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ENGINEERED WASTE MANAGEMENT FACILITY SAMPLING AND ANALYSIS PLAN JANUARY, 1992

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ENCLOSURE

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ENGINEERED WASTE MANAGEMENT FACILITY

SAMPLING AND ANALYSIS PLAN

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
Fernald, Ohio

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

January, 1992

U.S. Department of Energy
Fernald Office

FINAL
Revision 1

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LIST OF ACRONYMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CSF	cancer slope factor
DOE	U.S. Department of Energy
DQO	data quality objective
EWMF	engineered waste management facility
EDS	energy dispersive spectroscopic
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FMPC	Feed Materials Production Center
HEAST	Health Effects Assessment Summary Tables
HSL	Hazardous Substance List
NEPA	National Environmental Policy Act
PCB	polychlorinated biphenyl
PLM	polarized light microscopy
QAPP	Quality Assurance Project Plan
RAO	remedial action objective
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RI/FS - EIS	remedial investigation/feasibility study - environmental impact statement
SAP	Sampling and Analysis Plan
SEM	scanning electron microscope
TBC	to be considered
TOC	total organic carbon
USCOE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
XRD	X-ray diffraction

1.0 INTRODUCTION

Per the Consent Agreement between the U.S. Department of Energy (DOE) and U.S. Environmental Projection Agency (EPA), the Feed Materials Production Center (FMPC), renamed on August 23, 1991 and hereinafter called the Fernald Environmental Management Project (FEMP), divided its Remedial Investigation/Feasibility Study (RI/FS) into five operable units. While effective in implementing the RI/FS under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the operable unit concept does not address the siting, design, or construction of a site-wide disposal/storage facility. Therefore, this sampling and analysis plan (SAP) has been developed as an addendum to the RI/FS Work Plan (March 1988), and describes the sampling, laboratory analyses, and related field tasks necessary to support the evaluation of an engineered waste management facility (EWMF) for disposal/storage of waste generated through remediation activities.

The EWMF is in a very preliminary design stage and is intended to supply the on-property disposal/storage capacity that will be required should the alternative of on-property disposal/storage be selected.

The current EWMF concept consists of 45 slab-on-grade concrete vaults with a total capacity of 2,400,000 cubic yards. This volume is based on preliminary estimates of all operable unit waste volumes excluding the rescoped Operable Unit 3 quantities. The vaults are designed to accept waste in the form of a grout slurry (pumped in to solidify) - wet vaults - or waste placed in discrete containers - dry vaults. The actual waste form will be determined in the future based on the results of raw waste leachate and treatability studies, as well as waste retrievability considerations. Some wastes, such as contaminated Operable Unit 5 soils, may potentially be placed in the vault untreated.

The exterior dimensions of each vault are approximately 644 feet long by 145 feet wide by 26 feet high. Both the wet and the dry vaults will have a double liner and leachate collection and leak detection systems. If the EWMF is used for permanent disposal, a final 16-foot cover consisting of compacted backfill, a low permeability clay layer, a drainage layer, an intruder barrier, and a topsoil layer would be constructed over the vaults.

However, it is important to note that the study area physical characteristics, final waste volume determination, and associated leaching potential of the raw and/or treated wastes will affect the final EWMF design configuration and size. Therefore, all 330-340 acres specified in the SAP will be investigated for potential EWMF use.

The siting study area is located within the FEMP property boundary, north and east of the production area (Figure 1). A detailed review of existing site and regional data sources was undertaken in the preliminary stages of this SAP preparation. The review identified additional data requirements for evaluating the viability of siting the EWMF at the FEMP. This addendum describes the sampling and analysis required to fill the identified data gaps and is organized into four sections with supporting tables, figures, and an appendix. Section 1.0 provides the introduction and addendum organization. Section 2.0 presents the review of available site data. Section 3.0 details the data quality objectives (DQOs) and justification for the samples, including programmatic needs for each specific technical area of focus. Section 4.0 addresses the programmatic sampling strategy and details sample locations, collection, and analyses. Appendix A presents the geochemical analytical procedures.

