites Near the Integrated Disposal Facility.



The ash pit is west of and outside the study site. The ash disposal pile occupies a position that would extend about 250 m (820 ft) inside the IDF fence in the northwest portion of the study site. The disposal pile is about 4 m (13 ft) high at the eastern end and slopes to about ground surface at about the western edge of the study site. In the performance assessment documented in PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*, Fayer and others obtained 10 shallow cores from the site for analyses of anions and metals. Their purpose was to identify any wind-blown contamination from the ash disposal pit. They did not find any evidence of contamination in the upper 10 cm (4 in.) of soil, but did find high sulfate (3 to 46 times greater than background) in the lowest 10 cm in 5 of the cores (depths between 94 cm and 170 cm [37 and 67 in.]). They did not analyze any of the remaining core material. They speculated that metals and anions from coal ash contamination may have been leached from the surface samples resulting in the high sulfate at depth.

A transfer line runs through the northwestern part of the IDF study area. The transfer line is clearly marked on the surface as an underground radiation area. DOE/RL-92-05 shows the transfer line on a map extending from the BY Tank Farm to the BC Controlled Area. However, DOE/RL-92-05 does not discuss the operational history of the line or what material it transported. The exact location of the transfer line is not known because it does not appear in the *Waste Information Data System* (WIDS) database. Any unplanned release of substantial volume from the transfer line could have affected the shallow vadose zone beneath the northwestern part of the study area. Chapter 4 and Appendix A describe tasks to characterize that portion of the transfer line and the area between the line and the IDF site.

In addition to the facilities described in the previous paragraphs, the 216-A38-1, 216-A-45, and 216-A-10 Cribs and injection well 299-E24-111 are located east of the study area. The 216-A-38-1 Crib was never used (DOE/RL-92-04). Injection well 299-E24-111 operated from September 1980 to February 1981 and received 3780 L (1,000 gal) of calcium chloride and calcium nitrate solutions spiked with ^{134}Cs and ^{90}Sr during infiltration experiments. The injection well never received any waste (DOE/RL-92-04).

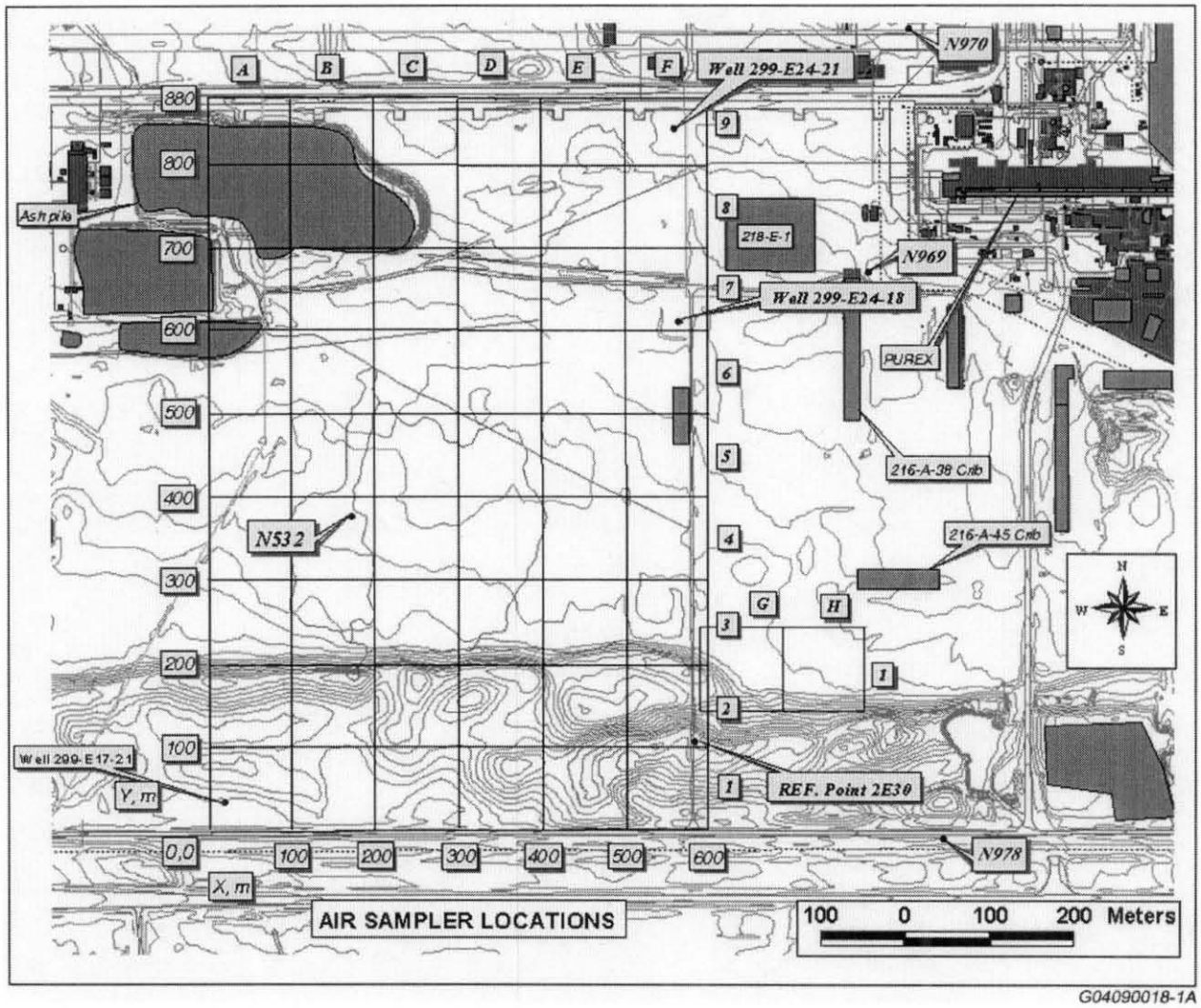
The closest past-practice liquid waste disposal facility to the study area is the 216-A-45 Crib, which is located about 150 m (490 ft) east of the study area. The 216-A-45 Crib received 103,000,000 L (27,000,000 gal) of process condensate from the 202-A Building between 1987 and 1989. Scintillation logs from the boreholes monitoring the crib were evaluated in 1993 (DOE/RL-92-04). The logs show elevated gamma-ray intensity from 12 m to the bottom of the boreholes at 46 m depths that is two to three times background levels. Because the crib is 150 m (490 ft) from the study site and because it was taken out of service in 1989, the vadose zone beneath the IDF site is unlikely to have been affected, especially at depths that will be encountered during excavation. A similar argument holds for the 216-A-10 Crib, which is located about 320 m (1,050 ft) east of the study site.

Although these cribs and burial ground are unlikely to have affected the vadose zone at the study site, Chapter 4 and Appendix A give a rationale to evaluate impacts from these facilities using samples collected during drilling of two groundwater monitoring wells located along the eastern border of the study site.

2.7 AIR QUALITY

In the 200 Areas ambient air is monitored to obtain baseline concentrations of radionuclides, to determine the impact of operations on the local environment, and to monitor diffuse emissions from sources in the separations area. Figure 2-12 indicates the location of three existing downwind air monitors (N969, N970 and N978) and one new air monitor (N532) that will be used during preoperational monitoring activities.

Figure 2-12. Map of the Proposed Locations of Air Samplers.



G04090018-1A

Average concentrations of airborne particulate radionuclides (exclusive of blowing vegetation such as tumbleweeds) measured from 1995 through 2002 on air filters near the IDF site are given in Table 2-3. Table 2-3 also shows the average concentrations from air monitoring stations at Toppenish and Yakima, two distant Washington State communities upwind of the Hanford Site. These results and results from other air monitors in the 200 Areas are far less than the DOE derived concentration guides (reference values used as indexes of performance) and below applicable DOE guidelines (HNF-EP-0573-6, *Hanford Site Near-Facility Environmental Monitoring Annual Report, Calendar Year 1997*, and PNNL-12088, *Hanford Site Environmental*

Report for Calendar Year 1998). Also, the onsite air monitoring station results are within the measurement uncertainties of the offsite monitoring results.

Table 2-3. Average (pCi/m^3) Particulate Radionuclide Concentration From Air Monitors Located Near the Integrated Disposal Facility, 1995 Through 2002.

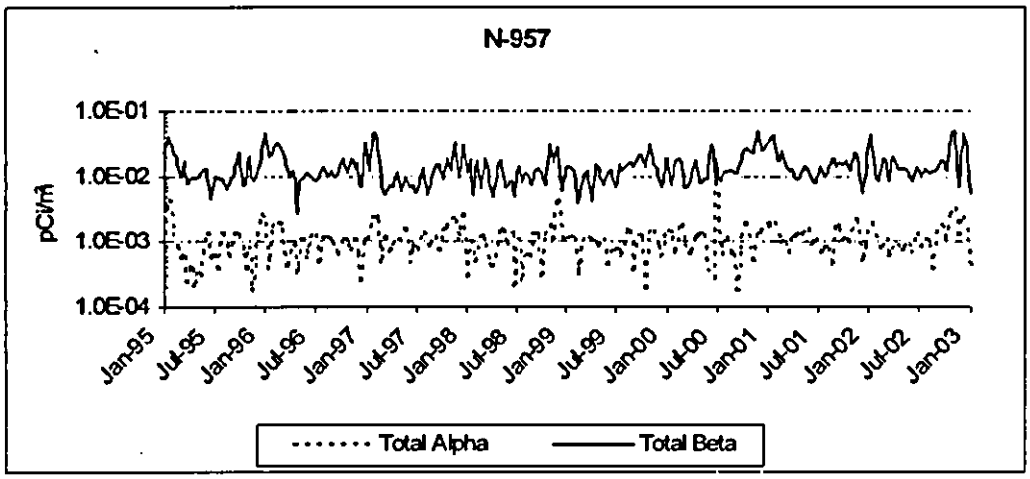
Air Sampler	Radionuclide	Number of Samples	Number of Detections	Average Result ± 2SD[a]	Maximum Result Uncertainty[b]	Distant Community Result ± 2SD	DCG[d]
N-957 (up wind)	Total alpha	210	174	1.1E-03 ± 1.6E-03	8.4E-03 ± 4.6E-03	5.7E-04 ± 1.0E-03	2.0E-02
	Total beta	210	210	1.5E-02 ± 1.8E-02	5.0 E-02 ± 4.6E-03	1.4E-02 ± 1.6E-02	9.0E+00
	^{90}Sr	16	7	7.0E-05 ± 2.0E-04	2.3E-04 ± 9.2E-05	1.6E-07 ± 8.8E-04	9.0E+00
	^{234}U	16	14	1.3E-05 ± 1.5E-05	3.3E-05 ±1.2E-05	1.7E-05 ± 1.7E-05	9.0E-02
	^{235}U	16	2	3.3E-06 ± 3.6E-06	6.7E-06 ± 5.8E-06	4.1E-07 ± 3.7E-06	1.0E-01
	^{238}U	16	13	1.2E-05 ± 1.5E-05	3.7E-05 ± 1.2E-05	1.6E-05 ± 1.5E-05	1.0E-01
	^{239,240}Pu	16	3	5.1E-06 ± 2.5E-05	5.3E-05 ± 1.6E-05	2.9E-07 ± 1.8E-06	2.0E-02
N-968 (up wind)	Total alpha	208	179	1.1E-03 ± 1.6E-03	5.7E-03 ± 1.8E-03	5.7E-04 ± 1.0E-03	2.0E-02
	Total beta	208	208	1.5E-02 ± 2.2E-02	7.4E-02 ± 7.6E-03	1.4E-02 ± 1.6E-02	9.0E+00
	^{90}Sr	16	10	1.7E-04 ± 3.8E-04	8.0E-04 ± 1.6E-04	1.6E-07 ± 8.8E-04	9.0E+00
	^{234}U	16	15	1.8E-05 ± 1.5E-05	3.2E-05 ±1.3E-05	1.7E-05 ± 1.7E-05	9.0E-02
	^{235}U	16	9	7.0E-06 ± 1.4E-05	2.2E-05 ± 1.0E-05	4.1E-07 ± 3.7E-06	1.0E-01
	^{238}U	16	15	1.5E-05 ± 1.4E-05	2.7E-05 ± 9.5E-06	1.6E-05 ± 1.5E-05	1.0E-01
	^{239,240}Pu	16	5	3.3E-06 ± 9.6E-06	1.9E-05 ± 9.4E-06	2.9E-07 ± 1.8E-06	2.0E-02
N-969 (down wind)	Total alpha	204	174	1.2E-03 ± 1.7E-03	7.1E-03 ± 2.6E-03	5.7E-04 ± 1.0E-03	2.0E-02
	Total beta	204	203	1.6E-02 ± 2.0E-02	5.6E-02 ± 3.4E-03	1.4E-02 ± 1.6E-02	9.0E+00
	^{90}Sr	16	8	1.7E-04 ±43.8E-04	1.0E-03 ± 2.5E-04	1.6E-07 ± 8.8E-04	9.0E+00
	^{234}U	16	15	1.5E-05 ± 1.5E-05	2.7E-05 ±1.2E-05	1.7E-05 ± 1.7E-05	9.0E-02
	^{235}U	16	7	4.8E-06 ± 8.9E-05	1.6E-05 ± 7.4E-06	4.1E-07 ± 3.7E-06	1.0E-01
	^{238}U	16	13	1.1E-05 ± 1.0E-05	1.9E-05 ± 7.4E-06	1.6E-05 ± 1.5E-05	1.0E-01
	^{239,240}Pu	16	3	3.1E-06 ± 5.1E-06	9.9E-06 ± 6.9E-06	2.9E-07 ± 1.8E-06	2.0E-02
N-970 (down wind)	Total alpha	209	177	1.2E-03 ± 3.6E-03	2.4E-02 ± 1.1E-02	5.7E-04 ± 1.0E-03	2.0E-02
	Total beta	209	203	1.8E-02 ± 6.8E-02	4.9E-01 ± 4.0E-02	1.4E-02 ± 1.6E-02	9.0E+00
	^{90}Sr	16	7	1.7E-04 ± 3.1E-04	5.8E-04 ± 1.4E-04	1.6E-07 ± 8.8E-04	9.0E+00
	^{234}U	16	13	1.4E-05 ± 1.6E-05	3.2E-05 ±1.3E-05	1.7E-05 ± 1.7E-05	9.0E-02
	^{235}U	16	8	5.8E-06 ± 1.1E-05	2.0E-05 ± 1.0E-05	4.1E-07 ± 3.7E-06	1.0E-01
	^{238}U	16	15	1.2E-05 ± 1.2E-05	2.8E-05 ± 1.1E-05	1.6E-05 ± 1.5E-05	1.0E-01
	^{239,240}Pu	16	7	5.7E-06 ± 1.4E-05	2.9E-05 ± 1.2E-05	2.9E-07 ± 1.8E-06	2.0E-02
N-978 (down wind)	Total alpha	206	179	1.2E-03 ± 1.7E-03	5.4E-03 ± 3.9E-03	5.7E-04 ± 1.0E-03	2.0E-02
	Total beta	206	205	1.5E-02 ± 2.2E-02	8.3E-02 ± 5.7E-03	1.4E-02 ± 1.6E-02	9.0E+00
	^{90}Sr	16	7	8.3E-05 ± 1.7E-04	2.3E-04 ± 1.1E-04	1.6E-07 ± 8.8E-04	9.0E+00
	^{234}U	16	14	1.4E-05 ± 1.3E-05	2.4E-05 ±1.2E-05	1.7E-05 ± 1.7E-05	9.0E-02
	^{235}U	16	7	4.8E-06 ± 8.4E-06	1.4E-05 ± 6.6E-06	4.1E-07 ± 3.7E-06	1.0E-01
	^{238}U	16	14	1.1E-05 ± 1.1E-05	2.0E-05 ± 7.6E-06	1.6E-05 ± 1.5E-05	1.0E-01
	^{239,240}Pu	16	6	3.4E-06 ± 1.1E-05	1.4E-05 ± 6.7E-06	2.9E-07 ± 1.8E-06	2.0E-02

[a]2SD = Two times the standard deviation.
[b]Overall analytical error.
Pacific Northwest National Laboratory air sampling locations in Yakima and Toppenish, averaged values 1997-2001 (PNNL-14295).
[d]DCG = U.S. Department of Energy derived concentration guide (air).

PNNL-14295, *Hanford Site Environmental Report for Calendar Year 2002.*

Figure 2-13 shows near-facility total alpha and total beta air sampling data collected upwind and downwind of the IDF. Figure 2-14 graphs the air sampling data collected for those radionuclides that were routinely detected or are of environmental concern.

Figure 2-13. Five-Year Summary of Total Alpha and Total Beta in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 1 of 2)



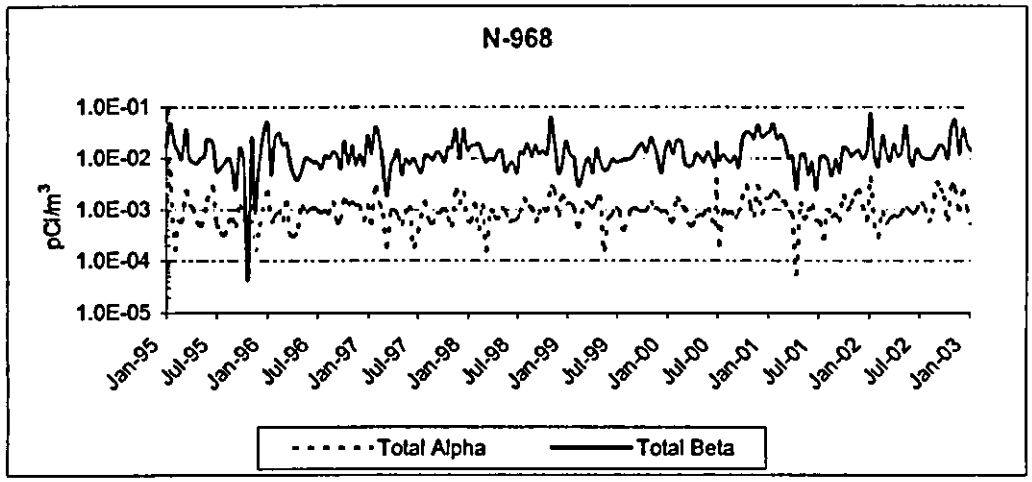
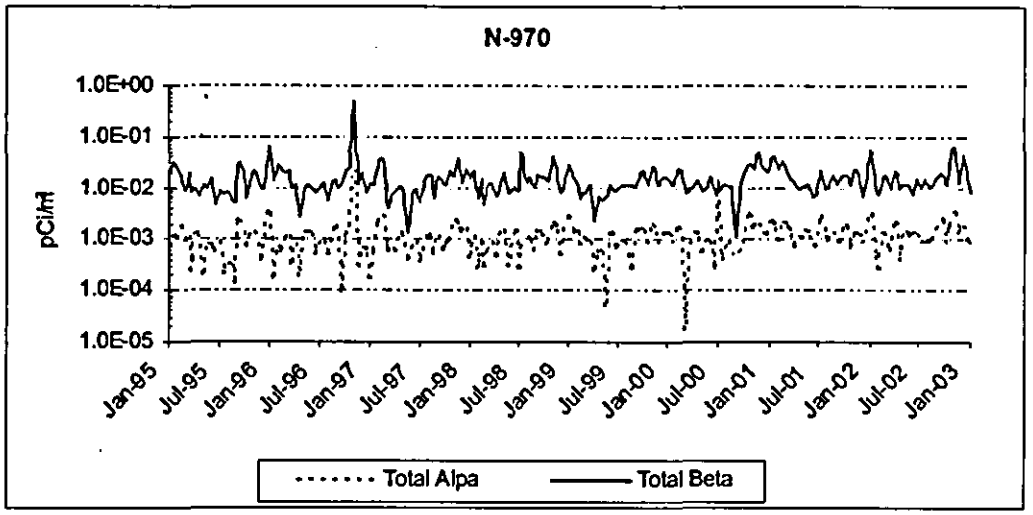
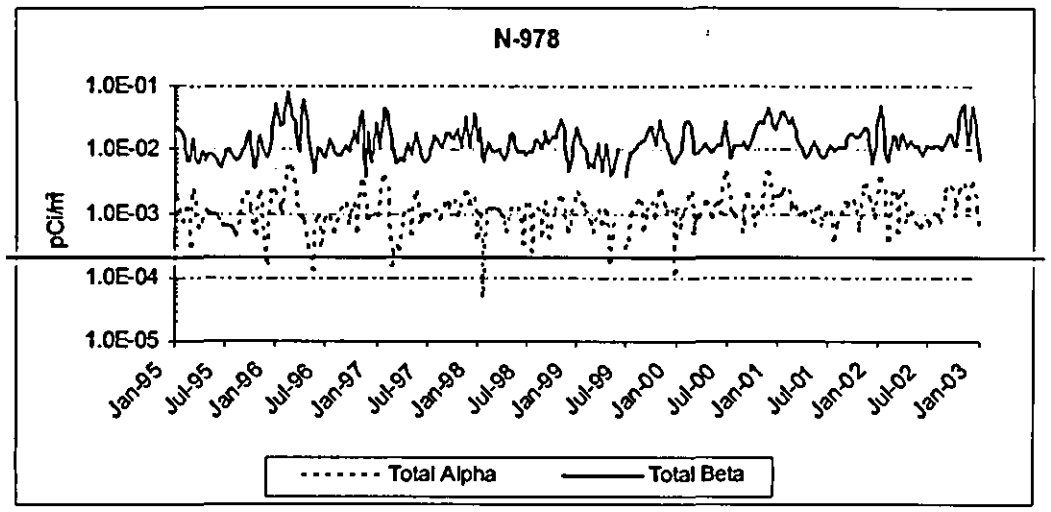


Figure 2-13. Five-Year Summary of Total Alpha and Total Beta in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 2 of 2)





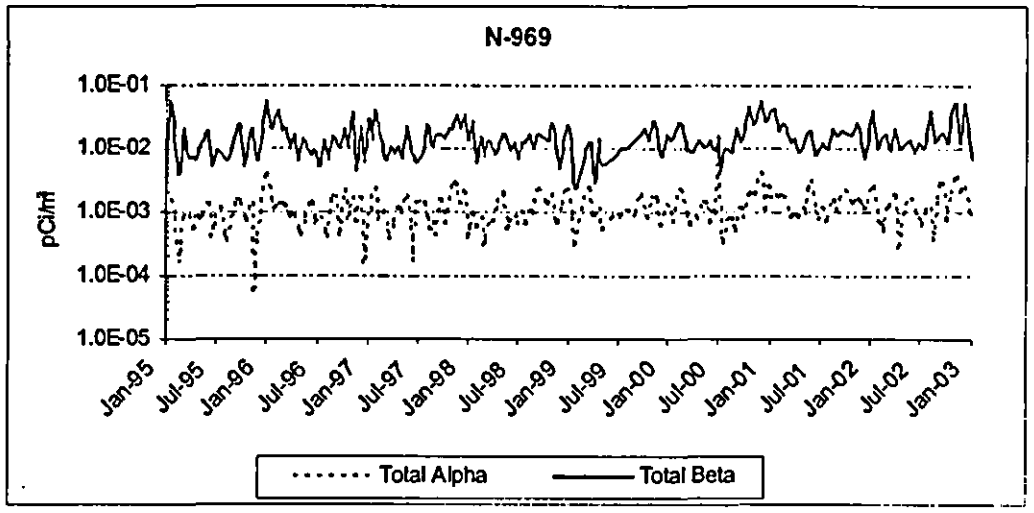


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 1 of 7)

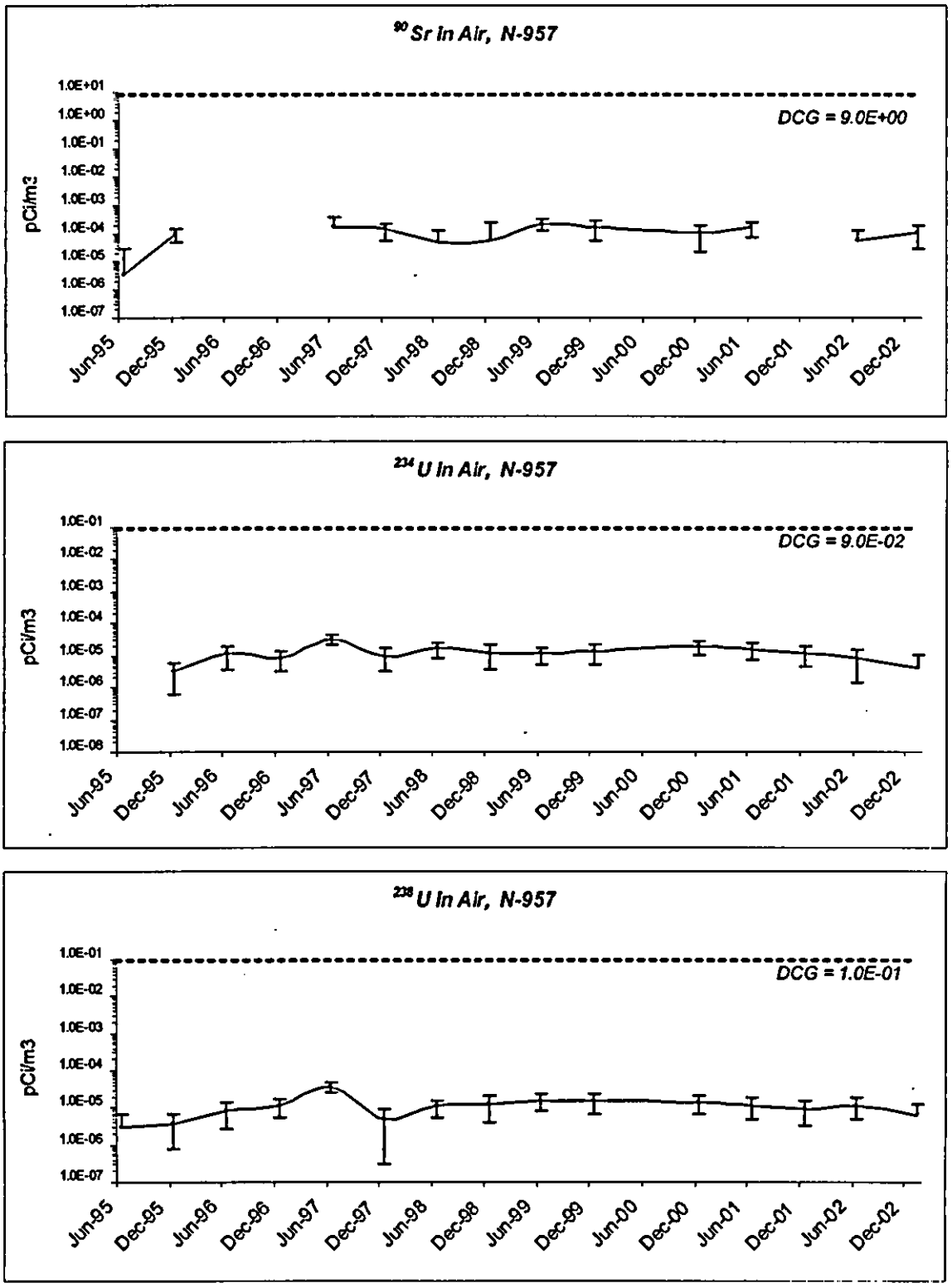
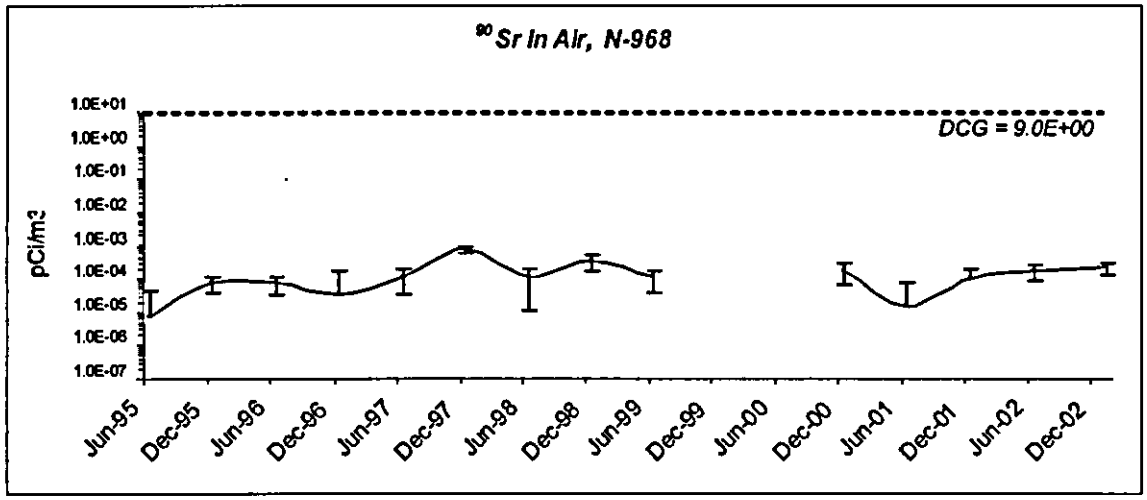
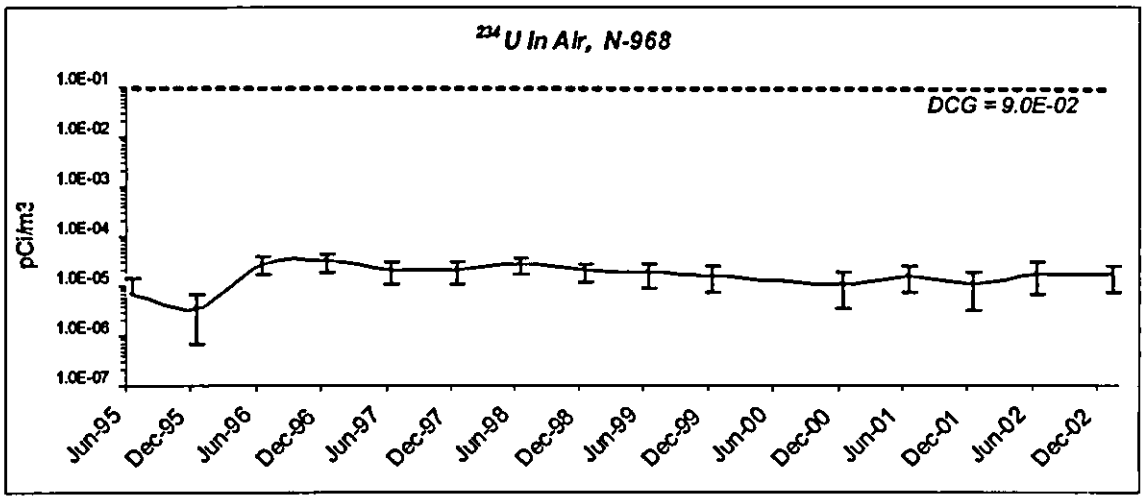