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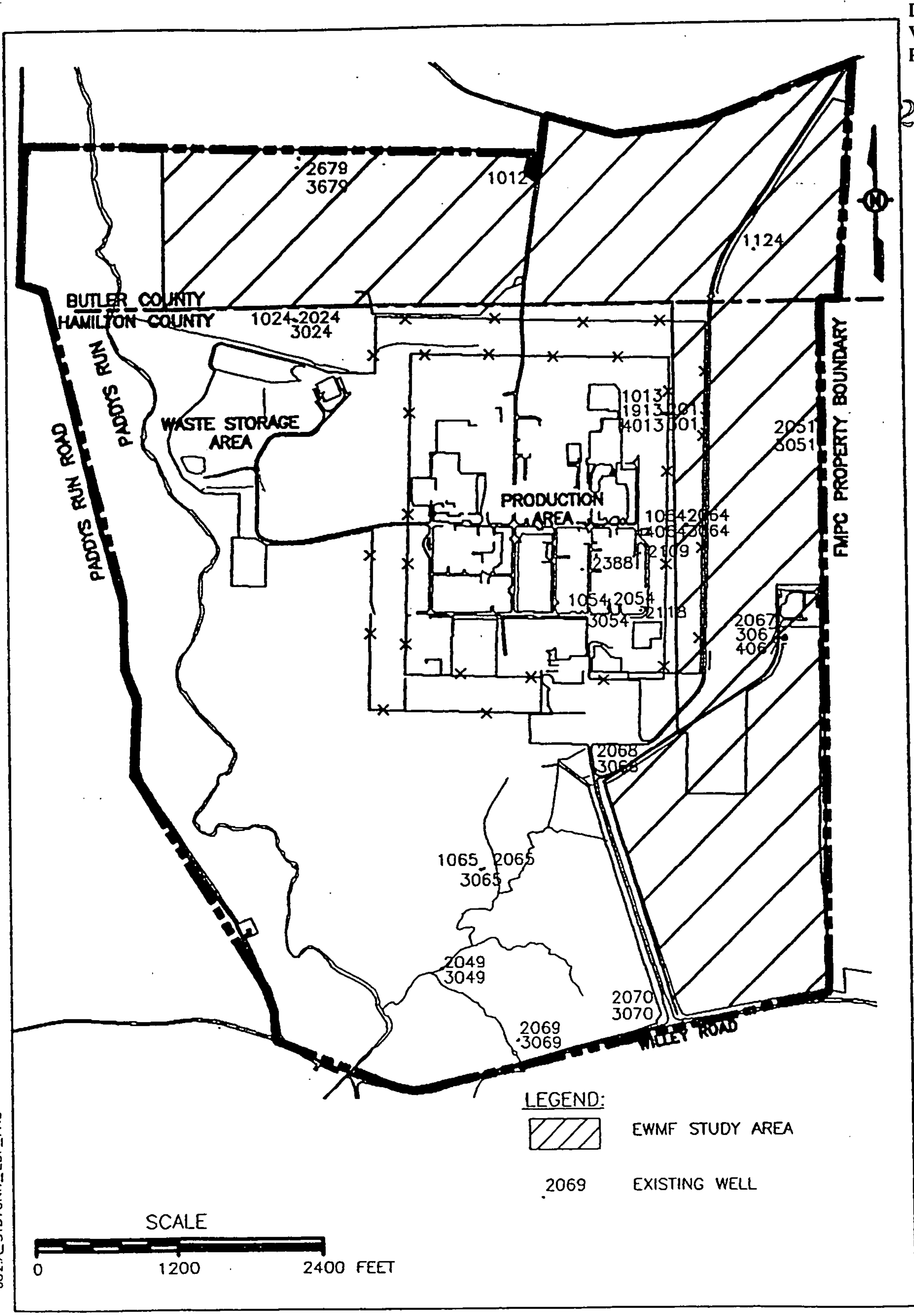

FIGURE 1. EXISTING WELLS TO BE USED IN EWMF STUDY AREA

2.0 REVIEW OF AVAILABLE DATA

2.1 Available Geologic/Hydrogeologic Data

The major source of geologic and hydrogeologic data available for the FEMP is the RI/FS database. The RI/FS database was reviewed for information pertinent to the study area. Figure 1 shows the location of groundwater monitoring wells currently within or near the EWMF study area which can be incorporated into the site evaluation.

The piezometers and 1000-series wells installed to date indicate that the glacial overburden consists of discontinuous sands in a clay-rich till matrix. The upper part of the till matrix contains fractures and root tubes which allow the infiltration of surface water into the sands to create bodies of perched groundwater. The number of borings and wells in the area of investigation is not sufficient to determine the distribution of these sand lenses or the chemical nature of the perched groundwater within them.

Within the investigation area for the EWMF there are very few groundwater monitoring wells because installation of wells in the Great Miami Aquifer has been driven by the need to determine the nature and extent of contamination from the waste pits and production area. Additional 2000-series monitoring wells are required in order to determine potential contaminant pathways under the investigation area. This includes the lateral boundary conditions between the bedrock valley and the Great Miami Aquifer which have not been addressed in the RI.

This SAP addresses these data gaps and recommends the installation and sampling of additional wells. Although no groundwater samples will be taken, the program presented is necessary to obtain stratigraphic and water-level information necessary for the determination of flow direction and gradients under the investigation area. This data will also be utilized in the fate and transport groundwater modeling effort.

2.2 Available Geotechnical Data

A comprehensive search of the available data was performed to locate information for the study area. The following data sources were reviewed:

- "Soil Survey of Butler County, Ohio," U.S. Department of Agriculture (USDA), Soil Conservation Service, 1980
- "Soil Survey of Hamilton County, Ohio," USDA, Soil Conservation Service, 1982
- Remedial Investigation/Feasibility Study database
- Topographic Maps, Drawing No. 75X5500 G00064 & 75X5500 G00065, Feed Materials Production Center, Westinghouse Materials Company of Ohio
- "Report of Foundation Investigation, Feed Materials Production Center; Fernald, Ohio," U.S. Army Corps of Engineers, Ohio River Division Laboratories, Mariemont, Ohio; February, 1952

The review of these references indicated: 1) the majority of the boring data exists only for the production and operable unit areas and boring data for the EWMF study area are insufficient to support an EWMF FS-level design; and 2) geotechnical test data of the study area are not available.

2.3 Available Geochemical Data

Elemental concentrations in soils and background levels of heavy metals in Ohio farm soils have been reported in Shacklette and Boerngen (1984) and Logan and Miller (1983). However, these reports are not sufficient for providing background elemental levels in soils for the risk assessment and they will not provide site-specific data for the EWMF acreage.

Currently, there are no site-specific data on:

- Mineralogy of the glacial overburden and outwash deposits that may serve as potential flow paths to receptors
- Leachate compositions derived from untreated and treated waste forms
- Chemical interaction of waste leachate, if any, with glacial overburden materials
- Adsorption ratios of constituents on flow-path materials and engineered barrier

Flow paths must be evaluated to determine the suitability of the site for the disposal and management of mixed waste. The mineralogy along the flow paths to the human receptors needs to be known to assess the retardation of contaminants along these paths. Additionally, leachate compositions and adsorption ratios are required to model contaminant migration along the flow paths.

Measurements of particle size, total organic carbon (TOC), density, porosity, and permeability of surface soils present in the EWMF acreage have been characterized and summarized in soil survey reports for Butler and Hamilton counties, Ohio (USDA 1980 and 1982, respectively). Limited cation exchange capacity (CEC) and TOC data for the glacial overburden were collected as part of the FEMP RI/FS, but additional samples will be collected from the EWMF acreage for further characterization of these parameters (see Section 3.3). Also, a limited number of glacial overburden samples are currently undergoing mineralogical analysis. However, data from these studies are not specific to the siting study area subsurface soils.