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 2 of 7)





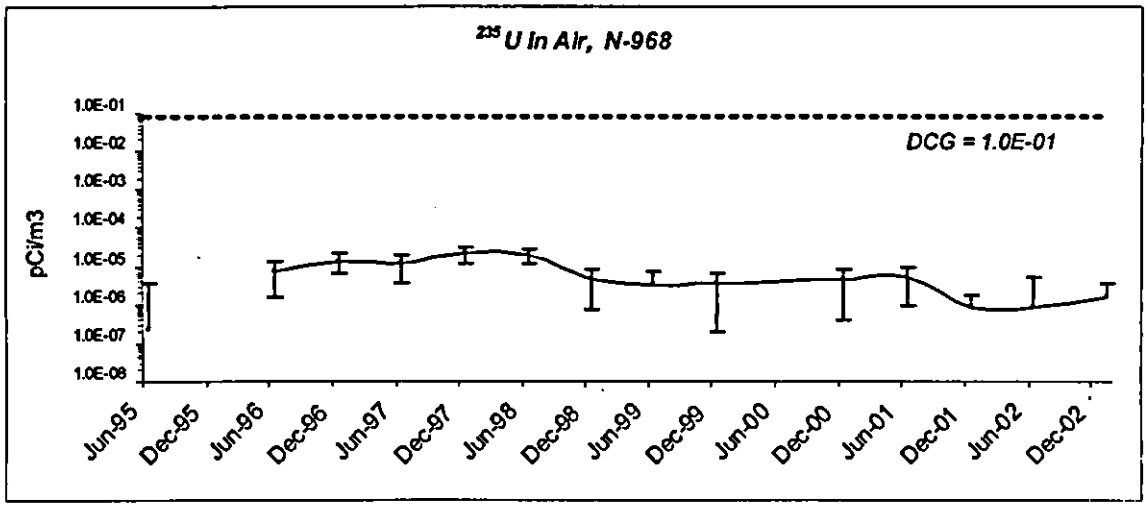


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 3 of 7)

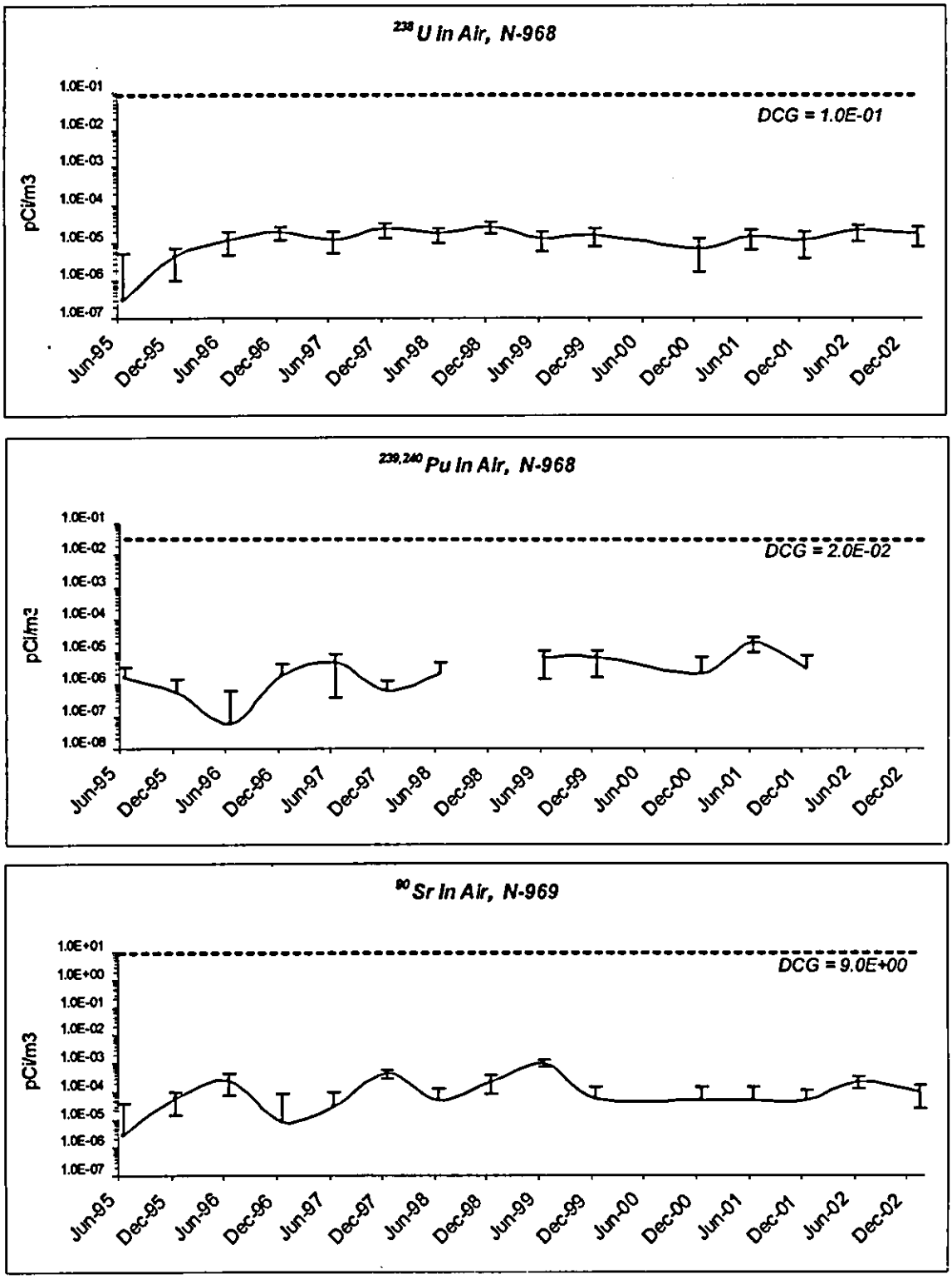


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 4 of 7)

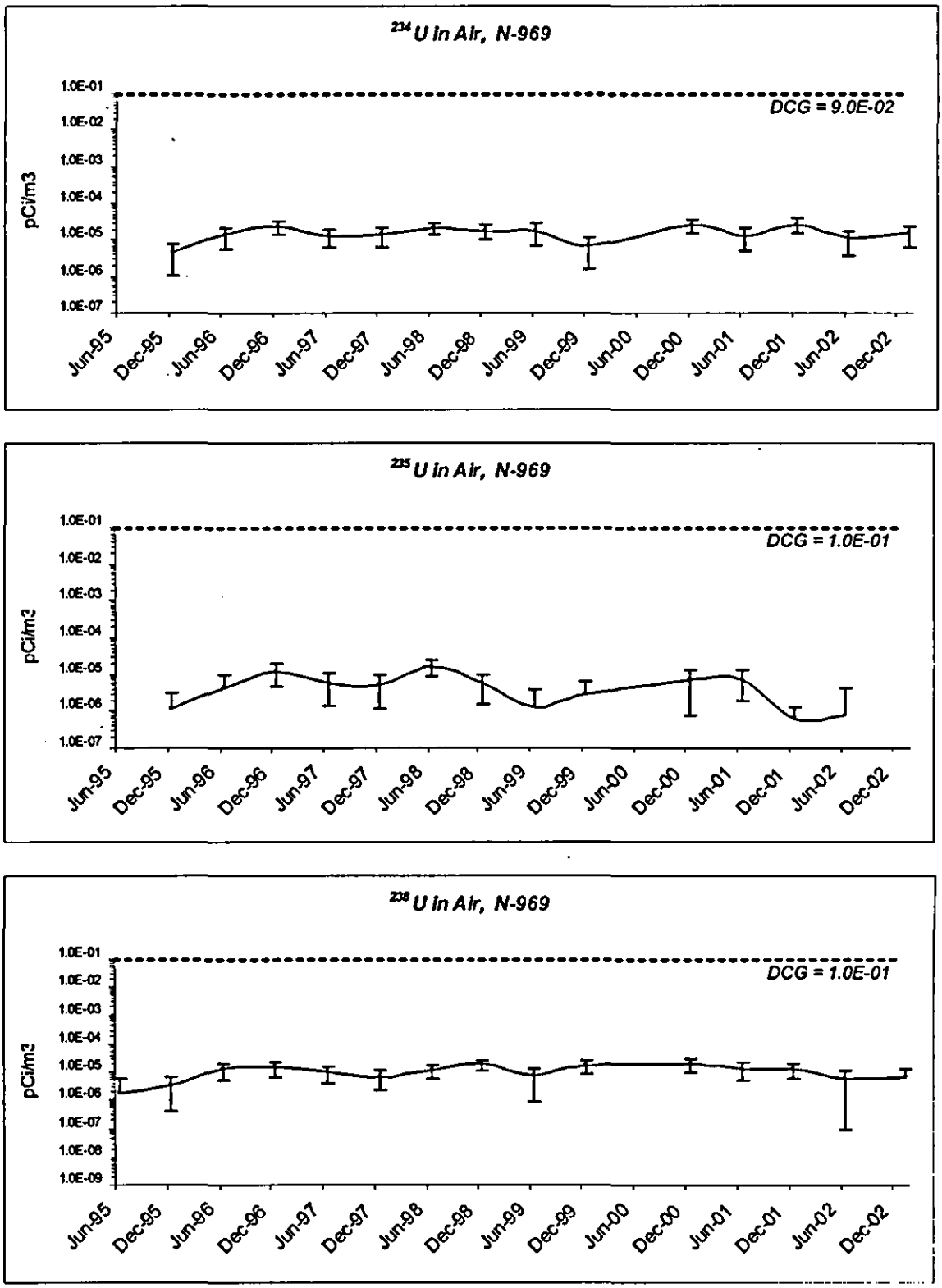


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 5 of 7)

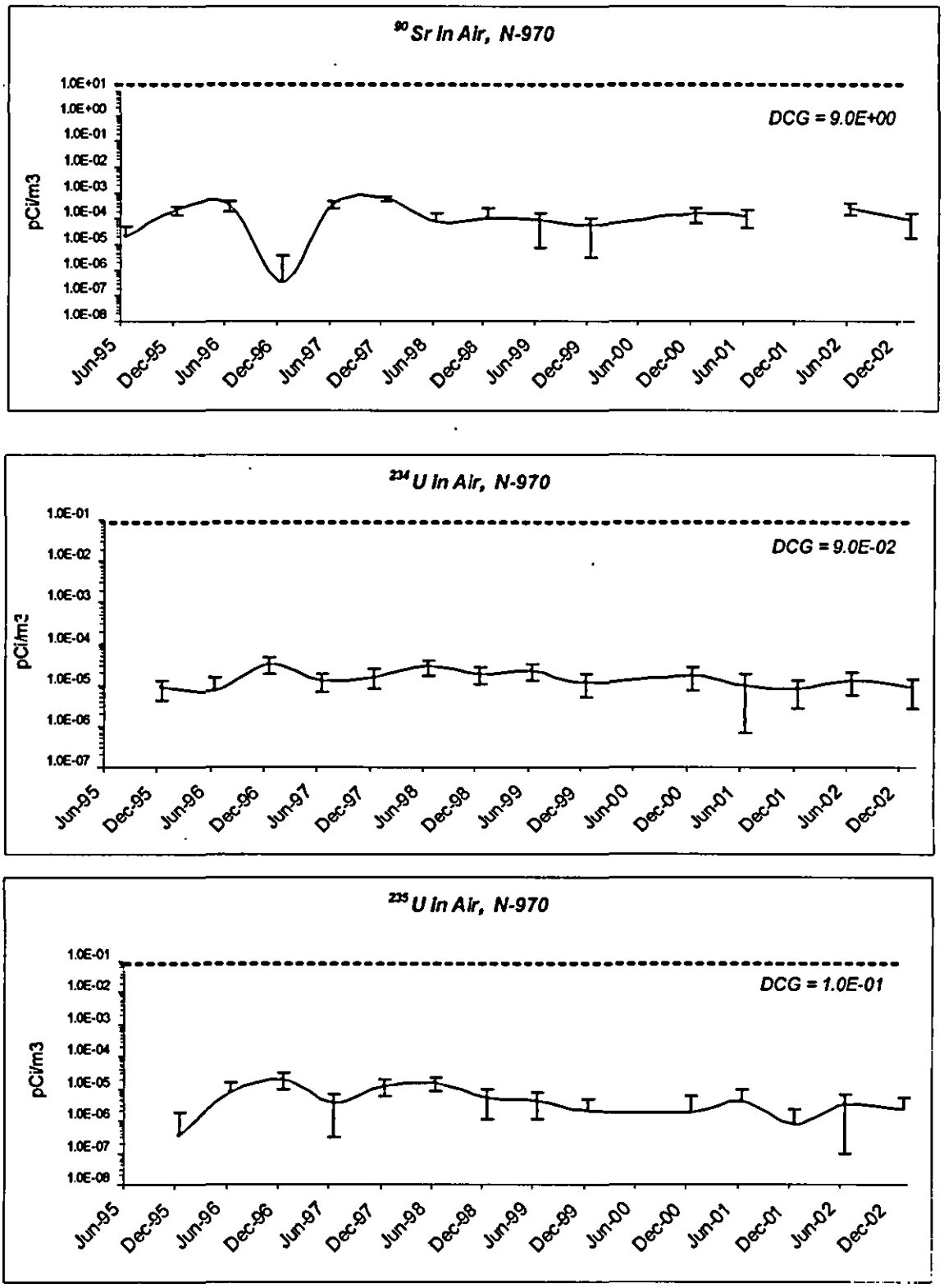
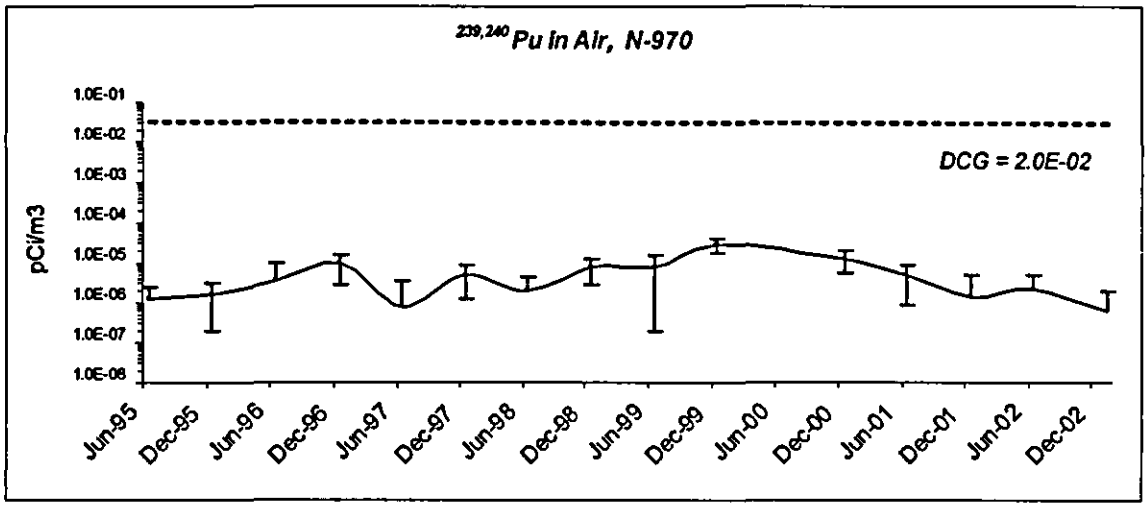
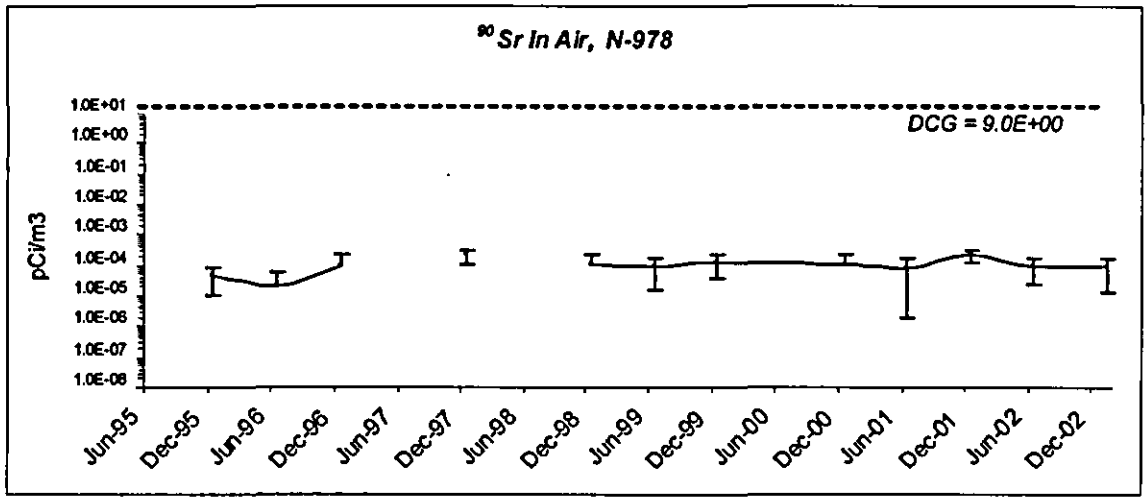


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 6 of 7).





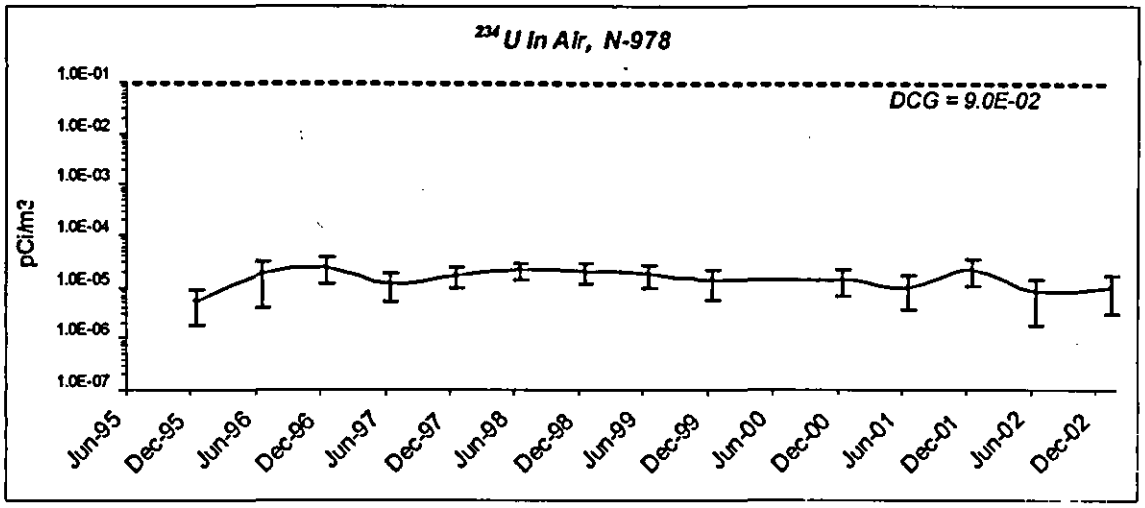
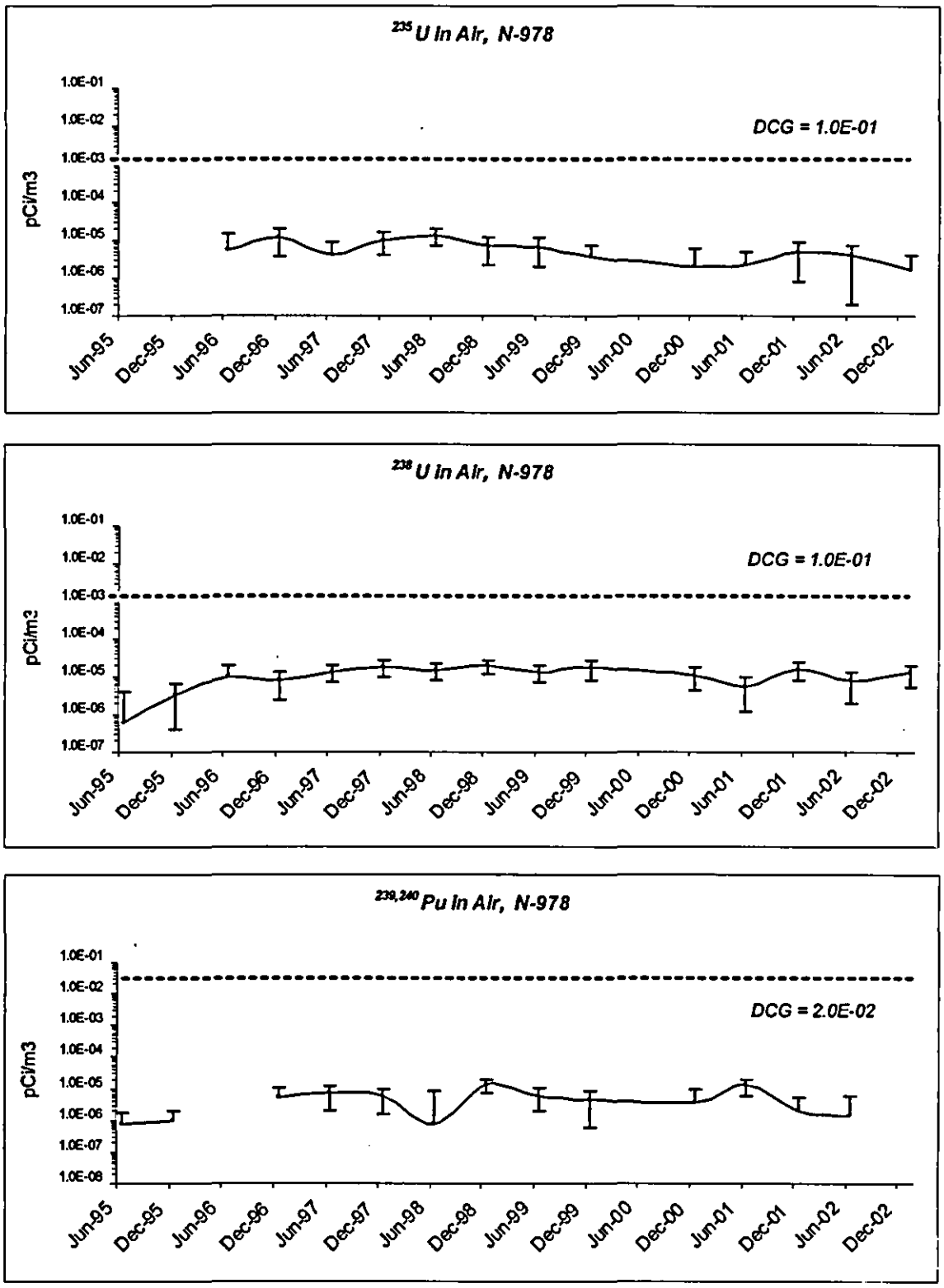


Figure 2-14. Five-Year Summary of Radionuclide Concentrations in Selected Air Samplers. Stations N-957 and N-968 are up wind and Stations N-969, N-970, and N-978 are down wind. (Sheet 7 of 7).



2.8 THERMOLUMINESCENT DOSIMETERS

A network of thermoluminescent dosimeters (TLD) is positioned in and around the 200 Areas to monitor dose rates from external radiation sources (primarily gamma rays). The environmental TLDs measure dose rates from all types of external radiation sources. These include cosmic radiation, naturally occurring radiation in air and soil, and fallout from nuclear weapons testing, as well as any contribution from the Hanford Site activities. These outside radiation sources cause an estimated ± 20-percent deviation in TLD analyses. The results are reported in units of millirems per year.

The TLD measurements are taken to determine dose rates in the operations area environment. From these data, the contribution of the Hanford Site activities to the dose rates in these areas can be discerned.

The Hanford Site uses the Harshaw 8807 dosimeter and the Harshaw 8800 TLD reader. The TLD packaging, which uses an O-ring seal, protects the TLDs from light, heat, moisture, and dirt. The TLDs are placed 1 m (approximately 3 ft) above ground at each location. The TLDs are placed near inactive surface-water disposal sites and other facilities (e.g., tank farms, cribs, and the facility fence line). Changing conditions in the vicinity of the TLD sample locations, such as remediation activities, removal or storage of radioactive material, and tank farm operations may cause fluctuations in TLD analyses over time. The TLDs are exchanged each calendar quarter (i.e., January, April, July, and October).

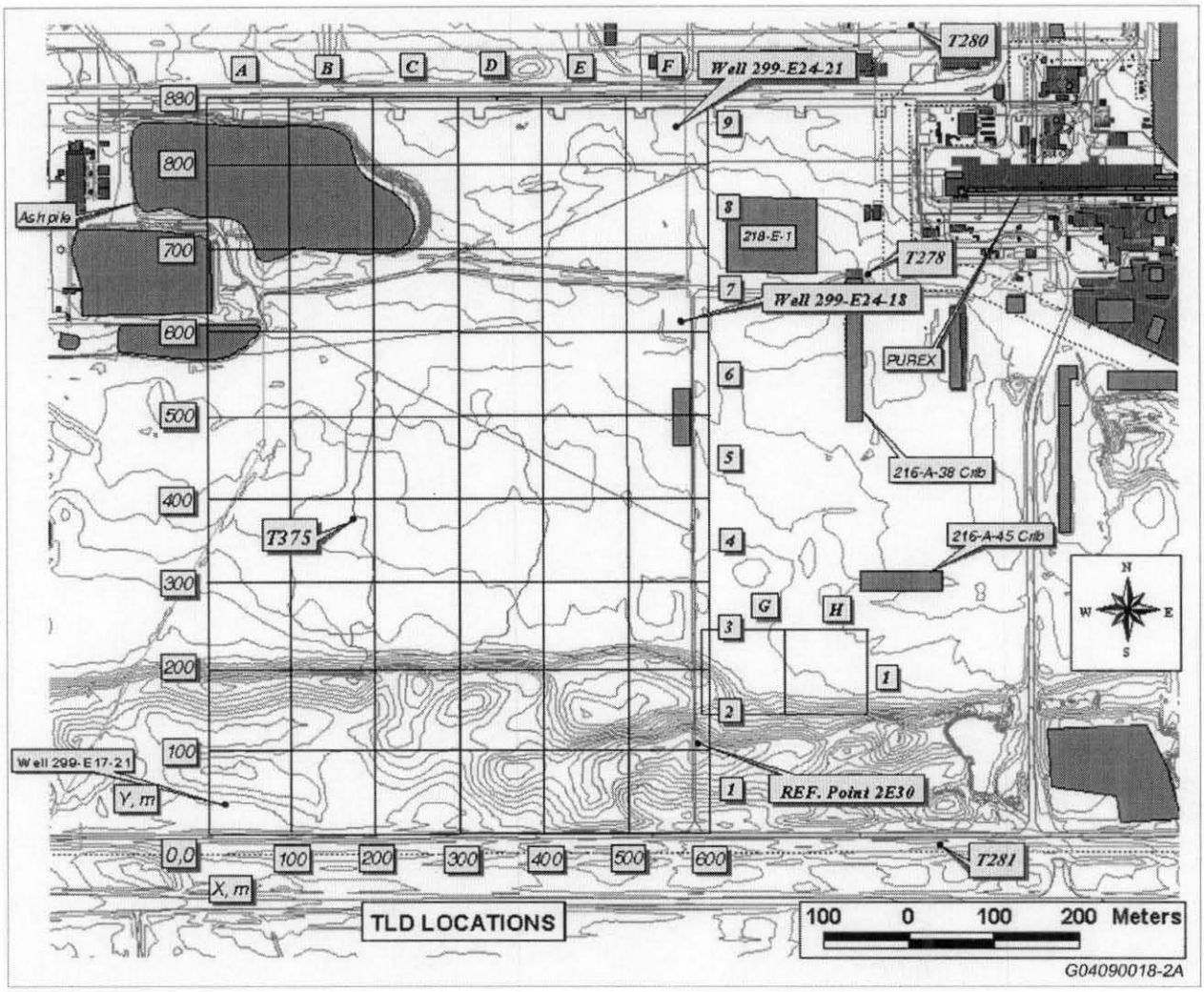
Figure 2- 15 shows the location for the three existing TLD monitoring stations (T278, T280 and T281) located east of the IDF study site and the one new TLD station (T375) to be used during preoperational monitoring. Table 2-4 summarizes the dose rates recorded for 1996 through 2003. The average for all of the 200 Area TLDs from 1996 through 2003 was approximately 115 mrem/yr.

2.9 BIOLOGICAL MONITORING

2.9.1 Site Description

The IDF will be located southwest of the PUREX Facility in the 200 East Area (Figure 1-1). Positioned along the IDF site's eastern boundaries are a number of PUREX cribs and the 218-E-1 Burial Ground. Located in the western portion of the site are the 200 East Area ash pile and numerous tile fields and septic systems. The general area contains minor waste sites, study sites, the BY Tank Farm-to-BC controlled area transfer line, water lines, and numerous roads that crisscross the area providing access to wells, boreholes, and other facilities (Figure 2- 11).

Figure 2-15. IDF Study Site Showing the Location of the Existing and Proposed TLD Monitors.



The 200 East Area lies on a plateau in the central portion of the Hanford Site (Figure 1-1) approximately 11 km (7 mi) south of the Columbia River. This site contains various radionuclide and hazardous waste process facilities and waste disposal facilities (e.g., liquid waste cribs and solid waste burial grounds). The habitat of the 200 Areas originally was mature shrub-steppe desert characterized by such vegetation as big sagebrush (*Artemisia tridentata*) and Sandberg's bluegrass (*Poa sandbergii*). However, this sagebrush habitat generally has been disturbed. These disturbed areas support a variety of plants such as introduced bunchgrasses (*Agropyron spp.*) and invasive species such as Russian thistle (*Salsola kali*) and cheatgrass (*Bromus tectorum*). Large tracts of mature shrub-steppe desert habitat also exist outside these areas.

Animal species that commonly would occur in this portion of the 200 West Area are similar to those found before human use of the area, but wildlife generally are present in reduced numbers where the vegetative cover is sparse. The exception would be nonnative species that have taken advantage of the changed habitats. Common native species include the horned lark (*Eremiphila*

alpestris), American robin (*Turdus migratorius*), black-billed magpie (*Pica pica*), song sparrow, western meadowlark (*Sturnella neglecta*), red-tailed hawk (*Buteo jamaicensis*), side-blotched lizard (*Uta stansburiana*), Great Basin pocket mouse (*Perognathus parvus*), deer mouse (*Peromyscus maniculatus*), and black-tailed jackrabbit (*Lepus californicus*). Occasional visitors include the long-billed curlew (*Numenius americanus*), badger (*Taxidea taxis*), coyote (*Canis latrans*), and mule deer (*Odocoileus hemionus*) (PNL-2253, *Ecology of the 200 Area Plateau Waste Management Environs: A Status Report*).

Several species of insects also occur in this area, with grasshoppers, spiders, and darkling beetles (*Tenebrionidae*) being the most common in the 200 Areas (PNL-2465, *Darkling Beetle Populations (Tenebrionidae) of the Hanford Site in Southcentral Washington*, PNL-2713, *Shrub-Inhabiting Insects of the 200 Area Plateau, Southcentral Washington*).

Nonnative species taking advantage of the altered habitats within the 200 Areas include the domestic pigeon (*Columba livia*) and the house mouse (*Mus musculus*). Additional information on existing habitat and associated species can be found in PNL-6415, *Hanford Site Environmental Policy Act (NEPA) Characterization*.

The eight plant species considered to be endangered, threatened, or sensitive by the Washington Natural Heritage Program (1997) that are known to occur on or near the Hanford Site are listed along with their designations in Table 2-4. According to WHC-EP-0554, *Vascular Plants of the Hanford Site*, seven of these are upland species. The upland species present are northern wormwood (*Artemisia campestris spp. Borealis var. wormskiodii*), Hoover's desert parsley (*Lomatium tuberosum*), Piper's daisy (*Erigeron piperianus*), gray cryptantha (*Cryptantha leucophea*), Palouse milkvetch (*Astragalus arrectus*), and coyote tobacco (*Nicotiana attenuata*). Currently, none of these plant species are listed as federal threatened or endangered species. However, three local upland species, northern wormwood, Hoover's desert parsley, and Columbia milkvetch, are candidates for federal protection.

Table 2-4. Washington Natural Heritage Program Threatened or Endangered Plant Species Found in Benton County as of April 2004.

Common Name	Scientific Name
State Endangered	
Persistent sepal yellowcress	*Rorippa columbiae*
Umtanum desert buckwheat	*Eriogonum codium*
State Threatened	
Awned halfchaff sedge	*Lipocarpha aristulata*
Grand redstem	*Ammannia robusta*
Loeflingia	*Loelflingia squarrosa*
Lowland toothcup	*Rotala ramosior*
Palouse goldenweed	*Haplopappus liatriformis*
Rosy pussypaws	*Calyptridium roseum*

The bald eagle and peregrine falcon are the only federally listed threatened or endangered wildlife species observed near the 200 Areas of the Hanford Site. Federal candidate species present near the 200 Areas are the ferruginous hawk and loggerhead shrike. As documented in WHC-EP-0513, *Biological Assessment for Threatened and Endangered Wildlife Species Related to CERCLA Characterization Activities*, the pygmy rabbit, a shrub-steppe species listed as a federal candidate species and state threatened species, has not been observed on the Hanford Site since 1984. According to WHC-EP-0402, *Status of Birds at the Hanford Site in Southeastern Washington*, the sage grouse, another federal candidate shrub-steppe species, has not been observed at the Hanford Site since the mid-1980's and probably no longer resides at the Site. State-listed threatened or endangered wildlife species present on Site are the peregrine falcon and ferruginous hawk. State candidate species observed near the 200 Areas are the golden eagle, burrowing owl, sage thrasher, Swainson's hawk, striped whipsnake, Merriam's shrew, and sage sparrow (WHC-SD-EN-EE-009, *Biological Assessment for State Candidate and Monitor Wildlife Species Related to CERCLA*). Other animal species of concern are listed in Table 2-5.

Table 2-5. Animal Species of Concern (Threatened, Sensitive, or Candidate) for Benton County, Washington State, as of April 1, 2004.

Common Name	Scientific Name
State Threatened	
Bald eagle	*Haliaeetus leucocephalus*
Ferruginous hawk	*Buteo regalis*
Sage grouse	*Centrocercus urophasianus*
State Sensitive	
American peregrine falcon	*Falco peregrinus anatum*
State Candidate Species	
Black-tailed jackrabbit	*Lepus californicus*
Burrowing owl	*Athene cunicularia*
Flammulated owl	*Otus flammeolus*
Golden eagle	*Aquila chrysaetos*
Lewis' woodpecker	*Melanerpes lewis*
Loggerhead shrike	*Lanius ludovicianus*
Merlin	*Falco columbarius*
Sagebrush lizard	*Sceloporus graciosus*
Sage sparrow	*Amphispiza belli*
Sage thrasher	*Oreoscoptes montanus*
Striped whipsnake	*Masticophis taeniatus*
Townsend's ground squirrel	*Spermophilus townsendii*

The specific site designated for the proposed facility is largely undisturbed. However, the area immediately surrounding the site generally is devoid of native vegetation. Over the years the area has been disturbed by various waste management activities, as well as construction of roads, buildings, storage basins, and other facilities. The human activities and ongoing construction

efforts have greatly reduced the likelihood that any protected species occur in the near vicinity. During the sampling activities, biologists have surveyed the area for any species of concern and none have been observed to date.

2.9.2 Historical Information

Rockwell Hanford Operations (RHO), Westinghouse Hanford Company (WHC), and Waste Management Technical Services monitored radionuclide levels in the 200 East Area to document the effect of the burial grounds, liquid waste disposal facilities, and waste management activities conducted in and around these sites for a number of years (WHC-EP-0145-2, *Westinghouse Hanford Company Environmental Surveillance Annual Report - 200/600 Areas, Calendar Year 1989*; WHC-EP-0145-4; WHC-EP-0573, *Westinghouse Hanford Company Environmental Surveillance Annual Report - 200/600 Areas, Calendar Year 1991*; WHC-EP-0573-1; WHC-EP-0573-2; WHC-EP-0573-3; WHC-EP-0573-4, WHC-EP-0573-5; and WHC-EP-573-6).

Vegetative and fecal material sampling also has been conducted routinely in the 200 Areas for a number of years. Samples were initially collected beginning in 1978 on a grid system. Two of the grid sites (E-28 and E-29) were located in the general study area; grid site E-28 was located in the middle of the proposed IDF site.

Tables 2-5 and 2-6 summarize reported values in vegetation samples collected at grid sites 28 and 29 for ^{137}Cs and ^{90}Sr from 1979 through 1990. No vegetation samples were collected in 1978. Tables 2-7 and 2-8 summarize reported values in animal fecal samples collected at grid sites 28 and 29 for ^{137}Cs and ^{90}Sr from 1978 through 1985. No fecal samples were routinely collected after this date. In 1990 when emphasis was placed on near-facility monitoring; these grid sites were replaced by new sample locations nearer facilities or waste sites.

Table 2-5. Radionuclide Summary for Vegetation Collected at Grid Site 28 (pCi/g).

	Year										
Radionuclide	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
^{137}Cs	0.48	ND	ND	ND	0.16	ND	0.13	NC	0.22	0.16	NC
^{90}Sr	0.32	ND	NA	ND	NA	NA	ND	NC	NA	0.1	NC

NA = not analyzed.
NC = not corrected.
ND = not detected in sample.

Table 2-6. Radionuclide Summary for Vegetation Collected at Grid Site 29 (pCi/g).

	Year										
Radionuclide	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
^{137}Cs	ND	ND	0.6	0.6	ND	0.32	ND	0.25	ND	0.1	0.05
^{90}Sr	0.07	ND	NA	NA	NA	NA	0.2	0.14	NA	0.19	0.1

NA = not analyzed.
ND = not detected in sample.

Table 2-7. Radionuclide Summary for Animal Feces Collected at Grid Site 28 (pCi/g).

Radionuclide	Year							
	1978	1979	1980	1981	1982	1983	1984	1985
^{137}Cs	1.0	1.28	NC	ND	0.9	0.3	NC	0.27
^{90}Sr	0.3	1.0	NC	NA	ND	NA	NC	NA

NA = not analyzed.
NC = not corrected.
ND = not detected in sample.

Table 2-8. Radionuclide Summary for Animal Feces Collected at Grid Site 29 (pCi/g).

Radionuclide	Year							
	1978	1979	1980	1981	1982	1983	1984	1985
^{137}Cs	3.3	1.56	NC	ND	ND	ND	0.51	0.43
^{90}Sr	0.2	0.9	NC	NA	ND	NA	NA	NA

NA = not analyzed.
NC = not corrected.
ND = not detected in sample.

2.10 SUMMARY

The review of existing hydrogeologic and environmental information presented in this chapter illustrates the potential impact of past-practice waste disposal activities and contaminant dispersal processes on the IDF site. In particular, the following items are addressed in Chapter 3 as an integral part of the DQO process.

- **Wind-Borne Particulate Contaminants.** The prevalence of windblown dust in the Pasco Basin generally, and the prevailing winds from the west-northwest in the 200 East Area specifically, indicate that particulate contaminants from facilities located near the IDF site could be moved onto the IDF site. In addition, contaminants may be spread by windblown tumbleweeds and other vegetation. Also, the dispersion of particulates to the east and southeast of the study site is likely during excavation of the trenches.

- **Biological Dispersion.** Both plants and animals can spread near-surface contamination. Plants, especially tumbleweeds, growing on contaminated soil sites become dislodged and are carried across the site by wind. Burrowing animals transport contaminated soil to the surface where it can be further dispersed by the wind. Animals also ingest the salt associated with some near-surface soil column disposal and surface spill sites. Animals (both prey and predators) contact these sources and disperse the contaminants through deposition of urine and feces. Spot contamination occurs randomly as a result of these biodispersion processes and can be identified by ground-level radiometric surveys and opportunistic sampling of biological media as available.

- **Soil Column Contamination.** Adjacent cribs and ditches may have allowed lateral spreading of contaminants along the borders and through some portions of the demonstration site. This has been shown to occur east of the IDF site around the PUREX cribs. Also, existing information suggests that low-level radioactive contamination in surficial soils occurs in areas adjacent to the site. Finally, the coal plant ash pile in the northwestern part of the site may have contributed to surface and near-surface contamination.

- **Groundwater Quality.** Mobile contaminants at concentrations near or above drinking water standards exist in groundwater beneath the IDF site; these contaminants also occur in components of the waste to be vitrified. The situation is complicated by a very flat water table and changing groundwater flow directions in the south-central part of the 200 East Area. Groundwater monitoring is not covered by this plan, but is to be addressed separately as part of the groundwater monitoring program.

3.0 DATA QUALITY OBJECTIVES PROCESS

This chapter describes the relevant components of the general DQO process as an aid in designing a cost-effective data collection plan for the preoperational environmental baseline for the IDF site. As indicated in Chapter 1, this plan is a blueprint for characterizing the environment before beginning any operational activities. Information gained in the preoperational monitoring phase also should be used in designing the operational and postoperational monitoring systems.

In 1995, the DQO process was used to define the subsurface characterization needs to support the low-activity tank waste disposal site (Immobilized Low-Activity Waste [ILAW]) PA and develop an environmental monitoring plan (WHC-SD-WM-PLN-109). That DQO exercise was directly applied to the preoperational monitoring plan (RPP-6877, Rev. 0) for the ILAW Disposal Facility site before it became the IDF site. Although the site remains the same, the trench design has changed and the facility mission has changed to include mixed waste and low-level waste along with the ILAW. The following sections are from RPP-6877, Rev. 0, with updates where the original plan has moved forward. The original DQO study is deemed still relevant to the site and is provided as background information.

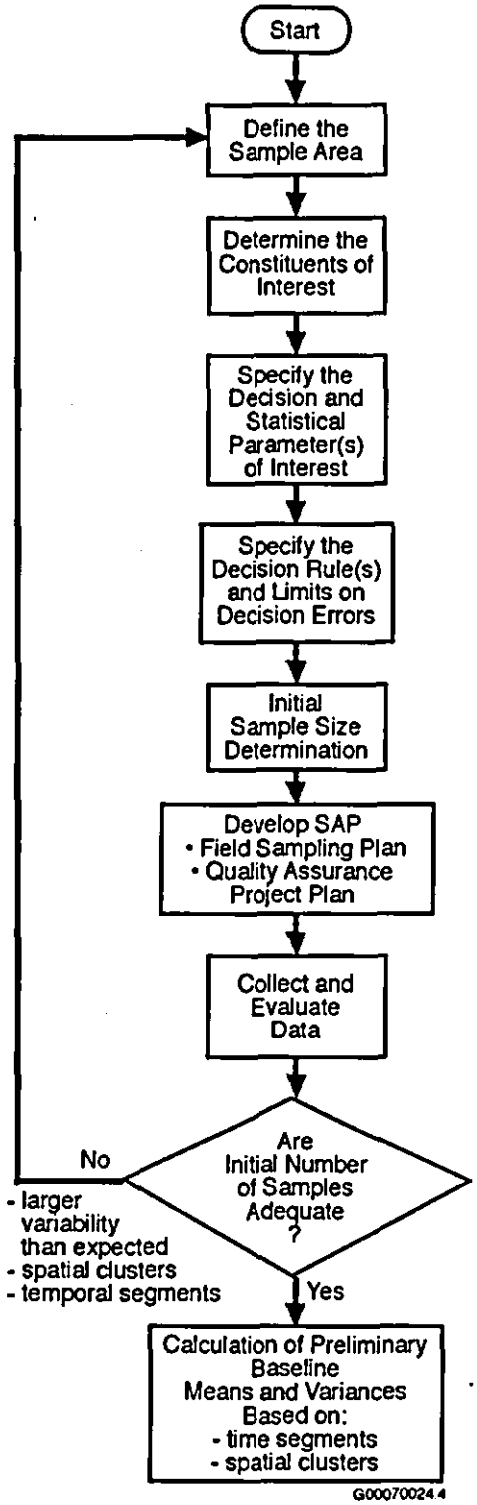
3.1 DESCRIPTION OF DATA QUALITY OBJECTIVE PROCESS AND LIMITATIONS

Data quality objectives ensure that the type, quantity, and quality of environmental data used in making decisions are appropriate for their intended applications. The process for developing DQOs involves the following seven primary steps:

- Statement of problem (Section 3.3)
- Decision and expected action (Section 3.4)
- Decision inputs (Section 3.5)
- Study boundaries (Section 3.6)
- Decision rule (Section 3.7)
- Limits on decision errors (Section 3.8)
- Optimize sampling design (Section 3.9).

The DQO process includes both qualitative and quantitative components. The quantitative aspect uses statistical methods to design the most efficient field investigation to control the possibility of making an incorrect decision. The qualitative aspect seeks to encourage good planning for field investigations and complements the statistical design. The process is both flexible and iterative. The end product or objective of this effort is a cost-efficient SAP. For the data collection effort, emphasis is on addressing the question "what decision will be made with the data or information acquired?" Figure 3-1 is a generalized flow chart depicting the overall DQO process.

Figure 3-1. DQO Process Flow Chart.



This preoperational monitoring plan will specify the type, quantity, and quality of subsurface data needed to support decisions related to baseline environmental quality of the site before long-term disposal of low-level waste. A preliminary application of the DQO process has been chosen as the most appropriate and cost-effective approach to meet the project needs. As more details and decisions about the site develop (e.g., as preoperational baseline data are acquired), a more thorough and detailed application of the DQO process can be developed. A phased DQO approach, where knowledge gained in the early phase helps determine future data needs and quality desired, is preferred over other types of characterization and monitoring efforts (e.g., simultaneous acquisition of data) because of the potential cost reduction.

3.2 DATA REQUIREMENTS AND REGULATORY DRIVERS

Regulatory or regulatory-related drivers exist for the preoperational monitoring efforts addressed in this plan. These include the following:

- Characterization and monitoring guidelines based on Title 10 *Code of Federal Regulation* (CFR) Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste," (commercial LLW sites)
- Environmental characterization and monitoring requirements set forth in DOE Order 435.1 (formerly DOE 5820.2A), *Radioactive Waste Management*
- DOE Order 450.1, *Environmental Protection Program*
- DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

Although the IDF site is not a commercial site, the guidance documents (e.g., DOE/LLW-67T, *Site Characterization Handbook for Low-Level Radioactive Waste Disposal Facilities*) for complying with 10 CFR 61, provide a logical and prudent set of guidelines. Fortunately, much of the information suggested in these guidance documents has been acquired for the Hanford Site already. This information has been published in numerous documents and is widely available. Site-specific data are the principal data required by 10 CFR 61.

The following principal factors govern the proposed sampling strategy:

- Meet the site data needs for preoperational environmental monitoring
- Acquire information on the nature and presence of manufactured objects and materials on or near the surface
- Conduct site characterization and monitoring activities in a cost-effective manner through careful planning and integration of sampling efforts where possible.

The following sections discuss the steps used in the DQO process for this plan.

3.3 STATEMENT OF PROBLEM

To develop the DQOs that adequately address surface and subsurface preoperational characterization and monitoring data needs at the IDF site, the overall performance objective or goal must be identified.

Although the proposed IDF site is in an area not previously used for any major Hanford Site operations, it is located close to surface and subsurface contamination resulting from past practices at the PUREX Facility and tank farms, and past operation of Hanford Site utilities (e.g., the 200 East Powerhouse Plant).

An environmental baseline is needed before startup of the IDF to assess the degree to which previous operations affected the immediate environment. Existing geological, soil, air, and biotic conditions must be defined before the site is disturbed during facility construction or operation.

3.3.1 Conceptual Model

A conceptual model is used to describe and illustrate the potential contaminant pathways and the known and suspected sources of contamination, which in turn help determine the type and amount of monitoring data needed. The conceptual model recognizes that both the surface and subsurface conditions must be factored into data needs. Elements of the conceptual model include sources of potential soil contamination at the site, potential airborne particulates and liquid leaks associated with operating the site, and contaminant dispersal pathways.

3.3.1.1 Elements of Conceptual Model-Residual Soil Contamination

Based on process knowledge and past waste-disposal practices, incidents of soil column contamination that could be encountered or may exist in the project area are as follows. (See Figure 2-11 for locations of waste disposal facilities):

- The 218-E-1 Burial Ground and associated unplanned release (UPR-200-E-53) are approximately 20 m to 25 m (65 to 82 ft) east of the northern part of the study area.
- Large volumes of contaminated wastewater were discharged to the soil column at the 216-A-10 and 216-A-45 Cribs east of the site. Subsurface migration of contaminants may have occurred that extended to an unknown depth and lateral distance into the site.
- Potential past leakage from the transfer line between the BY Tank Farm and the BC controlled area may have introduced contaminants along the western border of the study site.
- Prevailing winds from the southwest, west, and northwest, as well as occasional easterly winds, may have transported contaminant-bearing, fugitive dust particles onto the site from upwind sources (e.g., the BC controlled area cribs and trenches).

- Vegetation, such as tumbleweeds, that grew in waste sites and were blown by winds could have carried contaminants across the site.

- Burrowing animals could have carried contaminants from waste sites to the surface through ingestion or surface contact. These contaminants could then be spread across the site by deposition of urine and feces, as happened at the BC controlled area.

3.3.1.2 Elements of Conceptual Model-Plant Release Scenario

In addition to the conceptual model of existing soil and subsurface contamination, plant emissions and the waste product itself must be considered for the preoperational baseline. The current design includes operations buildings, maintenance buildings, a parking area, an area for spoils from excavations, and a disposal trench. Figure 3-2 shows a general facility design.

3.3.1.3 Particulate Emissions

The IDF will be constructed on 25 hectares and will consist of a lined landfill approximately 442 m wide by 555 m long and up to 15 m deep. The landfill will contain four layers of waste containers separated vertically by 9 cm of soil (Figure 3-2). The landfill will have a leachate collection system and vadose zone monitoring.

The nature of the air emissions may vary depending on their source. Most air emissions will be dust from excavation operations. It also is possible, but not likely, that particulate dust containing radioactive contamination from a hitherto unidentified source may become wind borne during excavation. No existing source currently is known in the study area, but surface geophysical surveys and soil sampling performed during preoperational monitoring will be used to establish a baseline.

The physical and chemical natures of the air emissions influence the dispersal pattern. Vapor-phase contaminants are not expected from the IDF, so any air emissions will consist of small particulates. The smallest particulates could be transported long distances with little deposition. Larger particles would be deposited close to the release point. The height of the release also would influence the likelihood of dispersion. This plan assumes the highest release point will be 15 m (50 ft) maximum (a spoil pile equivalent to the depth of one excavation). For purposes of this plan, the following assumptions were made.

- Multiple dust resuspension events will occur every year. (Blowing dust, as reported by the Hanford Meteorological Station [PNNL-13117], occurs an average of 5 days per year.)

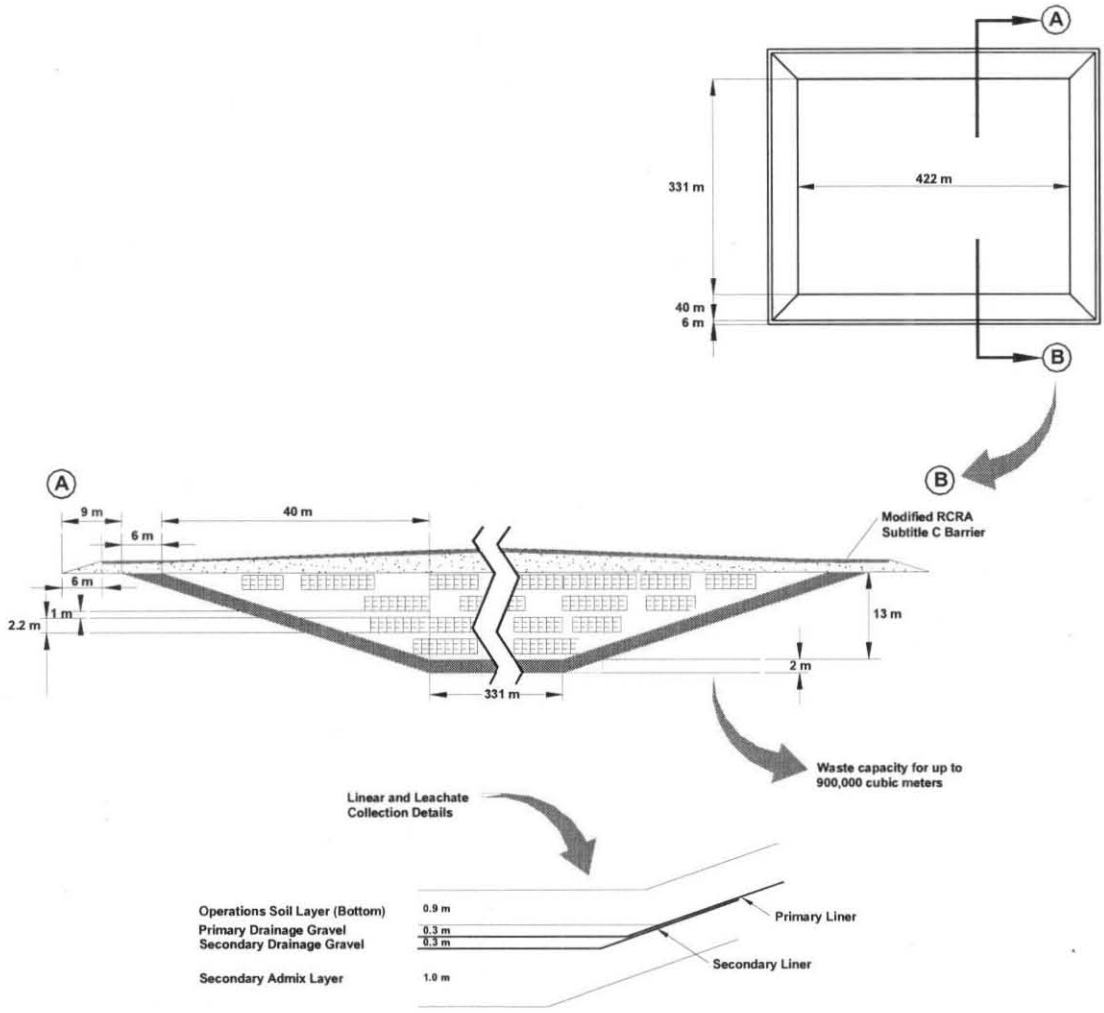
- Small particulates will remain airborne within 1000 m of the release point.