Existing FEMP waste characterization data consist primarily of elemental analyses of waste solids. Chemical and radiological analyses of surface water from several Operable Unit 1 waste units are also available, as are some extraction procedure (EP) and toxicity characteristic leaching procedure (TCLP) data from Operable Units 1 and 4 solids. However, these data are inadequate to support pathway analysis for the EWMF because treated waste forms are also required in order to evaluate contaminant migration from the EWMF. Therefore, the leachate data on cement-treated Operable Unit 1 waste will be obtained from a modified American National Standards Institute/American Nuclear Society (ANSI/ANS)-16.1-1986 leach test (Appendix A) that will be performed in parallel with Operable Unit 1 treatability studies.

2.4 Available Risk Assessment Data

The primary source of data reviewed for the EWMF risk assessment was the RI/FS database. Currently, insufficient data exist to adequately characterize the radiological or chemical constituents in the study area for the purpose of the evaluation of the EWMF as an on-site waste disposal/storage alternative per the "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988). The principal deficiency of the present radiological database is the sparse areal distribution of past sample locations. The chemical database suffers from both a lack of data locations and from a limited list of analytes at existing locations. The existing database is also insufficient to adequately characterize the constituent transport pathways operating within the study area.

Data from soil sampling and analysis will provide input parameters for the air dispersion models for fugitive dust emissions. The radiological and chemical samples will be collected during installation of the geotechnical borings and monitoring wells. Other additions to the RI database will be addressed in sampling and analysis plans for further work under Operable Unit 5. Baseline risk assessment issues for the EWMF study area will be addressed under Operable Unit 5.

2.5 Available Ecological Data

Ecological receptors and habitats within the FEMP boundaries have been thoroughly described by Facemire et al. (1990). In addition, a wetlands delineation has been completed as part of the RI/FS database. Because environmental impacts of construction may extend outside EWMF boundaries, a limited ecological survey is necessary to characterize habitats adjacent to the FEMP.

Radionuclide concentrations in vegetation and small mammals at and adjacent to the FEMP have been measured under the RI/FS (Figure 2). Fifteen percent of the samples collected were analyzed for chemical constituents. However, potential constituents have not been measured in the deciduous and evergreen trees which dominate the northern portion of the study area. Sampling of these trees is necessary to characterize baseline conditions. Soil sampling necessary to support chemical risk assessment for human health is also necessary for the ecological risk assessment.