- Deposition of some fraction of the transported particulates will occur at a uniform rate beginning at the point of release.

- The release point will occur at a height of 15 m (50 ft) or less.

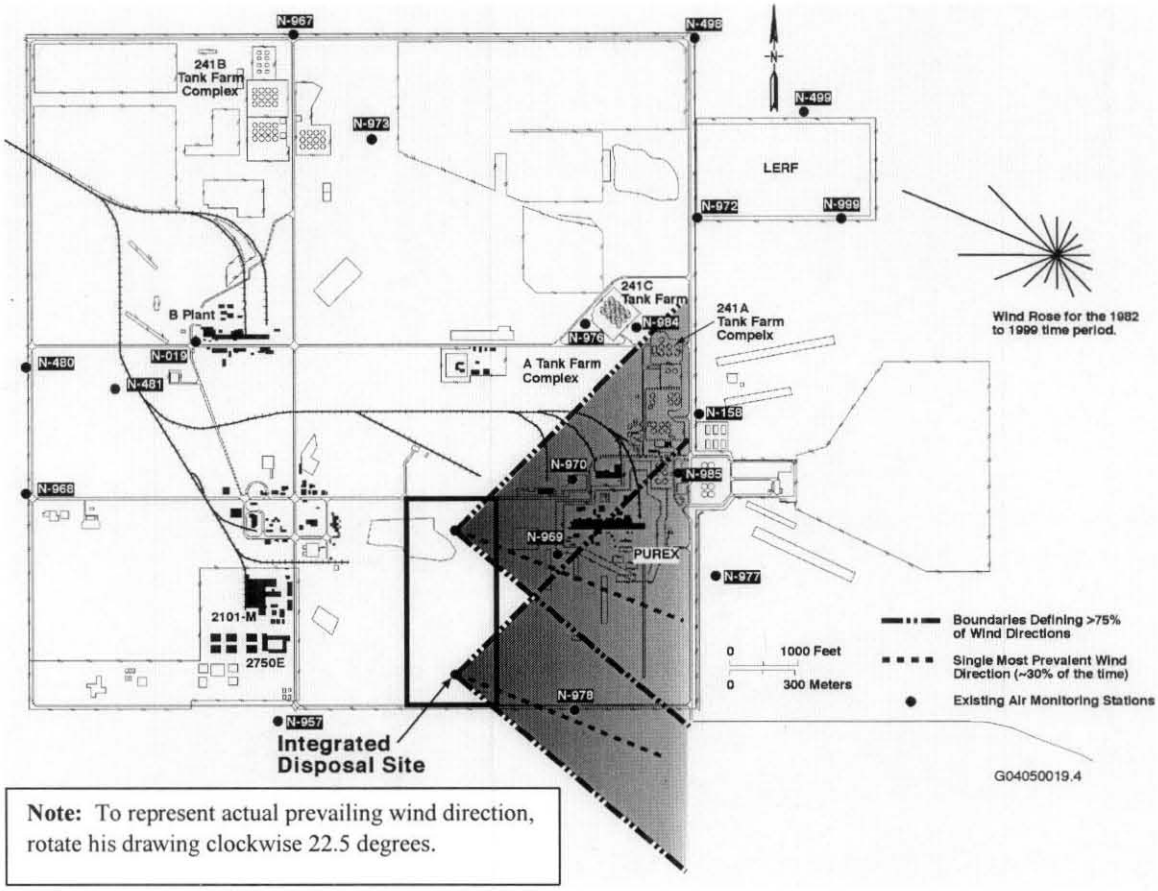
- Emissions are equally probable throughout the entire study area.

Figure 3-2. Conceptual Design for the Integrated Disposal Facility.



Considering the scenario and assumptions already discussed, a hypothetical particulate deposition would be greatest in the downwind shaded areas shown on Figure 3-3. If the release point were located in the western part of the site, more of the fenced area would receive deposition of hypothetical particulates. If the release point were located in the eastern part of the site, deposition would be minimal within the study area and more particulates would fall outside the fenced area.

Figure 3-3. Dispersal of Airborne Particulates from the Integrated Disposal Facility Site.



Note: To represent actual prevailing wind direction, rotate his drawing clockwise 22.5 degrees.

Waste Released to the Soil Column from the Waste Package. The physical, chemical, and radiological properties of the waste at the time of disposal have not been completely determined. The LLW will be incorporated in a solid physical form and contained in metal containers (DOE/RL-97-69 andDOE/ORP-2000-07). Thus, air emissions from the LLW waste form are unlikely. Mixed waste most likely will be transferred primarily in long equipment containers, 208-L drums, medium boxes, and small boxes. Low-level waste is expected to be received in MB-V boxes, small boxes, 208-L drums, medium boxes, and other containers. Some low-level waste will be bulk and some mixed waste could be transferred in bulk. For the purposes of this plan, a worst case scenario of a damaged waste package exposing waste to the elements and having waste particles dispersed by wind is assumed. The dispersion pattern is expected to be similar to that for earth particulate (Figure 3-3) and will be toward the east and southeast.

The disposal trench in the IDF is planned to have a series of engineered barriers (Figure 3-2). A modified RCRA-compliant cover is planned for the top of the trench to prohibit intrusion and infiltration. In the very unlikely event that the overlying barriers are breached, the waste canisters are breached, and the underlying barriers are breached, infiltration could result in some dissolution of waste and transport of contamination into the vadose zone. However, for the PA,

it is assumed that the waste will be leached and eventually reach the water table. In DOE/RL-97-69 and DOE/ORP-2000-07, Mann and others determined that during a 10,000-year period, the IDF's impact on a groundwater well 100 m downgradient of the facility from beta emitters would be a factor of two less than the performance objective and from alpha emitters would be a factor of five less than the performance objective.

New boreholes (299-E17-21, 299-E17-22, 299-E17-23, 299-E17-25 and 299-E24-21) were drilled at the IDF site (Figure 2-7) to facilitate site characterization in support of the PA. Appropriate data from these boreholes will be included in the preoperational baseline as deep vadose zone baseline information.

3.4 DECISIONS TO BE MADE

Primary decisions to be made can be presented as follows, based on the conceptual model.

- Determine the contaminants of concern in surface soils, subsurface soils, air, and available biotic media for both preoperational and ongoing operations monitoring.
- Determine the number of samples that should be obtained to establish a statistically valid baseline for surface soils.
- Determine the frequency of preoperational monitoring of surface and subsurface soils, air, and biota.
- Provide information to make decisions concerning the site's suitability. This information should answer the following questions.
  - Does the site contain any areas of contaminated surface or subsurface soil that would present a hazard to workers during construction or to plant employees later?
  - Does the site contain any areas of contaminated subsurface soil that could be confused with potential releases from the disposal site?
  - Will the deposition of contaminated or potentially contaminated airborne particulates on the site present a hazard to onsite workers or to receptors downwind from the site?
  - What is the existing groundwater quality in the vicinity of the site? (Groundwater monitoring will be addressed in a groundwater monitoring plan separate from this preoperational monitoring plan.)

The answers to these questions provide the basic framework for preoperational monitoring and a rationale to support the current SAP. Using conceptual models provided in Section 3.3.1, baseline information as provided according to this plan should be revised if necessary and integrated with other phases of the monitoring programs when more information becomes available.

3.5 DECISION INPUTS

The following inputs identified for the IDF site preoperational baseline and monitoring include information types that can be subjected to statistical design considerations (quantitative) and information types that support more subjective or judgmental (qualitative) decisions. The quantitative approach is applied where appropriate.

3.5.1 Information Categories

The following general information categories are needed to address the questions concerning baseline characterization and preoperational monitoring:

- Ground-level radiometric survey
- Biotic survey (biomonitoring)
- Concentrations of primary constituents of interest in surface soil and subsurface soil for establishing an environmental baseline (see Appendix A1 for target constituents)
- Indicators (e.g., gamma log) of contaminant distribution with time and depth in or near soil excavation sites
- Electromagnetic induction (EMI) and ground-penetrating radar (GPR) surveys to locate underground features
- Wind direction and frequency
- Near-surface stratigraphy and geology
- External radiation (TLDs)
- Baseline airborne particulate contaminants (primary constituents of interest (Appendix A).

Three sources of information input are not part of the preoperational baseline monitoring but can be used for preoperational and operational monitoring. These are projects in the vicinity of the IDF site that are or will be collecting data within the preoperational timeframe: Groundwater/Vadose Zone Integration Project at the Sisson-Lu well cluster site, data describing the subsurface that can be collected during subsequent operations (i.e., trench excavation and future drill holes), and historical data collected as part of Hanford Site environmental monitoring (e.g., air quality).

3.5.2 Resource Constraints and Cost Saving and/or Deferral Alternatives

Resources to obtain sufficient information to address the key questions listed in Section 3.4 are assumed to be available. Effective or cost-efficient use of resources could include applying

existing data to the maximum extent possible, using key indicator parameters as possible, and restricting analytes of concern to those that contribute materially to potential receptor exposure (critical analytes/critical pathway approach).

Use of Existing Data. Airborne particulate data are available as a result of ongoing monitoring programs in the vicinity of the IDF site. Also, a small number of analyses on samples from the ash disposal pit area are available from work done to support the 2001 PA (PNNL-13033). Finally, geophysical data have been collected from shallow boreholes at the borehole cluster site (borehole 299-W24-111) located about 190 m (625 ft) east of the study site in support of the Vadose Zone Transport Study (PNNL-13263, *Vadose Zone Transport Field Study: Detailed Test Plan for Simulated Leak Tests*). These data will be incorporated into the preoperational baseline as appropriate. Also, five characterization boreholes have been drilled along the perimeter of the site. Data collected during drilling and subsequent analysis of samples can be of use to the preoperational baseline.

Use of existing information can significantly reduce the sampling and analytical burden to address potential inhalation hazards for construction workers and plant operators caused by residual contamination from past facility operations located upwind and from future operations of the proposed disposal facility. The projects currently collecting air monitoring data (Hanford Environmental Surveillance Program and the Near-Facility Environmental Monitoring Program) will monitor air particulates during the operational monitoring phase for the IDF site.

The air monitoring network in the vicinity of the project site area, however, will have to be modified and/or supplemented for the preoperational monitoring phase and carried over into the operational monitoring phase. For example, during the lifetime of the project, large quantities of soil will be excavated and the potential for airborne particulates will increase greatly. Also future remedial actions at adjacent soil contamination sites may cause suspension of airborne particulate contamination for the duration of those projects. Air monitoring stations between these sources (e.g., the PUREX cribs and BC cribs and trenches) and the project fence line would be needed to differentiate offsite sources from project-related sources.

A groundwater monitoring well network is being installed at the site. Existing wells are being supplemented with additional wells for use in developing the preoperational baseline.

Identification of Critical Analytes and/or Pathways. The primary exposure route for humans and other ecological receptors is by airborne transport of particulates. Application of Tier 1 analyses (see Section 3.7.1.3 for a discussion of the tiered analytical approach) represent those analytes that might contribute the majority of the potential inhalation dose can greatly reduce the number of analyses required. The basis for this approach and a list of the Tier 1 analytes are found in Section 3.7.1.3. An alternative is to analyze all media for every constituent identified in the waste package. Analyzing for every constituent regardless of its hazard potential and relative source strength is inconsistent with the DQO process.

3.5.3 Information Sources

Existing data are available from numerous and ongoing environmental studies and monitoring programs and the published results of those programs (e.g., the Near-Facility Environmental

Monitoring Program, the Integrated Biological Control Program, the Surface Environmental Surveillance Project, the Hanford Groundwater Protection Project, Hanford Groundwater Performance Assessment Project, and the Hanford Meteorological Monitoring Network). The existing information will be evaluated and supplemented with new sampling and analysis and new surveys as needed.

Additional information may become available from other projects. For example, the Integrated Vadose Zone/Groundwater Project is sponsoring the Vadose Zone Transport Field Study located east of the IDF site (PNNL-13263). That study has generated several types of data concerning the upper vadose zone that can be incorporated with the data collected during preoperational monitoring.

Finally, the methods of obtaining data about the surface and subsurface soils, air quality, external radiation, and biota as described in this plan are the major source of information for the preoperational baseline. The strategy for collecting preoperational baseline data is included in Chapter 4 and Appendix A1.

3.6 STUDY BOUNDARIES

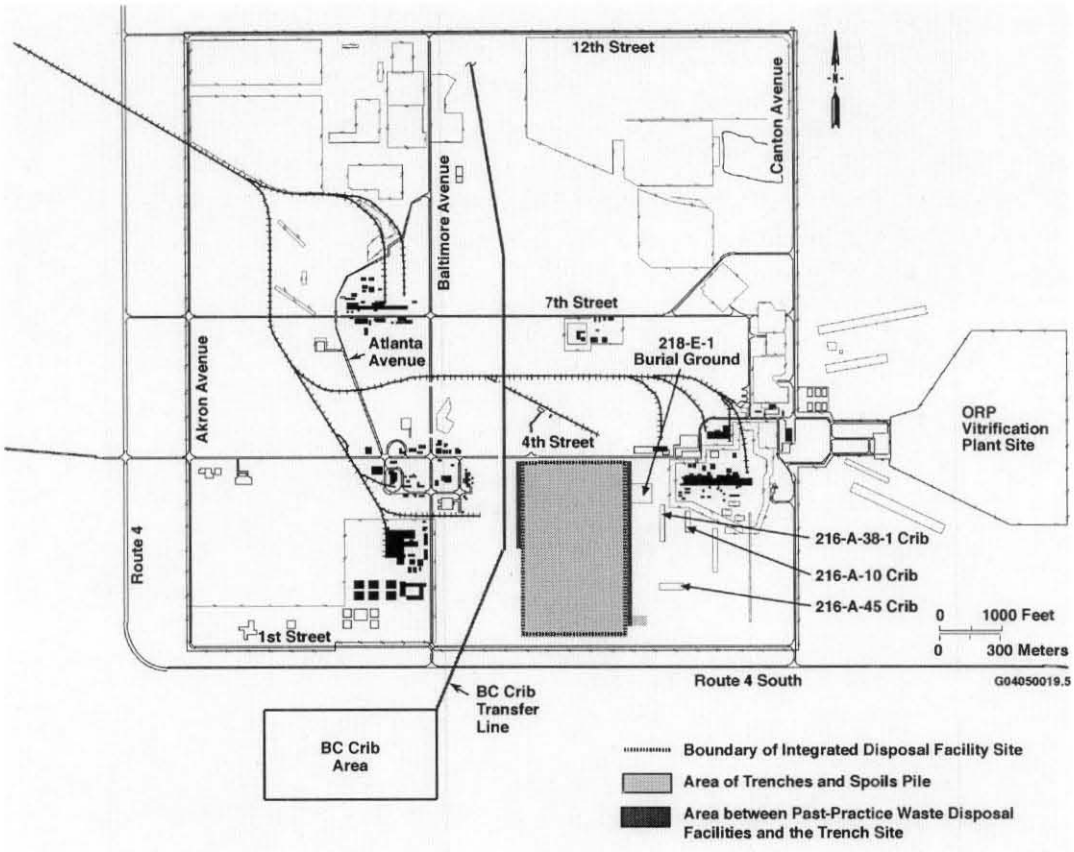
This section identifies the spatial and temporal boundaries for preoperational monitoring of the IDF site and the types of additional data needed to address the primary decision questions stated in Section 3.4. This step in the DQO process defines the set of circumstances covered by the questions being addressed. This step includes the following:

- Spatial boundaries that define what sample media should be monitored and from where the samples should be taken
- Temporal boundaries that describe when the samples should be taken and what time frame the monitoring should represent.

3.6.1 Spatial Boundaries

Two general areas of interest are shown in Figure 3-4. The first is the area occupied by the trench, the associated operational buildings, and the spoils pile. The second is a narrow area between the 218-E-1 Burial Ground, the 216-A-10 Crib, the 216-A-45 Crib, the BY Tank Farm-to-BC controlled area transfer line, and the proposed disposal site. Surface and subsurface soil characterization will be conducted in the IDF site, whereas subsurface characterization is emphasized for the area along the transfer line and between the study site and the past-practice waste disposal sites to the east. However, the primary focus of the following discussion is on the IDF site itself.

Figure 3-4. Spatial Sampling Areas for Preoperational Monitoring.



3.6.1.1 Geographic Domain

The area to which the primary decisional questions (Section 3.4) apply is the study site defined as the area within the fenced boundary of the proposed disposal facility plus a 60 m (197-ft) buffer zone surrounding the facility. The buffer zone allows for minor changes in finalizing the exact location of the facility. Because the disposal trenches could occupy all available space within the designated area, representative soil column and vadose zone data are needed for this entire area.

Impacts to the site from the BY Tank Farm-to-BC controlled area transfer line and the past-practice waste disposal facilities to the east will be evaluated within the 60 m buffer zone. Because these facilities could have affected the subsurface of the study site, the vadose zone (to about 23 m [about 75 ft] depth) between the study site and the waste disposal facilities is included in the preoperational monitoring boundaries. This depth ensures characterization of the paleosol found at the top of Layer 2 in the Hanford formation (PNNL-14586). The paleosol has the potential to pond water.

3.6.2 Temporal Domain Boundaries

The temporal domain boundaries of interest are set by the requirement for at least 1 year of data during the preoperational monitoring period. The frequency of sampling within that timeframe depends on the media sampled. For surface and vadose zone soils, a one-time sampling event is considered sufficient because the characteristics of those media generally will not change during the preoperational timeframe. However, for biotic sampling, seasonal variation should be considered when establishing sampling frequencies during the preoperational monitoring timeframe.

The Near-Facility Environmental Monitoring Program and the Hanford Site Environmental Surveillance Program conduct ongoing air monitoring. The Near-Facility Environmental Monitoring Program samples biweekly and the Hanford Site Environmental Surveillance Program samples biweekly, monthly, or quarterly depending on location and analytes of interest. Any additional facility-specific air sampling stations installed for the IDF preferably would be sampled biweekly for at least 1 year before IDF operations.

3.7 DECISION RULES

Decision rules address the major questions and issues previously discussed. In accordance with the DQO process, "if-then" statements are formulated that lead to actions based on the data or information. However, not all issues or questions identified are amenable to this approach. The following major questions are grouped as identified in Section 3.4 and are presented in the if-then decision format to the extent possible.

3.7.1 Constituents of Concern

Potential constituents of concern in environmental media (e.g., air, soil, biota) in the vicinity of the IDF site include the constituents that might be expected in the Waste Treatment Plant (WTP) waste package (DOE/ORP-2000-07) and the constituents potentially included in the mixed-waste and low-level waste packages.

> *If results of analyses for Tier 1analytes do not indicate the presence of contamination (that is, the concentration of a Tier 1 analyte does not exceed three times the standard deviation of the Hanford Sitewide background value), the Tier 1 analytes will be considered adequate to define the contaminants of concern (see Appendix A1).*[1]

The analyte list derived as mentioned can be amended as necessary to include those analytes that the 2005 PA finds to be the most significant contributions to the PA objectives.

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[1] Statements in italics are decisions rules that were developed to drive the data collection process.

3.7.1.1 Identification of Target Analytes

This section describes the approach used to identify the target analytes from the universe of potential or expected waste constituents.

Three important time periods and/or applications of the data need to be considered: preoperational, construction, and operational. For preoperational baseline purposes the existing contaminant background is of most concern. During construction, exposure of workers by contact with existing contamination in the area and disposal of contaminated soils are of major concern. For the operational and subsequent phases, the focus is on the constituents likely to be released by disposal facility operations. However, as discussed in Section 3.8, it is necessary to know the variability of the contaminants of interest (those expected to be released by the proposed disposal facility) already present in environmental media that could receive additional amounts of the same contaminants from facility operation. Because one goal of the DQO process is to ensure cost efficiency (i.e., *necessary and sufficient sampling and analysis*), planning data for the preoperational baseline environmental data needs are addressed to the extent possible.

3.7.1.2 Source/Exposure Scenarios and Considerations

Two sources of potential contaminants must be considered: constituents from past-practice operations in the 200 Areas and constituents that will be in the waste packages disposed of at the IDF. Constituents related to past-practice operations are of concern to preoperational monitoring when determining the existing contaminant background. Constituents related to the waste package are of concern to preoperational monitoring when determining an existing background against which to compare results from operational monitoring.

Constituents potentially present in environmental media from past-practice disposal and chemical processing activities are related to the composition of waste stored in single- and double-shell tanks that may be present in the IDF site. For example, SST (cascade) waste discharged to near-surface tile fields in the 200 East Area (e.g., BC cribs), is similar to the SST waste that will be processed. Biodispersion (e.g., burrowing animals bringing contaminants to the surface) and winds from the southwest result in transport of small amounts of particulate or particle-bound contaminants from the BC cribs and vicinity toward the study site.
The Envelope D waste composition (maximum concentrations) for HLW, is defined in the request for proposal, *Request for Proposals (RFP) No. DE-RP06-RL13308* (DOE-RL 1996) and is the SST-derived feed material for the immobilization process. This is the composition assumed by this plan to represent past-practice contamination that may be present in the proposed disposal site.

Another consideration is that past operations resulted in gaseous emissions that contained radioiodine and other volatiles (ruthenium, technetium, etc.) generated during dissolution of the irradiated nuclear fuel. Transport of these radioactive contaminants in the prevailing downwind directions from processing plant stacks could very likely have resulted in some deposition on the study area. This type of chemical fractionation could alter the average expected composition of disposed waste.

The following approach assumes that Envelope D composition represents the original HLW source, that chemical fractionation of liquid waste did not occur during past-practice handling and disposal operations, and that the inventory discussed in RPP-15834 and RPP-20692 represents the composition of the WTP waste packages. The inventory for mixed waste or low-level waste is available in the RPP-15834 and RPP-20692. Therefore, it is assumed that the mixed waste inventory can be approximated by the ILAW inventory. If the mixed waste inventory, or if final designs for the immobilization plants, or if the WTP waste package composition are altered significantly, the target analyte list for the preoperational baseline sampling plan will need to be evaluated and possibly altered accordingly.

The composition of the ILAW waste package to be disposed of to the IDF will be different from the original feed material (HLW) sent to the immobilization plants. During the immobilization process the original source term will be chemically fractionated to produce the waste package. DOE/ORP-2000-07 gives the inventory of constituents in the ILAW waste packages.

Unlike the ILAW with a known source for the waste feed and the resulting waste package, the mixed waste has several sources potentially resulting in several different waste package compositions. RPP-15834, *Integrated Disposal Facility Risk Assessment* describes the proposed waste streams and inventory. A complete list of the IDF inventory is presented in RPP-20692, *Inventory Data Package for the 2005 Integrated Disposal Facility Performance Assessment.*

The most probable exposure scenario is exposure of humans by inhalation or ingestion of particulate contaminants derived from contaminated soil or glass dust from the waste package. Previous and similar preoperational monitoring efforts by Chou et al. (HNF-SD-TWR-EV-001, *TWRS Phase I Privatization Site Environmental Baseline and Characterization Plan*) at the Waste Treatment Project site also considered a water-ingestion exposure route. Whereas the Waste Treatment Project plan had to consider liquid transfer lines associated with plant operations, the IDF has no liquid transfer lines associated with its operations. Also, the waste disposal trenches will have a RCRA-compliant cover and underlying liners and a leachate collection system. Therefore, the assumption is made that no liquid transfers are associated with the site.

The 1998 and 2001 PAs (DOE/RL-97-69 and DOE/ORP-2000-24) and RPP-15834 assumed that natural infiltration would react with the waste package and transport contaminants to groundwater. The results of the PAs specified which radionuclides had significant contributions to the total dose at the point of compliance (a well 100 m downgradient from the disposal facility). Those contaminants were considered when defining the Tier 1 list of analytes described in the following section.

3.7.1.3 Target Analytes and the Tiered Approach

The Office of River Protection and the River Protection Project have adapted a tiered approach for analytical characterization of waste sampled from SSTs and vadose zone sediment from new boreholes adjacent to SSTs. The tiered approach uses several suites of analytical methods for chemical and radiological characterization where each successive suite becomes more detailed (and expensive) to implement.

A typical Tier 1 analysis might include inductively coupled plasma (ICP) metals, anions, gross alpha, gross beta, and moisture content. In the tiered approach, the results of the Tier 1 analyses dictate which, if any, Tier 2 analyses are necessary. For example, if the results of Tier 1 analyses indicated that gross alpha was elevated above some background concentration, Tier 2 analyses would be implemented where Tier 2 would include radionuclide-specific alpha analyses.

Implementing the tiered approach allows for some customization of each suite of analyses to fit the sample types being analyzed. For example, the Tier 1 analysis suite for samples collected from Tank 241-AY-102 included analyses for ^{241}Am, plutonium isotopes, and ^{237}Np (among several others) because they were expected to be in the tank samples (PNNL-14344, *Tank 241-AY-102 Data Report*). The Tier 1 analytical suite for characterization of vadose zone sediment from boreholes in the TX Tank Farm, on the other hand, did not include these isotopes because these isotopes were not expected in the samples. However, if the Tier 1 gross alpha results for the sediment had been elevated, analyses would have been made for these and other isotopes.

The tiered approach for characterization and baseline purposes is in keeping with the philosophy of the DQO process. One goal of the DQO process is to ensure cost efficiency by implementing *necessary and sufficient sampling and analysis* to meet data objectives. The tiered approach greatly reduces the analytical burden.

Tier 1 Analyses and Target Analytes. A Tier 1 suite of analyses was chosen to represent the Envelope D and ILAW waste package compositions. The initial Tier 1 analytical suite was designed for the preoperational baseline characterization samples from the subsurface. Because of considerable overlay in the analytical methods needed for subsurface samples and surface samples, four analytical methods were added to the Tier 1 suite that are needed only for the surface samples. These methods are used to analyze for ^{90}Sr, isotopic uranium, ^{241}Am/^{244}Cm and isotopic plutonium. Table 3-1 lists the laboratory analytical methods used in the combined surface and subsurface Tier 1 suite.

Table 3-1. Analytical Methods and Analytes in the Tier 1 Analytical Suite.

Analytical Method	Target Analytes
Moisture content[1]	Weight percent moisture in subsurface sediment
pH[1]	pH of 1:1 sediment to water extract[2]
Specific conductivity[1]	Specific conductivity of 1:1 sediment to water extract
Inductively coupled plasma spectroscopy (ICP)[3]	Elemental concentrations in 1:1 sediment to water extracts, 1:1 nitric acid extracts, and surface soil including Al, Ba, Ca, K, Mg, Sr, Na, Si, Fe, P, and S
Inductively coupled plasma – mass spectrometry (ICP-MS)[1]	Isotopic concentrations in 1:1 sediment to water and 1:1 nitric acid extracts ^{99}Tc, ^{238}U, ^{53}Cr, ^{82}Se, ^{98}Mo, and ^{101}Ru
Alkalinity[1]	Alkalinity (as $CaCO_3$) of 1:1 sediment to water extracts at pH 4.5 and 8.3

Table 3-1. Analytical Methods and Analytes in the Tier 1 Analytical Suite.

Analytical Method	Target Analytes
Carbon analysis[1]	Total carbon, inorganic carbon, and organic carbon (by difference) of subsurface sediment
X-ray fluorescence (XRF)[1]	Trace element concentrations of Ni, Cr, Sc, V, Ba, Rb, Sr, Zr, Y, Nb, Ga, Cu, Zn, Pb, La, Ce, and Th in subsurface sediment
Ion chromatography (IC)[3]	Anions including fluoride, formate, chloride, nitrite, bromide, nitrate, carbonate, sulfate, oxalate, and phosphate in 1:1 sediment to water extracts, 1:1 nitric acid extracts, and surface soils
Alpha energy analysis	Concentrations of ^{241}Am/^{244}Cm in surface soil samples.
Gamma energy analysis (GEA)[3]	Gamma-emitting radioisotopes ^{40}K, ^{60}Co, ^{137}Cs, ^{154}Eu, and ^{238}U concentration in subsurface sediment and surface soil.
Gross alpha[1]	Total alpha activity in 1:1 sediment to water and 1:1 nitric acid extracts
Gross beta[1]	Total beta activity in 1:1 sediment to water and 1:1 nitric acid extracts
^{90}Sr[4]	Concentration on ^{90}Sr in surface soil samples
Isotopic uranium[4]	Concentrations of ^{234}U, ^{235}U, and ^{238}U in surface soil samples
Isotopic plutonium[4]	Concentrations of ^{238}Pu, ^{239}Pu, and ^{240}Pu, in surface soil samples

[1]Analysis of subsurface sediment samples only.
[2]1:1 sediment to water and 1:1 nitric acid extractions will be done on subsurface samples only.
[3]Analyses of both surface soil and subsurface sediment samples.
[4]Analysis of surface soil samples only.

In addition to the laboratory analyses, the Tier 1 suite includes spectral gamma geophysical logging (^{40}K, ^{60}Co, ^{106}Ru, ^{125}Sb, ^{126}Sn, ^{134}Cs, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{232}Th, ^{235}U, ^{238}U, ^{234m}Pa, ^{239}Pu, and ^{241}Am), radiation screening during drilling and sampling, GPR surveys, EMI surveys, ground-level radiometric surveys to screen for anomalous gamma- emitting radionuclides, observations of the surface during surface soil sampling, and a detailed geologic description of the samples. One aspect of the geologic description and the observations during surface soil sampling is to look for any indication that a sample has been affected by man. To a certain extent, the lack of anthropogenic influence suggest that no contamination exists.

Use of Tier 1 Results. The results of the Tier 1 analyses will be used in two ways. First, all of the Tier 1 analyses will be used to determine whether contamination is present. The results of the surface geophysical surveys and the ground-level radiometric surveys will indicate whether the near-surface soil has been disturbed and whether manufactured objects are buried in the shallow subsurface. The lack of disturbance suggests the lack of existing contamination. The observations made during drilling and sampling activities will indicate whether the samples

have any unusual attributes (e.g. discoloration, high moisture content, etc.). The lack of unusual attributes suggests the lack of existing contamination.

The concentrations of radionuclide and chemicals from the laboratory analyses will be compared to background values for the Hanford Site. If the Tier 1 analytical results are within three standard deviations of the Hanford Site background concentrations, the site is assumed to have no existing contamination.

If any of the Tier 1 results suggests that existing contamination is present, Tier 2 analyses will be defined and implemented.

Some of the Tier 1 results also serve as background or reference concentrations for leachate samples collected during vadose zone monitoring during facility operation and closure.

Process and Waste Disposal Knowledge. In addition to the systematic approach discussed earlier, records of past spills, effluent discharges, and process knowledge can be used to supplement the tiered approach.

Organics. Herbicides and pesticides are used to control vegetation growing over and intruding into waste sites and therefore may be expected in soils adjacent to where they have been applied. The general survey did not reveal any field evidence of suspicious occurrences (stained ground, odor, tip-offs, etc.).

3.7.2 Sample Size

The number of samples needed can be determined based on general statistical criteria in accordance with the following:

> *If the limits of acceptable errors are specified, for example if the level of confidence is 95%, margin of error is 10% and the statistical parameter of concern is the mean, the number of samples can be specified.*

This applies primarily to soil and air samples. Sampling points for characterizing the deeper vadose zone by drilling and sampling are selected based on professional judgment considering past operations, potential contaminant transport mechanisms through the vadose zone, and cost-effective environmental screening. Statistical criteria for the preoperational phase are addressed in Sections 3.8 and 3.9.

Biotic media generally are not amenable to systematic sampling. In this case, judgment must be used based on consideration of disturbance to the desert ecosystem and on availability of biological material.

3.7.3 Sampling Frequency

Sampling frequency is discussed in Section 3.6.2.

3.7.4 Site Conditions

Site conditions include the existing environment of the site, before construction and operation of the IDF. Appropriate aspects of the existing environment are radiation and inhalation hazards, contaminated surface and subsurface soils and vegetation in the construction area, and existing groundwater quality. These will be described based on a combination of existing data and data obtained during preoperational baseline monitoring. Proposed decision rules for which the performance contractor could use the environmental baseline data generated for this plan are discussed in the following paragraphs.

General Conditions. Comprehensive surveys of the IDF site will be conducted using surface geophysical methods to detect buried anthropogenic objects and discontinuous geologic features. A ground-level radiometric survey will be conducted to screen for anomalous gamma-emitting radionuclides. If geophysical or radiometric anomalies are encountered, follow-up sampling and/or excavation will be conducted at those sites. A decision rule is not appropriate for these "discovery"-type activities; however, the information will be incorporated into the preoperational baseline.

Personnel Exposure. Preoperational monitoring will establish the baseline preconstruction and operations worker safety issues involving both whole-body gamma radiation exposure and inhalation of particulate contaminants. Conservative decision rules the performance contractor could use include the following:

> *If whole-body gamma fields are less than 100 mrem/yr, unrestricted work access will apply.*
>
> *If average ambient particulate radionuclide concentrations (air filters) of key constituents in the vicinity of the project site are less than 1/100th of the derived concentration guides, respiratory protection (radiological) will not be required and existing airborne contaminants from upwind sources will not be considered as a hazard to personnel.*

Dose rates will be determined for penetrating radiation using TLDs. Respiratory protection from blowing dust associated with excavation and related operations of the trenches will have to be monitored as part of the operational monitoring activities. Good management practices during operations (e.g., wetting down exposed surfaces) can minimize this problem and reduce any resuspension of (potential) particulate contaminants, but may not be allowed where wetted soil will be placed near the waste form.

Surface Soil Contamination. Existing data from aerial gamma surveys show minor gamma contamination in the northern part of the IDF site (EGG-10617-1062). Also, possible anomalies could be associated with the ash disposal pile in the northwest. The spatial coverage of soil sample results throughout the site is inadequate to map the entire IDF site in detail. Results from a statistically based sampling plan for surface soils can be used to address this issue, as well as estimate existing contaminant variability for use in establishing a preoperational environmental baseline. A decision rule using surface soil sample results for the preoperational baseline within the site boundaries could be as follows:

If (or where) concentrations of contaminants of concern in the surface soil samples are greater than three times the established background for the Hanford Site soil, that area can be considered to be contaminated by past Hanford Site practices.

If analysis of surface samples, surface geophysical surveys, or biotic sampling indicate the existence of contamination in the study area, new boreholes may need to be drilled. Then sampling and analysis and geophysical logging from these boreholes may be needed to sufficiently describe the nature and extent of the contamination. Surface samples taken for baseline purposes (i.e., to define existing conditions immediately beneath the study area) can be archived for future analysis if they are free of contamination.

Subsurface Soil Contamination. Two conditions need to be considered in the preoperational baseline monitoring. They are the influence of past practices on the proposed disposal site and existing baseline conditions at the site.

As noted in the conceptual model and discussion of past-practice sources, a small potential exists for lateral spreading of contaminants at depth from sources near the east edge of the study area and the northern part of the west edge of the study area. Lateral spreading of contaminants in the vadose zone has been shown to occur at some of the PUREX past-practice, liquid waste disposal facilities in the southeast 200 East Area. Given the distance from the proposed disposal site to the nearest once-active facility (about 180 m [590 ft] to the 216-A-45 Crib), lateral spreading in the vadose zone beneath the study area is considered unlikely. Gamma logging and neutron moisture logging of existing boreholes, sampling and analysis and geophysical logging of the new groundwater wells along the east edge of the study site (PNNL-13283, *Second ILAW Site Borehole Characterization Plan*) will address this question.

Two new boreholes were drilled to establish the presence or absence of past-practice influences on the IDF site. The boreholes were drilled outside the east fence line of the study area to minimize pathways to groundwater. The boreholes were drilled to groundwater to intercept the potentially impermeable paleosol identified at about 18 m (60 ft) in borehole 299-E17-21 (PNNL-12257). The boreholes were geophysically logged with spectral gamma and neutron moisture tools. Because the east fence line is the closest to a potential subsurface source, the absence of contamination at that location can be taken as evidence that the vadose zone farther from the cribs (e.g., the interior of the study area) is not contaminated.

The presence or absence of contamination in the vadose zone will be based on the results of spectral gamma-ray and neutron moisture logs from boreholes along the east perimeter of the study site and on the results of laboratory analyses of Tier 1 analytes.

A decision rule for preoperational baseline purposes regarding use of Tier 1 analytical results as an indicators of subsurface contamination from past practice facilities east of the site could be as follows:

If (or where) the concentration of target compounds in the subsurface of the IDF site are less than three times the established background for the Hanford Site, then concentrations in the subsurface will be considered below levels of concern.

If Tier 1 results above background are observed (e.g., a concentration greater than three times the background signal for comparable lithology) or if contamination is suspected based on professional judgment, additional subsurface investigations using Tier 2 methodology may be necessary. The authority for additional investigations rests with the project manager.

Three approximately 15 m (50-ft) boreholes were drilled in the northwest portion of the IDF site to characterize any impact to the subsurface from the 241-B to BC Cribs pipeline in the area. The new boreholes were limited to 15 m (50 ft) deep because the excavated trench, including liner and leachate collection system, is not expected to be deeper than about 13 m (43 ft). The borings did not go deeper than 15 m (50 ft) to prevent creating a preferential pathway to the water table. These boreholes were geophysically logged and samples were collected for analysis of target compounds. The resulting preoperational data can be compared to existing Hanford Site background data for comparable lithologies (DOE/RL-92-24 and DOE/RL-96-12).

A decision rule for preoperational baseline purposes regarding use of Tier 1 analytical results as indicators of subsurface contamination from the 241-B to BC crib pipeline in the northwest part of the IDF could be the following:

> *If (or where) the concentration of target compounds in the subsurface of the IDF site are less than three times the established background for the Hanford Site, then concentrations in the subsurface will be considered below levels of concern.*

Possible contamination may be associated with the ash disposal pile in the northwest part of the proposed disposal site. To establish the preoperational baseline adjacent to the ash pile, three 3 m (10-ft) cores were placed around the perimeter of the pile for analysis of target contaminants that may be associated with coal ash. The ash pile itself was sampled as part of the systematic surface soil sampling. Samples of the ash also will yield background values for certain constituents (uranium, thorium, etc.) that are more concentrated in coal and coal ash than in soils.

Surface geophysical surveys (gamma surveys, EMI and GPR) and biotic monitoring (described in Chapter 4 and Appendix A1) were done in the area of the waste transfer line connecting the BY Tank Farm and the BC controlled area along the northern part of the west boundary of the IDF site. These activities were designed to accurately map the location of the transfer line and detect any near-surface artificial intrusion and soil contamination from transfer line leaks. The primary concern is worker safety during excavation of the trenches, as well as the establishment of a preoperational baseline.

Disposal of Contaminated Soil. During the preoperational monitoring period, contaminated soil in the IDF site may be identified. Disposition of any contaminated soil will require deciding whether to transfer the soil to the Waste Receiving and Processing Facility for further processing or transfer it to the ERDF for final disposal. The decision rule covering this issue is as follows:

> *If soil concentrations of key constituents exceed the industrial levels defined in the "Model Toxics Control Act"* [RCW 70.105D] *or equivalent risk-based standards established by the Hanford Site environmental restoration contractor, such soil may have to be removed and transferred to the Environmental Restoration Disposal Facility.*

Good management practices also apply to controlling excavated soil left at the construction site (i.e., spoils pile configuration that minimizes dispersal of windblown dust, use of dust suppressants, etc.).

3.8 SPECIFY LIMITS ON DECISION ERROR

This section describes statistical considerations used to augment the quantitative decisions and decision rules as discussed in Sections 3.4 and 3.7. Specifically, methods are provided to obtain the needed number of samples for characterizing existing environmental conditions before startup of the disposal facility. This section also discusses applying these baseline values for determining compliance with applicable standards (e.g., applicable or relevant and appropriate standards, limitations, criteria, and requirements). The methods presented in Sections 3.8.1 through 3.8.3 should be followed for all important parameters in media (e.g., soil, water, external radiation, and air) likely to indicate a contaminant release pathway from within the disposal site.

3.8.1 Statistical Objectives

Statistically, the primary objectives are as follows:

- To obtain adequate information for establishing the preoperational environmental baseline
- To identify and estimate the sources of data variability (i.e., spatial and temporal).

A sufficient number of samples must be taken to determine, with some degree of statistical confidence, the variation in existing or background concentrations (baseline condition) for each parameter of interest. Statistical considerations relative to the monitoring program design are based on guidance found in DOE-LLW-13Tg, *Low Level Waste Management Handbook Series: Environmental Monitoring for Low Level Waste Disposal Sites*; EPA/230-02-89-42, *Methods for Evaluation the Attainment of Cleanup Standards, Volume 1: Soil and Solid Media*; PB89-151047, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Interim Final Guidance*; and EPA/530-R-93-003, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance*; and *Statistical Guidance for Ecology Site Managers* (Ecology 1992); and *Guidance on Sampling and Data Analysis Methods* (Ecology 1995).

3.8.2 Selection of the Statistical Parameter

To obtain an adequate number of samples, selecting the appropriate statistical parameter(s) (e.g., the mean concentration or a specified upper percentile of the distribution or both) and developing relevant decision rules to address the questions described earlier are important. For example, for a compliance decision (e.g., surface soil contamination decision, [see Section 3.6]), if the regulatory standards are based on short-term or acute toxic effects on human health or the environment, an upper percentile soil concentration should be used to evaluate compliance with standards. However, if the regulatory standards are based on chronic or

carcinogenic threats, the mean concentration should be used to evaluate compliance with standards unless coefficients of variation (CV) [CV, $\bar{x}/s)*100$] are large or a large percentage of concentrations are below the limit of detection.

For decisions related to environmental baseline conditions, it is important to define background level in statistical terms. For purposes of this plan, the objective is to characterize the preoperational background conditions for the IDF site. In this case, the statistical objective is to provide adequate numbers of samples to define the mean and standard deviation for the identified key constituents of concern (i.e., parameters of interest).

3.8.3 Sample Size Determination (for Estimating Means)

As noted in Section 3.8, the statistical objective is to ensure that enough data are collected to obtain adequate estimates of the central tendency and variation in background for each parameter of interest. Attempts should be made to identify and estimate the sources of data variability (i.e., spatial and/or temporal variations). If the data contain a significant temporal component, considering different time segments (e.g., seasons) for which separate background averages are calculated is appropriate. Similarly, if the data contain significant spatial variation, separate background averages should be computed for each spatial group.

The sample size needed to yield a $(1-\alpha)\%$ confidence interval with a specified width is determined as follows:

- Level of confidence, $(1-\alpha)\%$
- Variability presented in the population, σ^2
- Magnitude of error that can be calculated, $d = |\bar{x} - \mu|$

The sample size needed is

$$n = \left(z_{1-\alpha/2} \frac{\alpha}{d} \right)^2 \tag{1}$$

Where $z_{1-\alpha/2}$ is the $100(1-\alpha/2)\%^{th}$ quantile of the standard normal distribution. When a reliable value for σ^2 is not available, but the relative population standard deviation (the coefficient of variation = σ/μ) is known, the needed sample size becomes

$$n = \left(z_{1-\alpha/2} \frac{\sigma/\mu}{d/\mu} \right)^2 \tag{2}$$

Table 3-2 shows the sample size needed for various combinations of CV (percent) and acceptable margin of error. A confidence level of 95 percent and a margin of error of 10 percent are recommended in DOE-LLW-13Tg, page 5.3.

Table 3-2. Sample Sizes Needed for Various Combinations of Margin of Errors and CV (%) at a 95% Confidence Level.

CV (%)	Margin of Error			
	10%	20%	25%	30%
20	16	4	3	2
30	35	9	6	4
40	62	16	10	7
50	96	25	16	11
60	139	35	23	16
70	189	48	31	21
80	246	62	40	28
100	385	97	62	43
120	554	139	89	62
150	865	217	139	97

If the data exhibit temporal and/or spatial variations, more than one background average is needed and the required sample size must be increased accordingly. For example, assuming CV percent is estimated to be 30 percent (using existing information) and a 10 percent margin of error is deemed acceptable, a sample size of 35 is needed if a single background is determined to be sufficient to represent the entire set of characterization monitoring data for a given parameter. If two time segments are expected (say, summer and winter), the total number of samples = 35 * $\sqrt{2}$ + 2 = 52 and the number of samples to be collected for each season is 26. Specific temporal and spatial variations can be identified using analysis of variance (ANOVA) procedures once the characterization data have been collected.

Final determination of time segments and/or spatial clusters should be made only after the characterization data become available. Before preoperational monitoring, only a general idea of the number of time segments (or spatial clusters) is needed to enable determination of the total sample size for initial preoperational sampling. After initial data are analyzed, additional preoperational sampling may be required.

3.9 OPTIMIZE DESIGN FOR OBTAINING DATA

3.9.1 New Data

Very little information is available about surface and subsurface soil and biota in the IDF site because the site has not been used for chemical separations processes or waste disposal. Some air monitors are located in the general vicinity of the study site, and additional air monitoring data will be collected as part of the preoperational environmental monitoring. Only those data needs subject to statistical design (surface soil, subsurface sediment, and air)

are considered in this section. Other information and alternatives such as borehole geophysics, GPR, EMI, and gamma survey of vegetation are described in Section 3.7 and Chapter 4.

3.9.1.1 Surficial Soil Sampling Design

The statistical model defined by Equation 2 is used for the following discussion. The number of soil samples needed to define existing conditions within limits with a desired 10-percent margin of error (Table 3-2) vary widely depending on the CV for the area under consideration.

DOE-LLW-13Tg, page 4.7, recommends a sample spacing of 100 m by 100 m for a baseline soil sample collection grid. Samples can be taken systematically at the center of each grid or randomly within each grid square, as shown in Figures 3-5a and 3-5b, respectively.
The systematic random sampling as shown in Figure 3-5b provided the same spatial coverage as the systematic grid center sampling with a total of 56 samples. Because with the random sampling the samples are not regularly located at the center of each grid square, the short-scale spatial variability of less than 100 m can be better captured using random sampling than the grid center sampling scheme. This is an advantage to the future mapping of the IDF site when geostatistics can be applied using the initial baseline samples.

As discussed previously, the initial baseline sample results should be used to determined if an adequate number of samples have been taken. If more samples are needed, the grid can be supplemented. For 56 samples and a margin of error of 10 percent, the calculated CV for preoperational data must be no more than 37 percent (Equation 2). Considering the low concentration and range of CV from the few existing data (1999 monitoring data for ^{90}Sr, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, and $^{239/240}Pu$ [PNNL-13230]) the sampling design shown in Figure 3-5b should result in the collection of adequate number of soil samples for the initial baseline. This can be validated with the CVs from the analytical results of the initial 56 samples. If the CV for a soil constituent is less than 37 percent, no additional samples would be needed, otherwise, additional samples would be needed to satisfy Equation 2.

Figure 3-5a. Sample Grid with Samples Systematically Located at the Center of Each Grid Square.

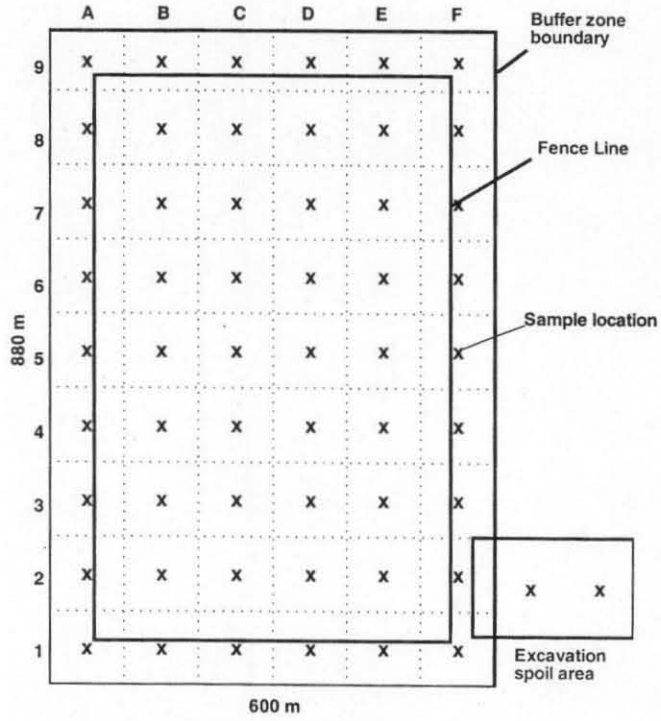
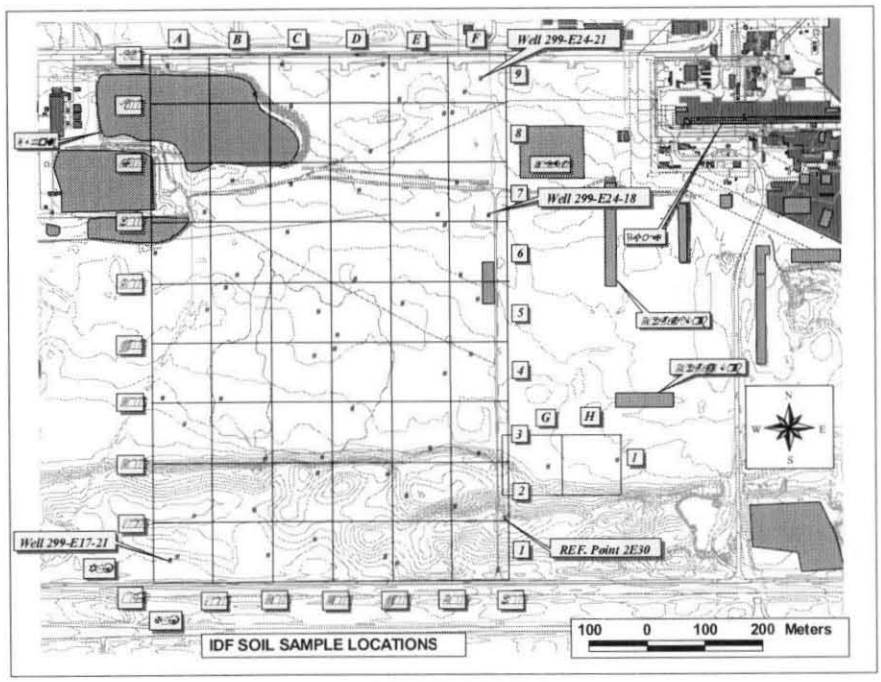


Figure 3-5b. Sample Grid with Samples Located Randomly Within Each Grid Square.



3.9.2 Subsurface Conditions Screening

As discussed in Section 3.8, the number of boreholes can be determined from the recommended margin of error of 10 percent and the relative population standard deviation (CV percent) at a confidence level of 95 percent. Some CV of the target constituents (Section A1-4.2.5) can be calculated from the existing and published Hanford Site background data (DPE/RL-92-24 and DOE/RL-96-12). Note that Equation 2 is used to determine the number of samples, which are assumed normally or log normally distributed. Based on the available Hanford Site background data, the number of samples ranges from 20 to 47.

Fifty one samples have been collected from borehole 299-E24-21 and analyzed for Tier 1 constituents. Eleven samples have been collected from borehole 299-E17-22 and will be analyzed for Tier 1 constituents. Both of these boreholes are along the east boundary of the IDF site. Forty samples have been collected for Tier 1 analyses from the three 15 m boreholes in the northwest part of the site. Thus, 102 samples of subsurface sediment will be available. The analyzed results for the target constituents will be compared to those of the existing background data. If the results suggest subsurface contamination is present, the need to define and analyze for Tier 2 constituents and for additional boreholes will be considered.

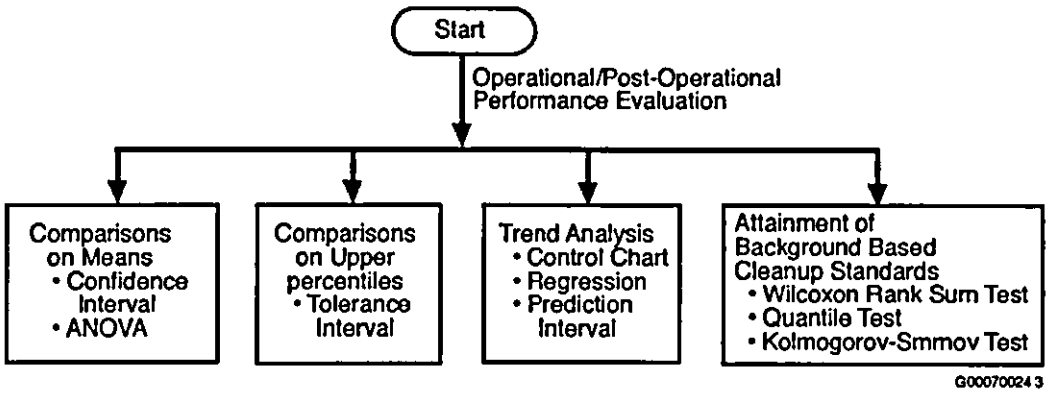
3.9.3 Application of the Baseline Data

Although defining other uses for the data is beyond the scope of this plan, it is important to recognize that future uses will be made of the preoperational baseline data. These uses could include the following:

- The data could be used as baselines for performance evaluation during the operational monitoring phase, which runs from the start of site operations until the site is decommissioned. Operational data are statistically compared to the preoperational baseline data and/or to regulatory controls to meet the monitoring objective, which is detection of a release.
- The data could be used as baselines for performance evaluation (attainment of cleanup standards) during the post-operational monitoring phase.

Figure 3-6 and Sections 3.9.3.1 through 3.9.3.6 summarize the applications and possible actions or decisions. It should be noted that at a future date operational and postoperational monitoring programs will be developed based on the monitoring objectives using the DQO process.

Figure 3-6. Application of Preoperational Monitoring Data.



3.9.3.1 Analysis of Variance

The ANOVA is a statistical method that provides an initial overall test of the equality of two or more means and determines the quantities necessary to make further specific comparisons among the means. In the context of environmental monitoring, monitoring points (with samples collected over a different time span) or a group of monitoring points (with samples collected at the same time) can be evaluated using the ANOVA procedure. For example, one comparison of interest is between the mean concentration of preoparational data and the mean concentration of the compliance (e.g., operational) data. Parametric ANOVA usually assumes that the data are distributed normally with a common variance. If data are not suitable for a parametric ANOVA, ANOVA based on ranks (nonparametric ANOVA or the Kruskal-Wallis test) may be appropriate. Details of these various ANOVA methods are given in PB89-151047 and EPA/530-R-93-003.

3.9.3.2 Confidence Interval

During operational monitoring, operational data may be required for comparison with a fixed regulatory standard (such as an alternative concentration limit) as stipulated in the facility permit. In this situation, the confidence limit on the mean of the operational data (for a particular constituent of concern) may be calculated and compared to the applicable regulatory standard. A lower one-sided 99-percent confidence limit is recommended in EPA/530-R-93-003. If the lower confidence limit exceeds the fixed regulatory standard, it is interpreted as statistically significant evidence that the true mean concentration exceeds the regulatory standard and therefore represents a possible permit violation.

3.9.3.3 Tolerance Intervals

During the operational phase, if the monitoring objective is to provide timely results to alert management about unusual conditions, tolerance limits can be constructed using preoperational (detection monitoring) or operational (compliance monitoring) data. A tolerance interval is constructed in such a way that it contains at least a specified proportion, P (called the coverage), of the population with a specified degree of confidence, $(1 - \alpha)\%$ (referred to as the tolerance coefficient). A coverage of 95 percent and a tolerance coefficient of 95 percent are used

following recommendations in PB89-151047 and EPA/530-R-93-003). These recommendations are consistent with methods for defining background concentrations as required under WAC 173-340, "Model Toxics Control Act Cleanup Regulation." Tolerance intervals can be constructed from the preoperational monitoring data. Individual samples collected during the compliance monitoring period found to be outside the tolerance limits signal possible environmental contamination.