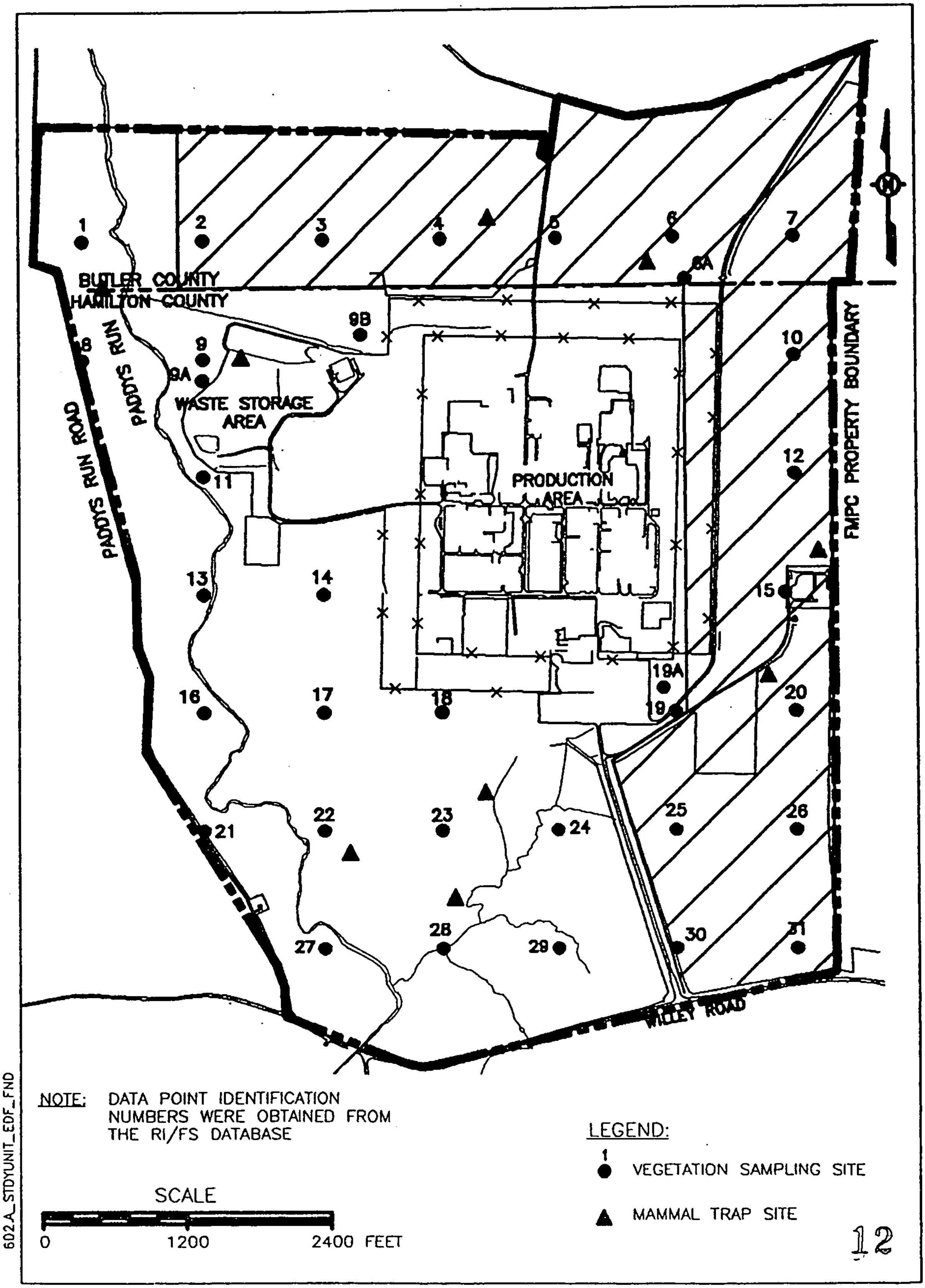

FIGURE 2. LOCATION OF VEGETATION/SOILS AND MAMMAL SAMPLING SITES ON THE FMPC

3.0 DATA QUALITY OBJECTIVES AND PROGRAM JUSTIFICATION

This sampling plan will specify a series of soil sample collection and analytical activities. The resultant data will be used to support the evaluation of criteria for a detailed analysis of the EWMF as an on-site waste disposal/storage alternative per the methodology given in "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988), specifically:

- The overall protection of human health and the environment
- Long-term effectiveness and permanence
- Short-term effectiveness
- Implementability
- Applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC)

The EWMF evaluation will be performed as part of an overall FS effort and presented in an EWMF Siting Report. This report will evaluate the EWMF against all screening criteria including short- and long-term design, ARARs/TBCs, The National Environmental Policy Act (NEPA), risk, and cost issues. To facilitate this screening process, a complete list of potential ARARs/TBCs will be submitted to the Ohio and U. S. EPAs for action independent of this SAP.