Parametric tolerance limits (appropriate for normally or log-normally distributed data) are of the form:

$$\bar{x} + ks \text{ (one sided)}$$

$$\bar{x} \pm ks \text{ (two sided)}$$

where $\bar{x}$ is the sample mean; k is a multiplier based on the coverage, the confidence level, and sample size; and s is the sample standard deviation. Values of k can be obtained from *Experimental Statistics* (Natrella 1966). These parametric limits depend heavily on the normality (or log-normality) assumption. Therefore, before using them, the adequacy of using normal (or log-normal) distribution as a model should be assessed by probability plots and/or statistical goodness-of-fit tests, such as the Shapiro-Wilk test or the Lilliefors test of normality (Gilbert 1987, Conover 1980).

When the normal or log-normal distribution cannot be justified, the use of nonparametric tolerance intervals may be considered. The upper tolerance limit is usually the largest observed value in a random sample. However, the nonparametric tolerance intervals require a large number of samples to provide a reasonable coverage and tolerance coefficient. The number of samples need for a coverage of P% and a tolerance coefficient of $(1 - \alpha)\%$ is (Gumbel 1958, page 68):

$$n = \log_{10} \alpha / \log_{10} P \qquad (3)$$

To have a minimum coverage of 95 percent with 95 percent confidence, 56 samples are needed. Additionally, for tolerance limits to be useful, resampling has to be allowed before a decision is reached because the tolerance limits have a built-in failure rate of (1 - P)%. For example, 1 in every 20 samples would be expected to be outside the 95 percent tolerance limits. To decrease the chance of a false positive decision because of either the built-in failure rate or the effects of gross errors in sampling and analysis, verification resampling is necessary. This is the best available approach to balance false positive and false negative decisions (Gibbons 1994).

3.9.3.4 Prediction Intervals

Prediction intervals are constructed to contain the next sample values from a population or a distribution with a specified probability (e.g., 95 percent). Prediction intervals are useful in two types of comparisons. The first is when compliance data are being compared to background (baseline) values. In that case, the prediction interval is constructed from the baseline data. Any future compliance data found to fall outside the upper prediction limit signal possible environmental contamination. The second type is when intra-point (e.g., well) comparisons are being made on an uncontaminated sampling location. In that case, the prediction interval is

constructed on past data sampled from the location and used to predict the behavior of future samples from the same sampling location. Details on how to construct prediction intervals are provided in PB89-151047 and EPA/530-R-93-003.

3.9.3.5 Control Charts

In many industrial applications, a control chart is constructed to compare the operational mean for a given constituent at a given time to the action level. For these applications, the sample mean is a better estimate of the true population mean than an individual value. Thus, using the sample mean can reduce the probability of a decision error. However, for a low-level waste disposal site, the control chart must be designed to compare individual values rather than means (unless replicate values are obtained from the same sampling location). This comparison is needed because of the directional nature of releases from the site. Not all sampling locations will be affected equally from a release of a contaminant that is transported by air or water. In fact, in most cases, only a few sampling locations are likely to be affected. If overall means were compared, a significant release might go undetected. The following steps to construct a control chart for individual sample values are recommended in DOE-LLW-13Tg pages 5.24 through 5.40:

1. Determine the operating background level (OBL) on the basis of preoperational background data by

$$OBL = \bar{x}_b + s_b \tag{4}$$

   where x_b and s_b are the preoperational background mean and standard deviation, respectively. Equation (4) assumes that normal and proper operation of a waste disposal site can result in some increase of concentrations above preoperational levels.

2. Set the action level (AL) as

$$AL = OBL + 1.5 * s_b \tag{5}$$

   where OBL and s_b are defined in the first step.

3. Construct a plot of concentration versus time for each constituent of interest at each sampling location showing lines representing $\bar{x}_b$, OBL, and AL. As the operational data are collected, plot the individual values and compare them to the AL. Watch for values exceeding the AL, as well as for any long-term trends exhibited in the data. Such trends may indicate a system that is out of control even though the AL may not have been exceeded.

   Equation 5 can be expressed as in the general form

$$AL = OBL + k * s_b \tag{6}$$

It can be shown that when k is chosen to be 1.5, the probability of a false positive decision error is 6.7 percent (or 1 out of 15). A second type of decision error (false negative or, in statistical terminology, a Type II error) results from failing to detect an existing problem. A lower AL

reduces the chance of making the second type of error, but increases the chance of making the first type. A proper balance can be achieved with an appropriate setting of the AL. Setting AL = OBL + 1.5 * s_b would give the optimum balance between the two types of decision errors if the costs associated with the false negative error are roughly the same as those of a false positive. The probability of making each error is 6.7 percent. Based on recommendations made in DOE/LLW-67T, page 5-40), the AL initially should be set at OBL + 1.5 * s_b (for individual samples) to protect against the possibility of either type of error. After some site experience is gained, if the costs of making false alarms are greater than those associated with a false acceptance, the AL might have to be revised upward.

Another important aspect is monitoring trends in the control chart. If a detectable trend (departure from random behavior) is evident at the time AL is exceeded, it should be taken as a signal for corrective action.

Attainment of Background-Based Standards. During operational and/or postoperational monitoring periods, if the regulatory compliance standards (e.g., cleanup levels) are based on background monitoring data, statistical tests such as the Wilcoxon Rank Sum (WRS) test and/or the Quantile test may be used (PNL-SA-17907, *Statistical Sampling Analysis Issues and Needs for Testing Attainment of Background-Based Cleanup Standards at Superfund Sites*). If the remedial action has "uniformly" reduced contaminant levels, but not to background levels, the WRS test should be used because under these conditions it has greater power than the Quantile test. However, if most of the cleanup unit has been remediated to background levels and only a few hot spots remain, the Quantile test is preferred because under these conditions it has more power than the WRS test. PNL-7409, *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-Based Standards for Soils and Solid Media*, gives detailed procedures on how to perform these tests as well as on how to determine the total number of samples needed. It should be noted that the WRS test is sensitive to differences between two means or medians; it may not detect differences in variances. The Kolmogorov-Smirnov two-sample test (see Conover [1980], pages 368-369) has the advantage over the WRS test because it is consistent against all types of differences that may exist between the two distribution functions. However, the data needed for this test are not yet available.

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4.0 DESCRIPTION OF CHARACTERIZATION TASKS

This chapter summarizes the tasks needed to acquire the preoperational baseline data and information discussed in the previous chapters. The detailed specification of number, location, and analyses for the various sample media are included in the SAP (Appendix A1). These tasks are developed according to the decisions to be made (see Section 3.4) and are intended to integrate and coordinate sampling and analysis activities necessary for characterizing the IDF site. Analytes of concern and the rationale for determining those analytes are discussed in Section 3.7. Table 4-1 summarizes the tasks, sample media, analyte/category measured, extent, and time periods for collecting baseline data. As described earlier, this plan covers only the preoperational baseline phase. Primary uses of the data are to confirm the suitability of the site, to develop a baseline for future operations at the site, and to aid the designs of future monitoring plans (e.g., operational and postoperational phases). This plan provides a foundation on which subsequent plans can be based and provides early site baseline data with which construction-related decisions can be made.

4.1 SURFACE AND NEAR-SURFACE CHARACTERIZATION

The surface and near-surface studies include preliminary screening and sampling for radiological and chemical soil contamination; the location and description of buried structures and waste disposal sites using GPR and EMI surveys, geologic mapping, and ground-based radiologic surveys.

The top 2.5 cm of soil constitute the depth for surface soil based on considerations of the potential for direct exposure and the chemical and physical properties of potential contaminants of interest. This definition is consistent with the routine operational monitoring being conducted in the 200 Areas (HNF-EP-0573-6).

4.1.1 Surface Contamination Map

Objective. Comprehensive characterization of the surface of the IDF site will be conducted using ground-level radiometric surveys to screen for anomalous gamma-emitting radionuclides. If radiometric anomalies are encountered, follow-up sampling and/or excavation will be conducted at those sites. This task will produce a surface map showing radiological assessment of the surface soils in the planned IDF site. No areas of extensive contamination are known in and around the site (WHC-SD-WM-SE-021, *Tank Waste Remediation System Complex Site Evaluation Report*). However, as previously noted, a 1988 aerial survey (EGG-10617-1062) showed low levels of gamma radiation in and near the north part of the proposed disposal site. Also, some areas of contamination are located adjacent to the site designated for construction and emissions from facilities in the 200 Areas over the past several decades may have contributed to surface contamination at the site.

Table 4-1. Summary of Tasks for the IDF Preoperational Baseline.

Task[a]	Media	Method and Analytes Measured	Extent	Time Period
Surface soil characterization and contamination map	Surface soil (top 2.5 cm) and vegetation	Ground-based gamma and beta screen Radionuclide and inorganic target analytes (see Appendix A1)	IDF site Area between the site and waste disposal facilities to the east BY Tank Farm-to-BC controlled area transfer line Excavation spoils area	Preoperational
Anthropogenic features	Near-surface soil	GPR and EMS for buried anthropogenic features and discontinuous geologic features	IDF site BY Tank Farm-to-BC controlled area transfer line Excavation spoils area	Preoperational
Surface geological features	Surface soil	Standard mapping techniques for topography, texture, and geologic features	IDF site BY Tank Farm-to-BC controlled area transfer line Excavation spoils area	Preoperational
Subsurface characterization: Shallow vadose zone	Subsurface soil (top 3 m)	Radionuclide and inorganic target analytes (laboratory analyses)	IDF site near ash disposal pit and downwind. BY Tank Farm-to-BC controlled area transfer line (if needed)	Preoperational
Deep vadose zone	Subsurface soil to 15 m (50 m) and 23 m (75 ft) depth	Laboratory analysis for target analytes Gamma ray and moisture logging	Area between IDF site and waste disposal facilities to the east IDF site and vicinity	Preoperational
Air monitoring:	Air	Key radionuclides and inorganics	Upwind and downwind stations properly located[a]	Preoperational and operational
Biological monitoring:	Plants and animals	Radionuclide and inorganic analysis of plant and animal tissues[b]	As available	Preoperational and operational
Groundwater monitoring	Groundwater	Existing groundwater quality	To be determined in separate groundwater monitoring plan	

Table 4-1. Summary of Tasks for the IDF Preoperational Baseline.

Task[a]	Media	Method and Analytes Measured	Extent	Time Period
External radiation	Plants and animals	Thermoluminescent dosimeters	Borders of IDF site	Preoperational and operational

[a]See Appendix A1, Field Sampling Plan for detail.
[b]Gamma-emitting radionuclides in or on vegetation will be detected as part of the ground-level radiometric survey.
EMS = electromagnetic induction surveys. GPS = ground-penetrating radar. IDF = Integrated Disposal Facility.

Data Needs. The data needs from this characterization effort are the location of radioactive and hazardous chemical contamination and wind direction.

Extent of Surveys. The surveys will be conducted at the IDF site, the area over the BY Tank Farm-to-BC controlled area transfer line adjacent to the site, and the area of the excavation spoils pile. The radiological surveys will be conducted throughout the IDF site and the excavation spoils area on a predetermined 100 m (328-ft) grid (Figure 2-15). Radiological surveys also will be done to ascertain any leaks that may have occurred from the BY Tank Farm-to-BC controlled area transfer line adjacent to the site.

4.1.2 Anthropogenic Features

Objective. Comprehensive characterization of any existing manufactured features in the near-surface of the IDF site will be done using geophysical surveys. Ground-penetrating radar and EMI surveys will be conducted to detect buried anthropogenic objects and discontinuous geologic features, such as clastic dikes. If anomalies are encountered, follow-up sampling and/or drilling or excavation will be conducted at those sites if necessary. This task will produce a map of near-surface manufactured and geologic features in the proposed disposal site. One water line is known to run roughly east-west across the northern part of the site. That water line and the BC transfer line are the only manufactured features expected to be encountered. Clastic dikes are known to exist beneath areas near the study site and may be encountered in the subsurface of the IDF site. The use of surface geophysics at the site is described in detail in the SAP (Appendix A1).

Data Needs. The data needs from this baseline characterization effort are the locations of anthropogenic intrusion into the proposed IDF site and the locations of subsurface geologic features that could affect the construction or operation of the IDF.

Extent of Surveys. Geophysical surveys will be conducted throughout the IDF site and the excavation spoils area on a predetermined 100 m (328-ft) grid (Figure 2-15). Geophysical surveys also will be done to delineate that portion of the BY Tank Farm-to-BC controlled area transfer line adjacent to the site. Geophysical surveys also will be used to investigate the location of the east-west water line in the northern part of the site.

Assess Potential for Contamination at BC Crib Transfer Line. The potential for contamination adjacent to the study site in the near surface from possible leaking of a transfer line connecting the BY Tank Farm to the BC controlled area (Figure 2-16) will be investigated. This will be a priority survey and will involve the following steps (see Appendix A):

1. Precisely locate the transfer line with GPR and EMI surveys.

2. Evaluate the potential for transfer line leaks using field-based radiological surveys of soils and, if possible, plants along the transfer line route. This takes advantage of the characteristics of certain plants to take up specific radionuclides (^{90}Sr and ^{137}Cs) through their root systems.

3. If radiological or geophysical surveys identify leaks that may have affected the study site, further investigation may be necessary, including mapping the extent of the leaks using the GPR and EMI and placing shallow (about 3 m [10-ft]) boreholes for conducting borehole geophysical surveys.

4.1.3 Surface Geologic Characterization

Objective. This task will document the presence or absence of clastic dikes, faults, and geologic strata exposed at the surface of the IDF site. Some of these features may disrupt normal layering in the subsurface and potentially provide either vertical pathways or lateral barriers in the subsurface. The task also will document the extent of sand dunes that need to be excavated before constructing some trenches. The result will be a geologic map that is the principal way to document the geologic surface features at the site.

Data Needs. The following data are needed to support the surface characterization:

- Topography and landform description of site
- Textural description of site sediments
- Presence and location of clastic dikes, faults, and sand dunes.

Mapping. Surface geologic mapping has been done for the Hanford Site at scales of 1:62,000, 1:24,000, and, most recently, 1:100,000. None of these maps was designed to provide the detail the DQO process determined to be necessary for the IDF site. It was determined that a scale of 1:500 would provide sufficient detail for the site. The geologic mapping, in conjunction with the geophysical surveys, will yield a complete picture of the near-surface geology of the IDF site. Mapping the IDF site will occur after trenches 1 and 2 (cells 1 and 2) have been excavated. This will allow a more detailed exposure of the site for geologic observations.

4.1.4 Surface Soil Characterization Activities

The preoperational baseline monitoring of the surface and near-surface soil at the IDF site is discussed briefly in the following paragraphs. More detailed discussion is found in the SAP (Appendix A1).

Objective. Field screening and soil sample collection and analysis will be conducted at the IDF site to detect contamination resulting from past practices at the Hanford Site and provide a preoperational baseline for later facility operations and closure. The sampling scheme is statistically based. The results will produce a statistical background for comparison of operational monitoring results once the disposal facility begins operations and postoperational results at the time of closure.

Soil samples will be collected and analyzed for the radiological and chemical constituents identified in Appendix A1 as target analytes. Based on the limited available information from the area and the lack of operations within the area, significant existing contamination is not expected to exist. However, if anomalous areas of contamination exist, additional samples may

be required. In that case, this preoperational monitoring plan will be revised to address the specific contaminated areas.

Generally, for a preoperational baseline monitoring effort such as this, background samples would be taken at areas remote from the study site for comparison with those from the study site. Several recent efforts at the Hanford Site, documented in DOE/RL-92-24 and HNF-2067, *TWRS Phase I Privatization Site Preconstruction Characterization Report*, have analyzed samples suitable for this preoperational monitoring effort to use as remote background data. Existing data will be supplemented with minimal samples collected as part of this preoperational effort. Use of these data will substantially reduce analytical costs.

Data Needs. The data needs from this characterization effort are the geographic distribution of target constituents and the statistical distribution of the activities and concentrations of target constituents.

Extent of Survey. Samples will be collected from the IDF site according to a statistically determined grid. Grid nodes are on 100 m (330-ft) spacing throughout the site (including the excavation spoils area). Samples will be taken at predetermined but random locations within each grid block. (See Appendix A1 for an explanation of the sampling grid design and sample locations.)

4.2 SUBSURFACE CHARACTERIZATION

This task will determine the presence of radiological and chemical contaminants in selected locations in the vadose zone at the IDF site. The primary concern is to provide a preoperational baseline of soil constituents and to ascertain whether past-practice operations have contributed contamination to the site. The information provides a baseline of the subsurface for later construction, operation, and closure.

4.2.1 Shallow Subsurface Characterization

Objective. This task will provide baseline characterization of the part of the proposed disposal site that is adjacent to the existing ash disposal pile in the northwest corner.

Fayer et al., in analyzing recharge data for the 2001 ILAW PA (PNNL-13033), suggested that any contamination from the 284 East Powerhouse, ash pit, and ash disposal pile that may exist in the area is probably deeper than about 1.8 m (6 ft). This baseline effort will obtain samples from three 3 m (10-ft) cores immediately adjacent to the ash disposal pile to determine whether metals have been leached from the ash since the power plant became operable in the mid 1940s. In accordance with the recommendations in the 2001 ILAW PA (PNNL-13033), the cores will be sampled at 20 cm (8-in.) intervals.

Samples from the short coreholes adjacent to the ash pile will be analyzed for only those target constituents that may be expected from contamination caused by coal ash. These include the metals and the anions. Note that analyses for these target constituents using the methods given

in Appendix A1 also will yield concentrations for several other metals and anions commonly associated with coal.

Data Needs. The primary data needed from this task are the contributions of target constituents to the shallow subsurface from the ash disposal pile.

Extent of Surveys. Shallow subsurface baseline data are restricted to the area immediately adjacent to the ash disposal pile and to a depth of 3 m (10 ft).

4.2.2 Deep Vadose Zone Characterization

Deep vadose zone characterization will be accomplished by analyzing samples obtained from five new boreholes and by borehole geophysical logging. Chapter 3 gives justification for and Appendix A1 gives the locations of the boreholes. The geophysical logging methods to be used include spectral gamma-ray and neutron moisture surveys. If subsurface contamination is found during the preoperational characterization of the subsurface, a determination of whether additional boreholes are needed to discern the nature and extent of the contamination will be made. If additional boreholes are needed, this preoperational monitoring plan can be augmented to reflect the additional activities. The decision to further investigate subsurface contamination rests with the project manager.

4.2.2.1 Objective

This activity documents the baseline characteristics of the IDF site before construction and operations. A second objective is to delineate any deep vadose zone contamination, although none is expected, resulting from past-practice activities that may affect construction and operation of the IDF.

4.2.2.2 Drilling.

Five new boreholes were drilled in and adjacent to the IDF site in 2001 and 2002. Three of the boreholes (C4169, C4170, and C4171) were drilled by auger to a depth of 15 m below ground surface in the northwest part of the site near the BY Tank Farm-to-BC controlled area transfer line. The locations of the auger holes were selected using professional judgment and accessibility of the drill sites. Two boreholes, 299-E24-21 and 299-E21-22, were drilled to depths of 102 m and 111 m (335 and 365 ft), respectively, along the eastern boundary of the IDF site. These two boreholes were sampled for preoperational baseline characterization purposes and competed as RCRA groundwater monitoring wells. (See Appendix A1 for borehole locations.)

The two boreholes drilled outside the east fence line of the study site are between the site and the 218-E-1 Burial Ground and between the study site and the 216-A-45 Crib. Samples from these boreholes are to determine what, if any, influence past-practice waste disposal facilities have had on the proposed location of the IDF.

The number of samples obtained from the three boreholes drilled within the northwestern part of the IDF site was determined from the expected statistical variability of the concentrations of

target constituents based on existing and published Hanford Site background data (see Section 3.9 for analysis of number of boreholes). The number of samples to be analyzed from the two deeper wells on the east boundary of the site will be based on professional judgment and selected to encounter any possible contamination from the disposal facilities east of the site associated with the paleosols beneath the site. All five boreholes were geophysically logged.

4.3 AIRBORNE PARTICULATE CONTAMINANT BASELINE MONITORING

This task will involve coordinating with existing environmental programs conducted by the Hanford Site Environmental Surveillance Program and the Near-Facility Environmental Monitoring Program for sampling and maintenance of the continuous air monitoring stations. Two downwind stations are currently sampled quarterly by the Hanford Site Environmental Surveillance Program and two upwind stations are sampled bi-weekly by the Near-Field Environmental Monitoring Program. In addition, installation of new stations will be needed.

4.4 BIOTIC MONITORING

The biota (plants and animals) that exist in an area where a new waste process or facility will be placed represent an important part of the environment. Plants can act as bioindicators of the quality of the environment because of their ability to take up and incorporate contaminants into their tissues. This can occur by direct uptake through their root systems or through aerial deposition of contamination on their surface structures (*Radioecology: Nuclear Energy and the Environment* [Whicker and Schultz 1982]). Animals also can act as indicators of environmental quality by direct ingestion of contaminated soil, water, plants, and prey items. Both also can affect the waste site by their activities. For plants (e.g., tumbleweeds), these activities can include growing on contaminated locations and then blowing to other areas; for animals (e.g., mice, ground squirrels), they can include burrowing into waste sites and bringing contaminated soils to the surface (Whicker and Schultz 1982).

For these reasons, sampling of plants and animals is an important component of preoperational surveys. All specimens collected will be treated in accordance with the accepted sampling procedures (see Appendix A1, Section A2.4.2) and will be analyzed for the same constituents as the soils; except for anions.

4.5 GROUNDWATER MONITORING

Groundwater monitoring for the preoperational environmental baseline will be addressed in a separate groundwater monitoring plan. That plan will examine the existing groundwater monitoring networks in the area and data from those networks to design the IDF network for environmental baseline purposes. Use of part or all of nearby existing networks for the preoperational, operational, and postoperational monitoring periods would substantially reduce costs associated with installing a completely new groundwater monitoring network, if one is determined to be necessary.

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APPENDIX A1

FIELD SAMPLING PLAN

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TERMS

AHA	activity hazards analysis
DOE	U.S. Department of Energy
EMI	electromagnetic induction
FSP	field sampling plan
GPR	ground-penetrating radar
ICP	inductively coupled plasma
IDF	Integrated Disposal Facility
MS	mass spectrometry
ORP	U.S. Department of Energy, Office of River Protection
PNNL	Pacific Northwest National Laboratory
RCRA	*Resource Conservation and Recovery Act of 1976*
SAP	sampling and analysis plan
TLD	thermoluminescent dosimeter
TWRS	Tank Waste Remediation System
XRF	x-ray flourescence

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APPENDIX A1

FIELD SAMPLING PLAN

A1-1 INTRODUCTION

This appendix and Appendix A2, provide the sampling and analysis plan (SAP) for preoperational monitoring of the Integrated Disposal Facility (IDF) site. The SAP contains two parts: a field sampling plan (FSP), Appendix A1, and a quality assurance project plan (QAPP), Appendix A2. These two components of the SAP will be used to control the sampling and data collection activities as described in the main body of this report (main document). The data collection activities described herein are the product of the data quality objectives process described in Chapter 3 of the main document.

The FSP was developed based on the decisions and decision rules discussed in Chapter 3 of the report. This FSP describes the rationale and procedures for sample selection and the analyses to be performed on soils, sediment, biota, thermoluminescent dosimeters (TLD), and air samples associated with surface and subsurface characterization at the IDF site. Chapter 4 summarized the various tasks, media, analytes to be measured, and extent of the proposed activity (see Table 4-1 of the main document). Procedures for sample collection, chain of custody, preservation, shipment, and chemical analysis are included by reference. Separate subsections cover specific media: surface soils, subsurface vadose sediments, biota, TLD, and air. It should be noted that the period of interest for this phase of the environmental planning for the project is the preoperational period. The data acquired according to this plan should be evaluated before developing an operational monitoring program.

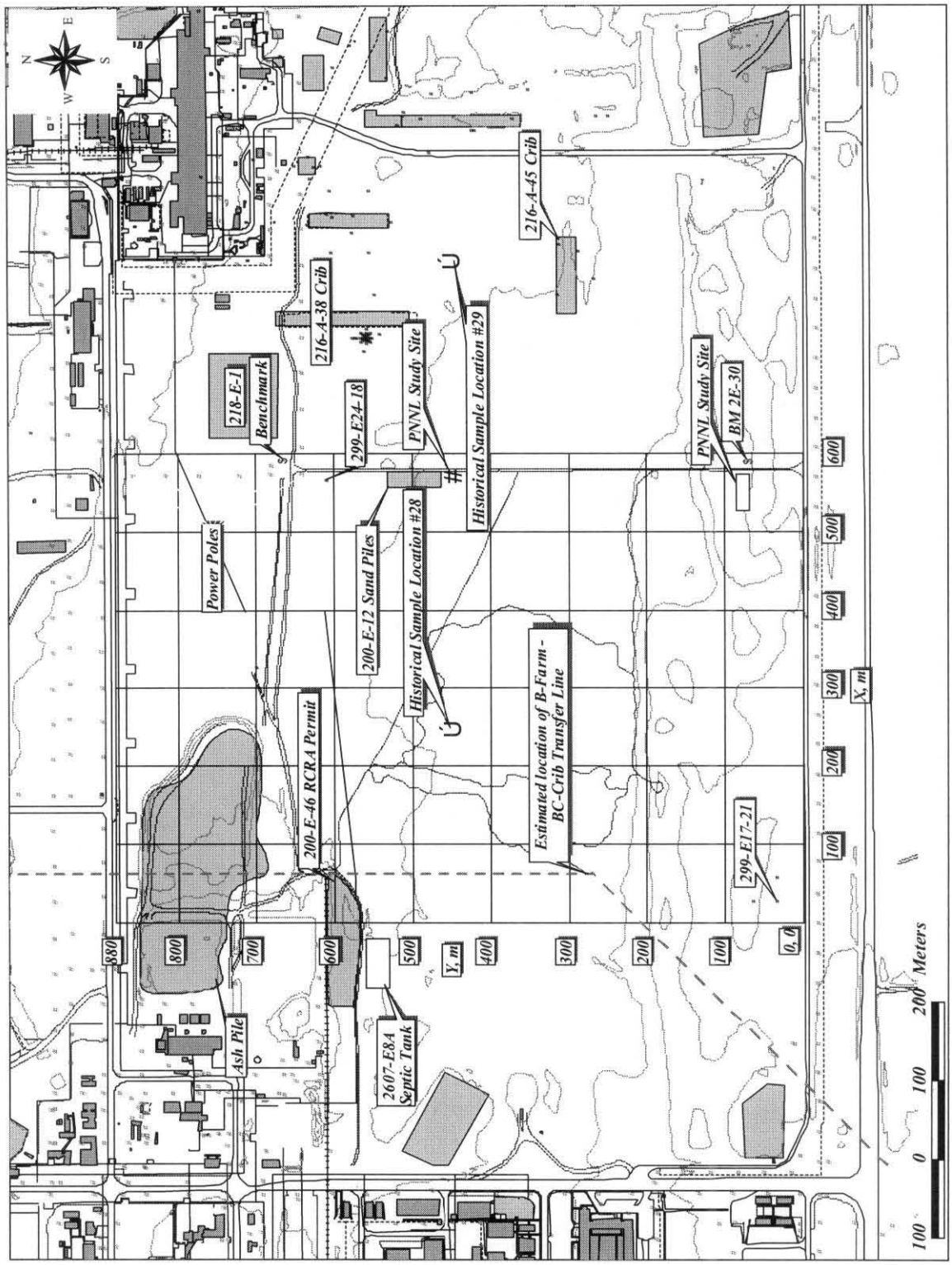
A1-2 SURFACE AND NEAR SURFACE CHARACTERIZATION

Surface and near-surface monitoring of the IDF Facility site include field radiological surveys, geophysical surveys, and radiological and chemical soil sampling.

A1-2.1 SURFACE RADIOLOGICAL SURVEY

A surface radiological survey was conducted of the IDF site and buffer zone. The survey was conducted on a 100 m by 100 m (328-ft by 328-ft) grid (Figure A1-1). This method used a Geiger-Müeller detector with a P-11 probe to detect beta and gamma contamination. Each grid line was surveyed by sweeping the hand-held instrument along a 1 m (3-ft)-wide path at 2.5 cm (1 in.) above the ground surface. The scanning speed did not exceed 25 cm (10 in.) per second. No contamination was discovered during the surveys.

Figure A1-1. Sample Grid for Geophysical Surveys.



Geophysical Surveys

This section describes the use of electromagnetic induction (EMI) and ground-penetrating radar (GPR) surveys at the IDF site. The geophysical surveys are used for the following reasons:

- Surveys allow precise interpretation of complex areas and recognition of features larger than one video frame.
- Depth interpretation can be well controlled.
- Multiple profiles can be compared and correlated.
- Hard copy and electronic files provide long-term data retention, which will be necessary for the environmental baseline.

Electromagnetic Induction

The objectives of the EMI and GPR surveys are the same: to identify and locate manufactured structures and discontinuous geologic structures. The following description of EMI is adapted from PNNL-10176, *A Survey of Existing and Emerging Technologies for External Detection of Liquid Leaks at the Hanford Site.*

Methodologies. The EMI surveys are based on the induction of electric currents in buried conductors by magnetic components of electromagnetic waves generated at the earth's surface. The waves originate from alternating currents at frequencies ranging from a few hertz to a few megahertz, which are passed through loops of wire on the ground. When the waves pass through a conducting body, they induce alternating electric currents in the conductive materials. These currents become the source of new electromagnetic waves that can be detected by suitable pickup coils (*Introduction to Geophysical Prospecting* [Dobrin 1976]). This method is highly recommended for detecting conductive (metallic) structures in the shallow subsurface. The procedure for EMI is found in BHI-EE-01, *Environmental Investigations Procedures*, Procedure No. 72, "Geophysical Survey Work."

The EMI method has been used widely at the Hanford Site primarily for detecting and mapping underground utilities, pipelines, buried debris, and other metallic or conductive materials. The depth of investigation is relatively shallow (<10 m [<33 ft]). As with GPR, the interaction and variability of the parameters affecting EMI emphasize the value of and need for trained and experienced personnel for both acquiring and interpreting data.

Interpretation of EMI Data. The EMI data are presented as a map or cross section of differences in conductivity. The quality of the maps and cross sections depends heavily on the skill and experience of the operators and interpreters. Thus, the data shall be collected and interpreted by a professional group who can determine the proper data acquisition conditions and set the equipment to perform correctly to the varying site conditions; the professional group must be able to interpret the data with respect to the site stratigraphy and geologic conditions.

Site Preparation. An orthogonal grid was established over the area of investigation (see Figure A1-1). The grid consisted of lines 100 m (328 ft) apart with the boundaries designated

with wooden stakes marked with grid coordinates. The ash disposal pile was not surveyed because the equipment does not penetrate deep enough to see through the accumulated ash to the underlying subsurface. Because the features targeted for detection are not point sources, each grid line was surveyed three times. One survey track was on the grid and the other survey tracks were approximately 1 to 2 m (3 to 6 ft) from the grid line, one on each side of the line.

Ground-Penetrating Radar

The objectives of the GPR survey were to identify and precisely locate manufactured structures (e.g., utilities, buried material, or excavations) in three dimensions up to 3 m deep and to identify discontinuous geologic structures.

Methodologies. GPR is an electromagnetic sounding method using radio frequencies to probe the ground for natural and manufactured features. The method provides a continuous record along a line traversed with its antenna. Interpreting this record provides both location and depth of buried materials and changes in geologic conditions. The procedures for GPR are in BHI-EE-01, Procedure No. 72.

The GPR systems need a source and a receiver. A radar antenna (source) emits an electromagnetic pulse several times a second. These electromagnetic impulses are directed into the ground in the form of waves. As the waves penetrate deeper through the geologic material, contrasts in electrical properties are encountered with changes in strata. These electrical contrasts (anomalies) cause some of the wave to be reflected back toward the surface where it is received by an antenna, while some of the wave continues downward. When enough anomalies have been encountered, very little of the signal remains to be reflected; this condition is termed the effective penetration depth. The time interval between the moments when the electromagnetic signal is emitted and when it is received from reflection depends on the properties of the material and on the depth at which the signal is reflected. Knowledge of site geology can be used to estimate the properties of the material and travel time so that the target depth can be estimated.

The antenna appropriate for this application is 100 mhz, which emphasizes coverage and depth penetration. An antenna is best selected after acquiring some representative test profiles across the project area during the initial phase of the investigation. The interaction and variability of the parameters affecting GPR emphasize the value of and need for trained and experienced personnel to both acquire and interpret the data.

Interpretation of GPR. A GPR profile represents a vertical slice or cross-section of the area traversed. The horizontal component represents the distance on the ground; the vertical component of the cross section represents time. Knowing the electromagnetic properties and radar wavelength allows a conversion of time to depth. The quality of the resulting maps and profiles relies heavily on the skill and experience of the operators and interpreters. Thus, the data shall be collected and interpreted by a professional group who can determine the proper data acquisition conditions and set the equipment to perform correctly for the varying site conditions; the professional group must be able to interpret the data with respect to the site stratigraphy and geologic conditions.

Site Preparation. Because of the thick vegetative cover over the IDF site, GPR was used to investigate anomalies identified during the EMI surveys and track the extent of underground structures such as the water line.

A GPR survey was performed within the grid of the BY Tank Farm-to-BC controlled area transfer line.

A1-3 SURFACE GEOLOGIC MAPPING

Geologic mapping has the following objectives:

- Identify geologic features (sand dunes, paleosols, clastic dikes, etc.) that may be present at the surface of the proposed disposal site
- Display geologic features on a map to facilitate later construction and operation of the proposed disposal site.

METHODOLOGIES

Standard geologic mapping techniques will be used to map the IDF site (*Field Geology* [Lahee 1961] and *Manual of Field Geology* [Compton 1962]). The base map will be a 1:500 topographic map with a 3 m (10-ft) or less contour interval. The area to be mapped includes the proposed IDF site, the excavation spoils area, and the buffer zone surrounding the site. No site preparation is necessary. However, the geological mapping will not be done until the excavation of cells 1 and 2 is completed. Geologic mapping will consist of mapping the excavations, which allows for a three-dimensional map for that portion of the site. Mapping after excavation will not devalue the geologic map for preoperational purposes because the excavation does not change the existing geology of the site.

A1-4 SURFACE AND NEAR SURFACE SOIL SAMPLING

This section describes the sampling plan for a preliminary assessment of soil contaminant conditions for the surface and near-surface soils. For surface soil sampling, the top 2.5 cm (1 in.) of the soil were collected and will be analyzed for the target constituents as identified in Section A1-4.3, unless otherwise specified. This sampling depth is consistent with the routine operational monitoring being conducted in the 200 Areas (PNNL-14295, *Hanford Site Near-Facility Environmental Monitoring Annual Report for Calendar Year 2002*). Surface soil samples were collected following DTS-SSPM-001, *Sampling Services Procedures Manual*, Technical Services Procedure 4.1.

A1-4.1 SAMPLING RATIONALE

The proposed site for the IDF was surveyed by aerial radiometric methods in 1988 (EGG-10617-1062, *An Aerial Radiological Survey of the Hanford Site and Surrounding Area Richland, Washington*). That survey indicated soil contamination caused by gamma-emitting radionuclides. The survey indicated that the northern part of the proposed disposal site lies in an area of minor detectable (or above-background) levels of gamma-emitting radionuclides. However, the existing data are inadequate to map the proposed disposal site area to the degree necessary for a preoperational baseline. Results from a statistically based sampling plan for surface soils are needed to address surface soil contamination issues (see Section 3.7.4 of the main document) as well as estimate existing background contaminant variability for use in plans for subsequent phases of the project.

A1-4.2 SAMPLING STRATEGY

Sampling strategies that address different soil sampling or survey objectives for this environmental baseline survey are discussed in Paragraphs A1-4.2.1 through A1-4.2.3.

A1-4.2.1 Integrated Disposal Facility Site

Surface Soil Sampling. The low-level waste guidance document (DOE 1990b) indicates that a spacing of 100 m x 100 m (328 ft x 328 ft) should be used for designing a baseline soil-sample collection grid. The grid can be designed as either a square grid or a square grid with a 45° offset (referred to as a diagonal grid). A diagonal grid was found to be optimal for the preoperational monitoring of the Tank Waste Remediation System (TWRS) (now U.S. Department of Energy, Office of River Protection [ORP]) Phase 1 Demonstration Site (HNF-SD-TWR-EV-001, *TWRS Phase I Privatization Site Environmental Baseline and Characterization Plan*). However, analysis of both the square grid and the diagonal grid showed that the diagonal grid gave no advantage at the more regularly shaped IDF site. Thus, a 100 m-by-100 m (328-ft-by-328-ft) square grid was chosen for preoperational monitoring at this site (Figure A1-1). Surface soil samples will be collected at or near the locations of randomly selected points within each 100 m-by-100 m block. Fifty-six potential sample points have been identified for analysis of target constituents within the main study area.

The sample locations shown on Figure A1-2 were located using the global positioning system before sample collection.

As discussed in Section 3.8 of the main document, the initial baseline sample results should be evaluated to determine if enough samples have been taken. If not, the grid can be supplemented. On the other hand, if no spatial variability is exhibited in the data, it is highly probable that the area contains a homogeneous population and the baseline data obtained in accordance with this plan can be used as a preoperational baseline.

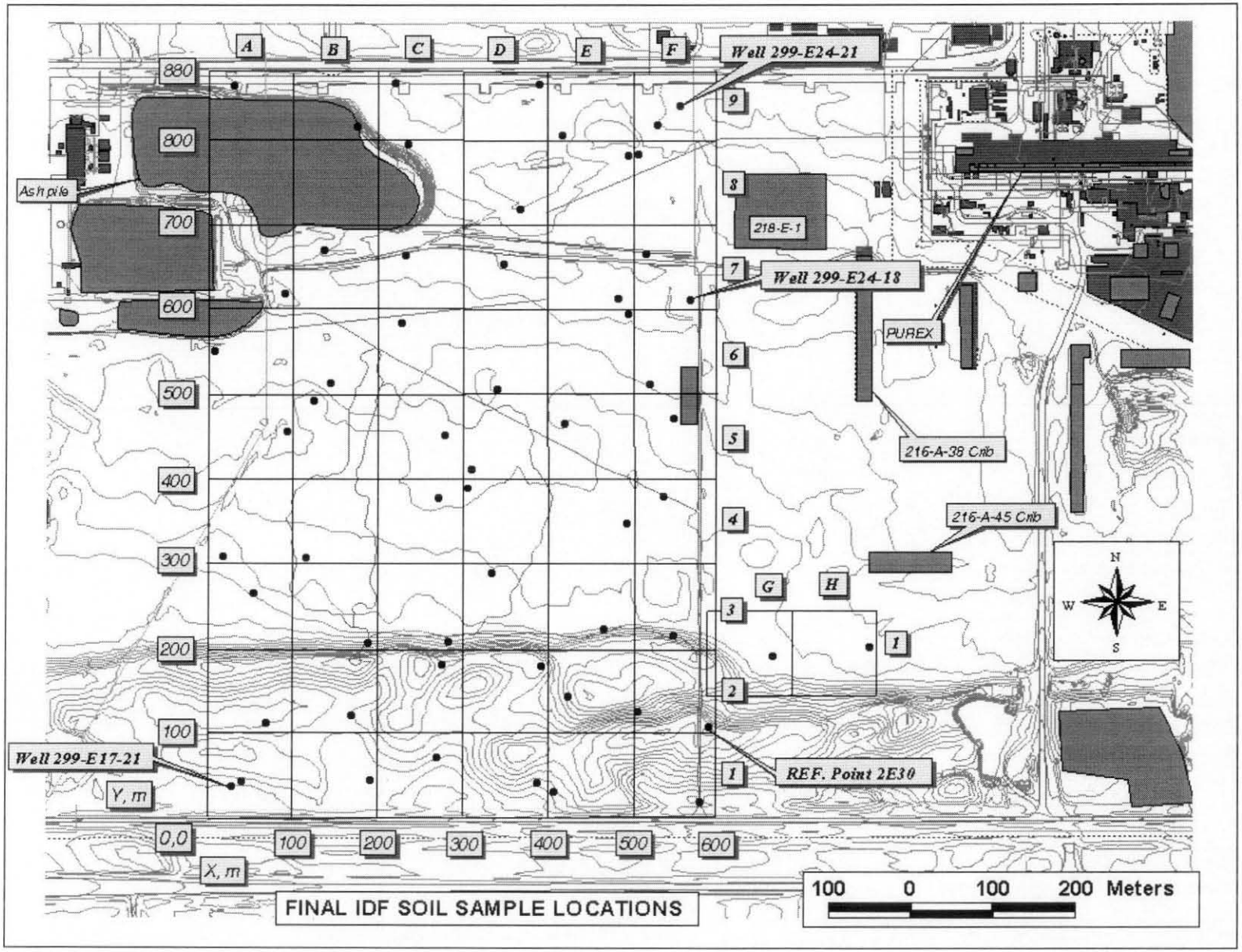


Figure A1-2. IDF Soil Sample Locations.

A1-4.2.2 Background Sampling

Preoperational monitoring for the IDF site will rely heavily on background samples collected for other studies. The U.S. Department of Energy (DOE) has determined background values for chemicals (DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*) and radionuclides (DOE/RL-92-04, *Hanford Site Background: Part 2, Soil Background for Radionuclides*) on the Hanford Site. Background samples were collected and analyzed for the TWRS (now ORP) Phase 1 privatization site environmental baseline and characterization (HNF-2067, *TWRS Phase I Privatization Site Preconstruction Characterization Report*). Using these predetermined background values will save substantial analytical costs. Existing background data will be supplemented by three background samples collected as part of this preoperational monitoring effort. The three samples were collected along the proximal baseline arc at the location of the background samples collected for the TWRS (now ORP) Phase 1 privatization site preconstruction characterization. The three additional samples will ensure that the existing background values are still valid given the major site changes that occurred (primarily because of the range fire in 2000) since the samples were collected in 1997.

A1-4.2.3 Subsurface Conditions Screening

Indications of soil contamination from the systematic soil sampling, the radiometric screening survey, or the geophysical surveys may indicate a need for more detailed sampling of the subsurface from boreholes (cone penetrometer) to assess contaminant depth distribution. If several "hot spots" are identified, a more systematic assessment of depth distribution throughout a larger portion of the proposed disposal site may be needed. The primary concerns are worker safety and the possible future need to dispose of excavated soil. For a single hot spot occurrence, a cone penetrometer can be used to access the subsurface. The boreholes can be geophysically logged and if contamination is encountered samples can be submitted to an analytical laboratory. Samples can be collected at 0.3 m (1-ft) intervals and composited every 1.5 m (5 ft).

If several hot spots are identified, a systematic subsurface interrogation of the entire proposed disposal site can be conducted using the cone penetrometer coupled with geophysical logging and sampling and analyses to assess vertical distribution of contamination. If this approach is deemed necessary by the project manager, a decision must be made concerning the appropriate sample spacing. The following approach addresses this issue.

Cone Penetrometer Spacing. The grid spacing required to find a hot spot of an elliptical shape with a prespecified size and confidence level can be determined using procedures described in *Statistical Methods for Environmental Pollution Monitoring* (Gilbert 1987, pages 121-131). Required information and the steps to determine the spacing are as follows.

1. Specify the length of the semimajor axis (L) of the smallest hot spot important to detect. That is, L is one half the length of the long axis of the ellipse. Based on results of previous spill studies in the 200 East Area, it is judged that a reasonable length for L would be ~5 m (16 ft).

2. Specify the expected shape (S) of the elliptical target, where

$$S = \frac{\text{length of short axis of the ellipse}}{\text{length of long axis of the ellipse.}}$$

Note that $0 \leq S \leq 1$ and that S=1 for a circle. If S is not known in advance, a conservative approach is to assume a rather skinny elliptical shape, perhaps S = 0.5 (see Gilbert [1987], page 121). This would result in smaller spacing between grid points than would occur with a circular or "fatter" ellipse. Hence, one would sample on a finer grid to compensate for lack of knowledge about the target shape.

3. Based on nomograph (for a square grid) as provided in Gilbert (1987), Figure 10.3, and the shape of interest, S (i.e., S = 0.5, see Step 2), find the ratio of L/G on the horizontal axis that corresponds to the prespecified ß, where G is the spacing between the grid lines and L is as defined in Step 1. The required grid spacing for various values of ß is provided in Table A1-2.

Based on the results shown in Table A1-1, a 5 m spacing between boreholes will allow for a 1-percent probability of not finding the hypothetical "hot spot." If information concerning the shape and size of the hypothetical hot spot is different from what was used in Table A1-1, a different grid spacing would result.

Table A1-1. Required Spacing Between Lines on a Square Grid to Detect a Hot Spot of Prespecified Shape.

Probability of Not Finding a Hot Spot[a] ß (%)	Ratio[b] (L/G)	Half Length[c] of the Hot Spot L (m)	Required Spacing Between Grid Lines[d] (m)
20	0.75	5	~6.7
10	0.84	5	~6
5	0.91	5	~5.5
1	~1	5	~5

[a]The shape of the hot spot was specified as: S = 0.5.
[b]Obtained from *Statistical Methods for Environmental Pollution Monitoring* Figure 10.3 (Gilbert 1987).
[c]Half length of the hot spot was specified as: L = 5 m.
[d]Calculated by dividing the half length (L) by the ratio (L/G).

A1-4.3 ANALYTICAL METHODS AND SAMPLE HANDLING

Standard analytical methods for soil and sediment analysis will be used for all required analyses. Soil-sample handling, labeling, chain-of-custody documentation, etc., will be as described for soil and sediment samples in Appendix A2.

Analytical methods and sample size requirements for the target analytes and related constituents of interest are summarized in Table A1-2. The methods listed are capable of meeting the quantification limits shown in Table A1-3. As indicated in Table A1-2, some methods may satisfy analytical requirements for more than one constituent group. For example, inductively coupled plasma-mass spectrometry (ICP-MS) can be used to quantify uranium, as well as many of the other metals. In addition, high-resolution spectral gamma-ray analysis may be capable of quantifying ^{241}Am, one of the principal alpha emitters in the target analyte list, as well as ^{137}Cs and other gamma emitters that may be of interest.

For purposes of this SAP, resources are assumed to be available to accommodate the complete list of target analytes. If conditions change, the list can be reduced by selecting the broadest screening methods (e.g., pH, specific conductance, gross alpha, gross beta) and reducing the number of analytical methods employed.

It also should be recognized that incremental (environmental) additions of hazardous chemicals, such as iron, in the waste (Envelope D composition and immobilized low-activity waste (ILAW) package composition) may not be detectable in environmental media. In contrast, small increases (e.g., 1 to 2 pCi/g in soil samples) for the major radioactive constituents (^{137}Cs, ^{90}Sr, or transuranics) would be easily detected. This is because natural background concentrations of heavy metals and other nonradioactive target analytes (i.e., if they occur naturally at relatively high concentrations) may mask any incremental addition caused by either past-practice Hanford Site releases or future operation of the IDF. Also, the source strengths of the major radioactive components relative to their detectability at typical environmental levels are much greater than the corresponding hazardous waste concentrations in the source relative to their detectability in environmental samples. This is another factor that could be considered by the project manager in allocating resources to the analytical portion of the environmental baseline study.

Table A1-2. Analytical Methods for Target Analytes in Soil. (2 sheets)

Analysis Category	Reference Method	Constituents
Moisture content[1]	Procedure SA-7 (PNL-MA-567)	Water content of sediment
pH[1]	PRO-87-09	pH of 1:1 sediment to water extract
Specific conductivity[1]	Procedure FA-2 (PNL-MA-567)	Electrical conductivity of 1:1 sediment to water extract
ICP[2]	Procedure PNNL-AGG-ICP-AES	Elemental concentrations (Al, Ba, Ca, Fe, Mg, P, K, Si, Na, Sr, and S) in 1:1 sediment to water and 1:1 nitric acid extracts
ICP-MS[1]	PNNL-AGG-415	Isotopic concentrations (^{99}Tc, ^{238}U, ^{53}, ^{82}Se, ^{98}Mo, and ^{101}Rr) in 1 :1 sediment to water and 1 :1 nitric acid extracts
Alkalinity[1]	Chapter 6.6 (USGS 2001)	Alkalinity as $CaCO_3$ in 1:1 sediment to water extracts at pH 4.5 and pH 8.3
Carbon[1]		Total carbon, inorganic carbon, and organic carbon (by difference)
X-ray fluorescence[1]		Trace element (Ni, Cr, Sc, V, Ba, Rb, Sr, Zr, Y, Nb, Ga, Cu, Zn, Pb, La, Ce, Th) concentrations in sediment.

Table A1-2. Analytical Methods for Target Analytes in Soil. (2 sheets)

Analysis Category	Reference Method	Constituents
Ion chromatography[2]	Method 300.0 (EPA-600/R-93-100)	Anion concentrations (fluoride, formate, chloride, nitrite, bromide, nitrate, carbonate, sulfate, oxalate, and phosphate) in 1:1 sediment to water and 1:1 nitric acid extracts
Alpha energy analysis[2]	To be determined	^{241}Am
Gamma energy[2]	PNNL-AGG-RRL-001	Gamma emitting radioisotope concentration (^{40}K, ^{60}Co, ^{137}Cs, ^{154}Eu, and ^{238}U) in sediment
Gross alpha[1]	PNNL-AGG-RRL-002	Total alpha activity in 1:1 sediment to water and 1:1 nitric acid extracts
Gross beta[1]	PNNL-AGG-RRL-002	Total beta activity in 1:1 sediment to water and 1:1 nitric acid extracts
^{90}Sr[3]	Laboratory-specific procedure: precipitation and gas-glow beta proportional counting	
Isotopic uranium[3]	Laboratory-specific procedure: anion exchange separation with alpha energy analysis	^{234}U, ^{235}U, ^{238}U
Isotopic plutonium[3]	Laboratory-specific procedure: anion exchange separation with alpha energy analysis	^{238}Pu, $^{239/240}$Pu
1:1 Sediment to water extract[1]		Sample preparation
1:1 Nitric acid extract[1]		Sample preparation

[1]Analysis of subsurface sediment samples only
[2]Analysis of both surface soil and subsurface sediment samples
[3]Analysis of surface soil samples only

EPA-600/R-93-100, *Methods for Determination of Inorganic Substances in Environmental Samples: US Environmental Protection Agency.*
PNNL-AGG-415, *Inductively Coupled Plasma Mass Spectrometric (ICP-MS) Analysis.*
PNL-MA-567, *Procedure Manual*, Procedure FA-2, "Calibration of Conductivity Meter and Measurement of Field Conductivity."
USGS, 2001, *Field Manual*, Book 9, "Techniques of Water Resources Investigation, Chapter 6.6, "Alkalinity and Acid Neutralizing Capacity."
ICP = inductively coupled plasma.
MS = mass spectrometry.

Table A1-3. Background Levels and Method Detection Limits for the Target Analytes. (4 sheets)

Constituent[a] Name (unit)	Method Detection Limit[b]	Hanford Site Background for Soils[c] (mg/kg or pCi/g)
Moisture content	Not available	Not available
pH	Not available	Not available
Specific conductivity (mS/cm)	1	Not available

Table A1-3. Background Levels and Method Detection Limits for the Target Analytes. (4 sheets)

Constituent[a] Name (unit)	Method Detection Limit[b]	Hanford Site Background for Soils[c] (mg/kg or pCi/g)
ICP Metals (µg/L for water) (µg/kg for soils)		
Aluminum	2 to 20,000	8080
Barium	200 to 20,000	12
Calcium	5000 to 500,000	10,100
Potassium	5000 to 500,000	1,370
Magnesium	5000 to 500,000	5,180
Strontium	50 to 5000	Not available
Sodium	5000 to 500,000	439
Silicon	50 to 5000	32.2
Iron	100 to 10,000	24,500
Phosphorous	Not available	Not available
Sulfur	Not available	Not available
ICP-MS (µg/L for water)		
^{99}Tc	0.5	Not available
^{238}U	0.5	0.00158
^{53}Cr	50	Not available
^{82}Se	100	Not available
^{98}Mo	25	Not available
^{101}Ru	5	Not available
Alkalinity (µg/L for water)	5000	3,410
Carbon analysis (µg/L for Water) and (µg/kg for soils)		
Inorganic carbon	500 to 12,500	Not available
Total carbon	1000 to 25,000	Not available
X-ray fluorescence (mg/kg for soils)		
Nickel	5	13
Chromium	5	10.9
Scandium	Not available	Not available
Vanadium	2	57.6
Barium	5	92.7
Rubidium	2	Not available
Strontium	2	Not available
Zirconium	5	23.6
Yttrium	2	Not available
Niobium	2	Not available
Gallium	5	Not available

Table A1-3. Background Levels and Method Detection Limits for the Target Analytes. (4 sheets)

Constituent[a] Name (unit)	Method Detection Limit[b]	Hanford Site Background for Soils[c] (mg/kg or pCi/g)
Copper	5	15.5
Zinc	5	53
Lead	5	6.3
Lanthanum	Not available	Not available
Cerium	Not available	Not available
Thorium	Not available	Not available
Ion Chromatography (μg/L for water) and (μg/kg for soils)		
Fluoride	500 to 5000	2.4
Formate	Not available	Not available
Chloride	200 to 2000	68.3
Nitrite	250 to 2500	21
Nitrate	250 to 2500	30.1
Bromide	250 to 2500	Not available
Carbonate	Not available	Not available
Sulfate	500 to 5000	192
Oxalate	Not available	Not available
Phosphate	500 to 5000	4.7
Gamma Energy Analysis (pCi/L for water) and (pCi/g for soils)		
^{40}K	Not available	13.1
^{60}Co	25 0.05	0.00132
^{137}Cs	15 to 0.1	0.417
^{154}Eu	50 to 0.01	0.000826
^{238}U	500 to 2	0.763
Gross alpha (pCi/L for water) and (pCi/g for soils)	3 to 10	Not available
Gross beta (pCi/L for water) and (pCi/g for soils)	4 to 15	19.78
^{90}Sr (pCi/L for water)	2	0.0806
^{241}Am	0.3 to 1	Not available
Isotopic uranium (pCi/L for water) and (pCi/g for soils)		
^{234}U	1 to 1	0.793
^{235}U	1 to 1	0.0515
^{238}U	1 to 1	0.763

Table A1-3. Background Levels and Method Detection Limits for the Target Analytes. (4 sheets)

Constituent[a] Name (unit)	Method Detection Limit[b]	Hanford Site Background for Soils[c] (mg/kg or pCi/g)
Isotopic Plutonium (pCi/L for water) and (pCi/g for soils)		
^{238}Pu	1 to 1	0.00158
$^{239/240}Pu$	1 to 1	0.00935

[a]Primary analytes of concern based on the Tier 1 suite of analyses for the IDF preoperational baseline.

[b]Method detection limits vary from laboratory to laboratory and from instrument to instrument. Except for XRF and ICP-MS, the values given here are contractual quantitation limits for the laboratories used by the Hanford Groundwater Performance Assessment Project for the methods listed in Table A1-3 and are near method detection limits. Values given for XRF are from a typical commercial laboratory. Values for ICP-MS are quantitation limits from the PNNL 325 Laboratory.

[c]Background values are from DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, and DOE/RL-92-04, *Hanford Site Background: Part 2, Soil Background for Radionuclides*.

[d]Background values are not available for some radioactive constituents; however, unconditional release criteria for offsite shipping of 50 pCi/g of total activity has been used at the Hanford Site.

ICP-MS = inductively coupled plasma-mass spectrometry
PNNL = Pacific Northwest National Laboratory.
XRF = x-ray fluorescence.

A1-5 SHALLOW VADOSE ZONE

As previously discussed, an ash disposal pile from the use of the 200 East Area Powerhouse remains in the northwestern part of the IDF site. Some potential for subsurface contamination exists beneath and adjacent to the ash pile. Three 3 m (10-ft) boreholes have been drilled adjacent to the ash pile to investigate potential contamination. This section describes the installation of, and sample identification and collection from those three boreholes. The tasks involved in installing these three boreholes are discussed in Sections A1-5.1 through A1-5.5.

A1-5.1 ACTIVITY PREPARATION

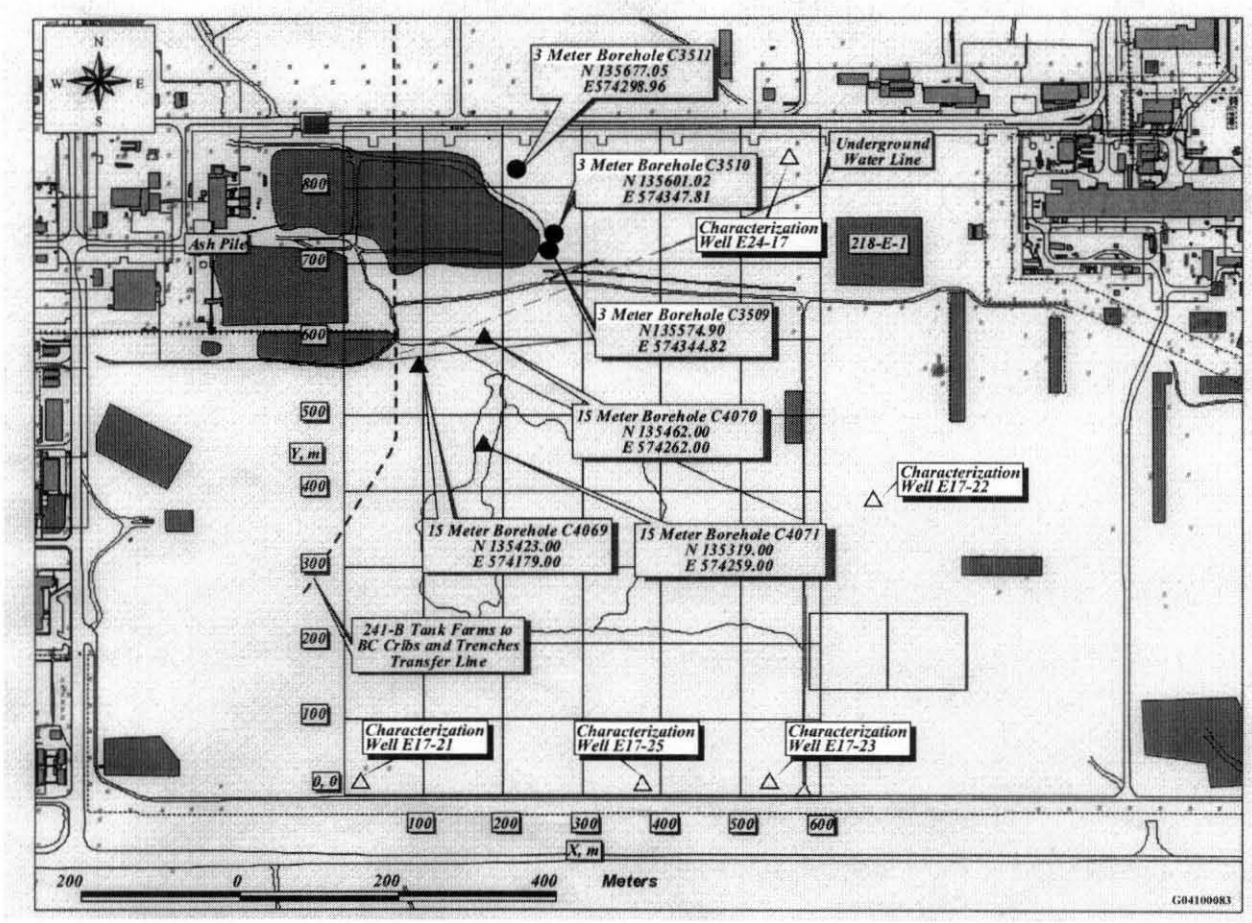
The preparation activities necessary before beginning field work for drilling the three shallow boreholes are essentially the same as those associated with drilling the deeper boreholes for preoperational monitoring.

A1-5.2 LOCATION AND DEPTH

Three 3 m- (10-ft-) deep boreholes were installed adjacent to the ash disposal pile for this study. Locations for the boreholes are shown in Figure A1-3. The locations and depths are based on professional judgment after considering results of previous studies of the 200 East Powerhouse

and associated ash pile (PNNL-13033, *Recharge Data Package for the Immobilized Low-Activity Waste 2001 Performance Assessment*). The boreholes will be placed adjacent to the steeper sides of the ash pile where runoff is greater and consequently the potential for subsurface contamination is greater.

Figure A1-3. Locations for Shallow and Deep Boreholes.



A1-5.3 INSTALLATION

Boreholes will be installed using a small-diameter (5 cm) cone penetrometer. All holes will be installed following established and approved procedures.

A1-5.4 SAMPLING AND ANALYSIS

Three 3 m-deep cone penetrometer holes will be sampled at 20 cm (50 in.) intervals as recommended in PNNL-13033. The samples will be sent to an offsite laboratory for analysis of selected target constituents. Those compounds are metals and anions from the target analyte list (Table A1-3) that represent the target compounds expected to occur in coal ash. Procedures for

sampling, chain of custody, and laboratory analyses are specified in the QAPP (Appendix A2). If anomalous zones are detected, follow-up boreholes may be needed to collect additional samples for laboratory analysis.

A1-6 ACTIVITY PREPARATION

A1-6.1 ACTIVITY PREPARATION

Preparation activities necessary before beginning field work for borehole drilling are as follows:

- Coordinate with team members
- Coordinate with support services as addressed in the quality assurance project plan (Appendix A2)
- Obtain supporting documentation
- Obtain monitoring equipment.

A1-6.2 LOCATION

Five deep boreholes were installed for this preoperational monitoring effort. The approximate locations are shown in Figure A1-2. Two of the boreholes are located east of the proposed site's boundary and are designed to determine the presence of subsurface contamination resulting from migration of contaminants from nearby past-practice waste disposal facilities. The northern borehole is located between the site and the 218-E-1 Burial Ground and the southern borehole is between the IDF site and the 216-A-45 Crib. Samples were collected from these boreholes for analysis by Tier 1 methods. Also, both boreholes will be used for geophysical logging (spectral gamma and neutron moisture). If anomalous zones are detected, follow-up boreholes can be used to collect soil samples for laboratory analysis.

Three boreholes were installed within the IDF site at the approximate locations shown in Figure A1-2. These boreholes are designed to provide a preoperational baseline for the target constituents in the subsurface of the proposed disposal site. The rationale for selecting three boreholes is given in Section 3.7 of the main document. The boreholes are located between the proposed locations for the IDF trenches (see Figure A1-2) and the existing pipeline extending from the BY Tank Farm to the BC Cribs. These boreholes will be geophysically logged and samples will be collected for analysis for target constituents.

A1-6.3 PLANNED DEPTHS

Because the design depth for the disposal trenches is 13 m (43 ft) (including liner and leachate collection system), the 3 boreholes within the disposal site were drilled to 15 m (50 ft) below grade. The depths of the boreholes are designed to just exceed the bottom of the future

excavations so they will not create preferential pathways to groundwater during facility operation.

The 2 boreholes east of the site were drilled to groundwater so as to encounter the paleosols identified in borehole 200-E17-21 at 18 m (60 ft) deep (RPP-6877, Rev. 0). If lateral spreading has occurred from past-practice disposal facilities, the contaminants most likely spread on top of the paleosols. As a cost savings, the boreholes were completed as *Resource Conservation and Recovery Act of 1976* (RCRA) monitoring wells and are now part of the groundwater monitoring network.

A1-6.4 GEOPHYSICAL LOGGING

All five boreholes were logged with spectral gamma-ray and neutron moisture tools following the "Geophysical Logging and Vadose Zone Neutron Moisture Logging" procedures given in DTS-OEM-001, *Operational Environmental Monitoring.*

All log data will be analyzed according to the established procedure, "Geophysical Log Data Analysis" in DTS-OEM-001.

A1-6.5 SAMPLING AND ANALYSIS

The three new boreholes located within the IDF site fence line were sampled at 0.3 m (1-ft) intervals and composited at 1.5 m (5-ft) intervals for analysis. The samples were sent to the Pacific Northwest National Laboratory (PNNL) laboratory in the 325 Building for Tier 1 analysis. Procedures for sampling, chain of custody, and laboratory analyses are specified in the quality assurance project plan (Appendix A2).

A1-6.6 DECOMMISSIONING

After the new boreholes are sampled and geophysically logged, they will be decommissioned in accordance with the requirements in WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells." The two deeper boreholes on the east side of the IDF site were completed as RCRA groundwater monitoring wells.

A1-7 AIR MONITORING

Airborne particulate data are available as a result of ongoing monitoring programs in the vicinity of the IDF site. As discussed in Chapter 2 of the main document, existing information needs to be supplemented with an upwind sampling station to provide for adequate preoperational environmental monitoring. The following discussion is relevant to preoperational monitoring only and is provided here to assist future monitoring plan design.

A1-7.1 MONITORING STATION LOCATIONS

Existing upwind and downwind air monitoring stations are at the locations shown in Figure 3-3 of the main document. Based on the proposed IDF location, the wedge-shaped shaded areas in Figure 3-3 of the main document cover over 75 percent of the annual average wind directions. The dashed line shows the most probable wind direction for a 22.5-degree sector or 11.25 degrees on either side of the line. Based on the annual average wind direction for the meteorological monitoring station in the northeast corner of the 200 East Area (Figure 3-3 of the main document), the locations of the existing downwind air particulate monitoring stations are judged to be adequate to detect annual average particulate contaminants in the proximity of the disposal site during the preoperational phase. In addition to the existing upwind monitoring stations N-158 and N-985, a new sampling station (N532, Figure 2-12) located proximal to and upwind of the proposed IDF location should account for contributions from the major waste management areas located farther upwind.

A1-7.2 FREQUENCY

Monitoring frequency should be monthly for the first year of the preoperational baseline to determine if seasonal effects occur. After data are analyzed from the first year of the preoperational monitoring period, the sampling frequency can be reevaluated. Filters will be changed weekly and combined for monthly analysis for constituents of interest. If seasonal effects occur, air monitoring should be extended for another year so data obtained from the preoperational phase can have the seasonal effects accounted for before constructing control charts (See Section 2.7).

A1-7.3 SAMPLING AND ANALYSIS

Procedures for particulate air filter sampling and analysis will be as described in DTS-OEM-001. Analysis for gamma-emitting radionuclides, transuranics, and ^{90}Sr and sample handling, chain of custody, are as described in the appropriate and relevant sections of Appendix A2.

A1-8 BIOTIC MONITORING

A1-8.1 GENERAL REQUIREMENTS

All personnel supporting this biological sampling effort will have completed the applicable training and will perform work in accordance with the following Hanford Site general requirements:

- DTS-CM-004, Operational Environmental Monitoring
- HNF-PRO-459, Environmental Training
- Site-specific health and safety plans, and an activity hazards analysis (AHA)
- Site-specific facility orientation.

A1-8.2 INTEGRATED DISPOSAL FACILITY GENERAL REQUIREMENTS

The requirements and procedures applicable to the IDF field biotic characterization activities are specified in DTS-SSPM-001. Applicable guidelines and procedures may include the following:

- SP 1-1, "Chain of Custody"
- SP 1-2, "Project and Sample Identification for Sampling Services"
- SP 1-3, "Control of Certificates of Analysis"
- SP 1-5, "Field Logbooks"
- SP 2-1, "Bottle Preservation"
- SP 2-5, "Laboratory Cleaning of Sampling Equipment"
- SP 2-6, "Sample Packaging and Shipping"
- SP 4-1, "Soil Sampling"
- SP 6-1, "Calibration and Control of Monitoring Instruments."

The field activities will conform to the requirements of a site-specific AHA to be completed before beginning sampling activities. A prejob safety meeting, attended by any personnel associated with the field work, will be held before the performance of the sampling effort. Comments and concerns will be addressed and resolved at that time.

An AHA checklist was developed for use by all parties involved in sampling activities or visiting the sample locations. A tailgate safety meeting was held at the job site each day before beginning operations.

A1-8.3 SAMPLING AND FIELD ACTIVITIES

Sampling efforts for the IDF site focused on collecting biotic data and media consisting of surface soil, vegetation, and small mammals. Historical information was reviewed and evaluated to determine the types of samples needed, the analyses required for potential contaminants of concern, and prospective sample site selection.

A1-8.3.1 Objectives

The primary objectives of the preoperational survey are as follows:

- Determining current levels of radionuclides in environmental media attributable to previous and ongoing operations of other waste management facilities in the area

- Providing data that will demonstrate the level of potential environmental impacts during the IDF construction and operations and, possibly, when corrective actions may be necessary

- Characterizing existing levels of radionuclides in the selected media and other environmental pollutants for comparison of past and future trends for the enhancement of routine operational monitoring

- Identifying potential pathways for human exposure and environmental impacts.

A1-8.3.2 Sample Site Selection

A detailed map of the IDF site has been developed that shows the location of existing and proposed buildings, waste facilities, and other structures. The location of nearby waste sites, such as burial grounds, cribs, etc., were noted in the field logbook. Using this information, the study site was reconnoitered to determine the prime areas for collecting biotic samples. Each sample site was marked and noted on a map, which was included in the field logbook or final report.

Marked locations were surveyed using a Trimble[1] 4000 SSi 9-channel global positioning system receiver and reduced to Washington State Plane (south zone) North American Datum of 1983; 1991 adjustment in meters.

A1-8.3.3 Field Screening

Collected biotic samples also were screened for radioactivity using a Geiger-Muller counter and an alpha detector.

A1-8.3.4 Equipment and Supplies

The following materials and equipment were used to perform the outlined tasks:

- Plastic sampling jars
- Glass sampling jars
- Sample jar labels
- Protection gloves
- Ice chest with wet or "blue" ice
- Absorbent (vermiculite) for shipping
- Permanent marking pens
- Safety glasses
- Sampling devices (trowels, spoons, augers, shovels)
- Plastic sealer bags
- Evidence tape
- Measuring tape.

[1] Trimble is a registered trademark of Trimble Navigation Ltd., Sunnyvale, California.

A1-9 THERMOLUMINESCENT DOSIMETERS

The TLDs are used to measure external radiation. The TLD preparation and analyses is, by DOE contract, the responsibility of the PNNL Calibration Laboratory. A letter of instruction will be prepared for submittal from the CH2M HILL Hanford Group, Inc., requesting the new TLD from the PNNL. This will be done to augment the TLDs already located near existing facilities in support of routine near-facility environmental monitoring at the Hanford Site. The equipment and methods employed are summarized in PNNL-14295, *Hanford Site Near-Facility Environmental Monitoring Annual Report for Calendar Year 2002.*

A1-9.1 THERMOLUMINESCENT DOSIMETER PLACEMENT

The TLD identifications and their coordinates will be provided in a table with the coordinates listed in the North American Datum 83-91, Washington South coordinate system. Site Services and Surveillance Radiological Control health physics technicians will place the new TLD (Figure 2-15) at no less than 1 m above the ground.

A1-9.2 ANALYSIS AND REPORTING

TLDs are exchanged routinely once per calendar quarter by the health physics technicians and delivered to the PNNL Calibrations Laboratory for analyses. The results of these analyses are received in approximately 45 days by the Environmental Monitoring and Investigations Near-Field Monitoring (NFM) team. The results are reported in millirems per day and millirems per quarter. Environmental Monitoring and Investigations, Near Field Monitoring, extrapolates these data down to millirems per hour and up to millirems per year to better track and trend the results throughout the calendar year.

The results of these data will be reported and compared to all other Hanford Site TLD data in the *Hanford Site Near-Facility Environmental Monitoring Annual Report* for the appropriate calendar year.

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APPENDIX A2

QUALITY ASSURANCE PROJECT PLAN

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APPENDIX A2

QUALITY ASSURANCE PROJECT PLAN

A2-1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is intended to be used with other associated project plans (i.e., field sampling plan, and job safety analysis)to ensure the following:

- Preoperational monitoring efforts are conducted safely and efficiently
- Sampling and analysis activities are carried out to achieve the specified data quality goals
- Quality of data gathered can be monitored and documented.

This QAPP applies specifically to various activities discussed in the preoperational monitoring plan (the main document). The QAPP is an element of the sampling and analysis plan (SAP) prepared specifically for this investigation and is consistent with other environmental work (EPA 1988a). All work performed pursuant to this plan should be done under the direction and supervision of or in consultation with, as necessary, a qualified engineer, hydrologist, geologist, or other expert with experience and expertise in hazardous waste management, hazardous waste site investigation, and/or hazardous waste site monitoring.

A2-2 PROJECT ORGANIZATION AND RESPONSIBILITIES

A2-2.1 TECHNICAL LEAD RESPONSIBILITIES

CH2M HILL Hanford Group, Inc. (CH2M HILL), will be the responsible technical organization.

A2-2.2 ANALYTICAL SYSTEMS LABORATORIES

As required by the SAP, samples will be routed to the appropriate and, in some cases, as yet unspecified laboratories for chemical analyses. All analyses shall be performed in compliance with Project Hanford Management Contractor (PHMC)-approved laboratory quality assurance (QA) plans and analytical procedures and in accordance with 10 CFR 830.122, "Quality Assurance" and where applicable, DOE/RL-96-98, *Hanford Analytical Services Quality Assurance Document* (HASQAD).

A2-2.3 HEALTH PHYSICS

Because the proposed IDF site is not in or near contaminated areas, a radiation work permit and Health Physics support will not be necessary.

A2-2.4 TRANSPORTATION LOGISTICS

Transportation Logistics shall provide guidance and instruction for the transport of samples. This shall include direction concerning proper shipping paperwork, and marking, labeling, and packaging requirements.

A2-2.5 EXTERNAL CONTRACTOR LABORATORIES

External participant contractors or subcontractors may be required to perform certain portions of task activities at the direction of the technical lead. Any contractor laboratory shall prepare QA and quality control (QC) procedures that identify the methods and analytical protocols for the parameters of concern in the media of interest within detection and quantitation limits in accordance with this plan. All analyses will be subject to standard internal and external quality auditing and surveillance controls.

A2-2.6 SUPPORT CONTRACTORS

Procurement of any other contracted field activities shall be in compliance with applicable procedure requirements. All work shall be performed in compliance with approved QA plans and/or procedures, subject to standard internal and external quality auditing and surveillance controls. Applicable quality requirements shall be invoked as part of the approved procurement documentation or work order.

A2-3 OBJECTIVES FOR MEASUREMENTS

This project is a preoperational monitoring activity to obtain the data as identified in the data quality objectives (DQO) process (Chapter 3 of the main document)). Thus, this section summarizes the data quality requirements to meet the intended use and objectives discussed in the main plan.

GENERAL PRECISION AND ACCURACY OBJECTIVES

As an outcome of the DQO process and as further discussed in the Field Sampling Plan (Appendix A1), the general requirement for precision (relative standard deviation of 25 percent) and accuracy (a margin of error of 10 percent) is intended for all phases of the IDF preoperational monitoring effort.

A2-4 SAMPLING PROCEDURES

A2-4.1 PROCEDURE APPROVALS AND CONTROL

In general, throughout all sample collection, preservation, transportation, and analysis activities required to perform work specified by this plan, applicable approved procedures (including subsequent amendments to such procedures) should be used. Specifics are discussed in Section A4.2.

A2-4.2 SAMPLING PROCEDURES

A2-4.2.1 Soils

Soil samples will be collected and preserved in accordance with the requirements outlined in DTS-SSPM-001, *Sampling Services Procedures Manual, Environmental Services*, SP 4-1, "Soil and Sediment Sampling."

A2-4.2.2 Air Sampling

Air sampling will be done in accordance with TP-HSO-RC-004, E*nvironmental Ambient Air Sampling*, and DTS-OEM-001, *Operational Environmental Monitoring*. Equipment used for air sampling for preoperational and/or operational purposes must be calibrated and maintained regularly and adjusted as necessary so the sampling flow rates, volumes, and masses are within their prescribed limits and representative samples could be obtained.

A2-4.2.3 Vegetation

Deep-rooted shrubs, and possibly grasses, will be collected in accordance with DTS-CM-004, *Operational Environmental Monitoring*, Section 7, "Vegetation Sampling."

A2-4.2.4 Small Animals

The collection and preservation of small mammal samples will be conducted following the guidance provided in DTS-CM-004, Section 8, "Animal Sampling."

A2-4.2.5 Field Logbooks

Field activities will be recorded in a field logbook according to the protocols outline in DTS-SSPM-001, SP 1-5, "Field Logbooks." Entries will be made in ink, signed, and dated. Photographs will be taken during sampling and to document any unusual circumstances encountered during the investigation.

A2-4.2.6 Chain of Custody

Chain-of-custody records will be maintained in accordance with the requirements of DTS-SSPM-001, SP 1-1, "Chain of Custody/Sample Analysis Request." The chain of custody form will establish the documentation necessary to ensure the traceability of the sample from time of collection until disposal.

A2-4.2.7 Sample Handling

Following collection, samples will be controlled in accordance with the requirements outlined in DTS-SSPM-001, SP 2-6, "Sample Packaging and Shipping." All samples will be labeled, sealed, and placed in a container for preservation on ice or using another appropriate cooling medium.

A2-4.2.8 Sample Labels

Each sample will be identified and labeled with a unique sample number. Numbers will be assigned in the field in accordance with DTS-SSPM-001, SP 1-2, "Project and Sample Identification for Sampling Services." The sample location and corresponding sample numbers will be documented in the field logbook.

A2-4.2.9 Sample Analysis Report

An approved analytical contract laboratory will be used to conduct laboratory analyses. The request for appropriate analyses will be included on the sample analysis request form as provided in DTS-SSPM-001, SP 1-1, "Chain of Custody/Sample Analysis Request." Laboratory-specific forms may be used in lieu of the site form and will be made available by the laboratory.

A2-4.2.10 Shipping

Shipping requirements will conform with DTS-SSPM-001, SP 2-6, "Sampling Packaging and Shipping."

A2-4.2.11 Decontamination

Hand-held equipment used for the direct collection of samples will have been previously cleaned in accordance with DTS-SSPM-001, SP 2-5, "Laboratory Cleaning of Sample Equipment."

A2-4.3 OTHER PROCEDURES

Required procedures that are not already identified in this QAPP will be identified in the task documentation. Documentation requirements will be addressed within individual procedures.

A2-4.4 PROCEDURE CHANGES

Should deviations from established procedures be required to accommodate unforeseen field situations, they may be authorized by the field team coordinator. Other types of procedure change requests shall be documented as required by River Protection Project (RPP) procedures governing their preparation in agreement with the customer technical lead.

A2-5 SAMPLE CUSTODY

All samples obtained during the course of this investigation shall be controlled as required by the DTS-SSPM-001, SP 1-1, from the point of origin to the analytical laboratory. Laboratory chain-of-custody procedures shall be reviewed and approved as required by RPP procurement control procedures and shall ensure the maintenance of sample integrity and identification throughout the analytical process. Chain-of-custody forms shall be initiated for returned residual samples. Results of analyses shall be traceable to original samples through the unique code or identifier specified in the chain-of-custody forms. All results of analyses shall be controlled as permanent project quality records as required by standard RPP procedures.

A2-6 CALIBRATION PROCEDURES

Calibration of all contractor measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by applicable contractor procedures. Equipment that requires user calibration or field adjustment shall be calibrated as required by standard procedures for user calibration.

All calibration of RPP or contractor laboratory measuring and test equipment shall meet the minimum requirements of Section II of *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA 1988b) and Section III of *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses* (EPA 1988c), and SW-846, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods*. Where applicable, such requirements shall be invoked through RPP procurement control procedures. Laboratory QA Plans for both Pacific Northwest National Laboratory (PNNL) and RPP shall address laboratory equipment to be calibrated and the calibration schedules.

A2-7 ANALYTICAL PROCEDURES

All analytical procedures approved for use in this investigation shall be in accordance with methods or equivalents approved by the U.S. Environmental Protection Agency (EPA).
In addition, standard reporting techniques and units shall be used wherever possible to facilitate the comparability of data sets in terms of precision and accuracy. All approved procedures shall

be retained in the project QA records and shall be available for review on request by the direction of the RPP technical lead.

A2-8 DATA REDUCTION, VALIDATION, AND REPORTING

Analytical data from sampling activities will be used primarily to determine the presence and amounts of analytes of interest in the locations or intervals of the sampled media. Analytical laboratories shall be responsible for the examination and validation of analytical results to the extent appropriate. The requirements discussed in this section shall be invoked, as appropriate, in procurement documentation prepared in compliance with standard RPP procedures. Results from all analyses shall be summarized in a validation report and supported by recovery percentages, QC checks, equipment calibration data, chromatograms, spectrograms, or other validation data.

All validation reports and supporting data shall be subjected to a detailed technical review by a qualified reviewer designated by the PHMC technical lead. All validation reports, technical reviews, and supporting data shall be retained as permanent project QA records in compliance with referenced procedures.

Statistical evaluations of validated data shall be based on appropriate methods identified through the DQO process. Results of the statistical evaluations shall be provided to the technical lead on a timely basis so that subsequent data collection activities, if necessary, can be planned based on another iteration of the DQO process.

A2-9 INTERNAL QUALITY CONTROL

The quality of analytical samples shall be subject to in-process QC checks in the field and at the laboratory Unless otherwise specified in the Field Sampling Plan, minimum field QC checks for surface soil sampling activities shall be as follows.

- **Duplicate Samples.** A minimum of 5 percent of the total collected soil and vegetation samples shall be duplicated where possible.
- **Method (Equipment) Blank Samples.** The minimum number of blank samples shall be equivalent to 5 percent of the total number of collected samples. Blank sampling shall be distributed throughout the entire sampling period.

Internal quality control checks performed by the analytical laboratories shall be in compliance with approved analytical procedure requirements.

A2-10 PERFORMANCE AND SYSTEM AUDITS

Acceptable performance for this project is defined as compliance with the requirements of this QAPP, its implementing procedures and appendices, and associated plans such as the Field Sampling Plan, and other applicable contractor QAPPs. All activities addressed by this QAPP are subject to surveillances of project performance and systems adequacy. Surveillances shall be conducted in accordance with appropriate contractor procedures and shall be scheduled at the discretion of the quality coordinator or technical lead.

A2-11 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratory that directly affects the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime. For this investigation, such measures are confined to laboratory equipment because all field measurements are related either to the measurement of the sample interval or to the determination of radiological or other health and safety hazards. Laboratories shall be responsible for performing or managing the maintenance of their analytical equipment; maintenance requirements, spare parts lists, and instructions shall be included in individual methods or in laboratory QA plans, subject to RPP review and approval.

A2-12 DATA ASSESSMENT PROCEDURES

As discussed in Section A2-8, a data validation report shall be prepared by the analytical laboratory summarizing the precision, accuracy, and completeness of the analysis. The report shall compare actual analytical results with the objectives stated in the contract with the laboratory. If the stated objectives for a particular parameter are not met, the situation shall be analyzed, and limitations or restrictions on the uses of such data shall be established.
The validation report shall be reviewed and approved by the technical lead, who may direct additional sampling activities if DQOs have not been met. The approved report shall be routed to the project quality records and included within the reports that will be prepared for submittal to the regulatory agencies at the completion of activities.

A2-13 CORRECTIVE ACTION

Corrective action requests required as a result of surveillance reports shall be documented and dispositioned as required by the statement of work or applicable corrective action procedures. Primary responsibilities for corrective action resolution are assigned to the technical lead and the QA coordinator.

Other measurement systems, procedures, or plan corrections that may be required as a result of routine review processes shall be resolved as required by governing procedures or shall be referred to the technical lead for resolution. Copies of all surveillance documentation shall be routed to the project QA records on completion or closure.

A2-14 QUALITY ASSURANCE REPORTS

As stated in Sections A2-10 and A2-13, project performance shall be assessed by the surveillance process. Surveillance documentation shall be placed in the project records on completion or closure of the activity. A report summarizing surveillance activity, as well as any associated corrective actions, shall be prepared by the QA coordinator at the completion of the project.

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