To assure the level of detail and data quality needed for the SAP's intended data use is achieved, DQO tables were prepared based on guidance given in "Data Quality Objectives for Remedial Response Activities (Development Process)" (EPA 1987). The SAP DQO tables appear as Tables 1 through 6 and summarize the following for each area of technical focus or activity:

- SAP activity objectives
- Prioritized data use(s)
- Appropriate analytical levels
- Constituents of concern
- Level of concern
- Required detection limits
- Critical samples

The balance of this section elaborates on the DQO tables by providing detailed justification for the discrete data needs of the following technical areas of focus:

- Geologic/Hydrogeologic
- Geotechnical
- Geochemical

- Risk Assessment
- RI/FS-Environmental Impact Statement (RI/FS - EIS)

3.1 Geologic/Hydrogeologic Programmatic Needs

The programmatic needs discussion presented in this section elaborates on the contents of DQO Table 1, which provides a summary of the level of detail and data quality required to support this technical activity.

This portion of the EWMF SAP investigation will involve the collection and analysis of geologic and hydrogeologic data and will support the following objectives:

- Soil samples to be used in the geochemical characterization of the site
- Soil samples to be used for the determination of radiological and chemical contaminant data
- Soil samples to assist in the geotechnical evaluation of the site
- Slug testing to provide estimates of the glacial overburden's hydraulic conductivity

This geologic/hydrogeologic investigation will supplement the limited RI/FS database currently available and provide lithologic, stratigraphic, and hydrogeologic information that is specific to the northern and eastern sections of the FEMP site. This information will be used to determine the ability of natural site material to contribute to the isolation of low-level radioactive and hazardous wastes by determining potential contaminant pathways.

3.2 Geotechnical Programmatic Needs

The programmatic needs discussion presented in this section elaborates on the contents of DQO Table 2, which provides a summary of the level of detail and data quality required to support this technical activity.

The amount of geotechnical data available for the study area is limited. The geotechnical properties of the site must be characterized in sufficient detail to determine its suitability for waste disposal/storage. To achieve the data quality objectives, a subsurface exploration program including field sampling and

TABLE 1
DATA QUALITY OBJECTIVES FOR THE RI/FS DETAILED ANALYSIS OF THE EWMF AS AN ON-PROPERTY WASTE DISPOSAL ALTERNATIVE - GEOLOGIC/HYDROGEOLOGIC

Activity	Geologic Strata/Groundwater Flow
Objectives	Provide additional geologic and hydrogeologic data in the EWMF area to support the groundwater fate and transport model for risk assessment purposes.
Prioritized Data Use(s)	Evaluation of alternatives: The primary purpose for installing the monitoring wells is to provide additional geologic and hydrogeologic data in support of the EWMF groundwater fate and transport model. Review of existing data has identified several locations lacking in information specifically in the vicinity of the EWMF. The location of the additional 1000- and 2000-series wells will fill critical data gaps and, in conjunction with the geotechnical boring data, will provide a higher level of confidence in the evaluation of fate and transport of radiological and chemical constituents from the EWMF to the surrounding environment during facility operation and postclosure. In addition, soil samples will be used to provide additional geotechnical engineering data for the EWMF alternative detailed analysis.
Appropriate Analytical Level	I, II, III
Constituents of Concern	Geologic/hydrogeologic - Not Applicable
Level of Concern	Geologic/hydrogeologic - Not Applicable
Required Detection Limits	Geologic/hydrogeologic - Not Applicable
Number of Samples	Five 1000-series and three 2000-series monitoring wells will be installed using cable tool drilling techniques. Subsurface soil samples will be submitted for the following geotechnical laboratory analyses: water content determination, Atterberg limits, grain size distribution, and specific gravity. The balance of the samples collected will be submitted for chemical, radiological, and geochemical analysis. Slug tests will be conducted on all installed 1000-series wells.

DATA QUALITY OBJECTIVES FOR THE RI/FS DETAILED ANALYSIS OF THE EWMF AS AN ON-PROPERTY WASTE DISPOSAL ALTERNATIVE - GEOTECHNICAL

Activity	Geotechnical (Soil Properties)
Objectives	Provide engineering data to support the evaluation of criteria for the RI/FS detailed analysis for the EWMF as an on-property waste disposal alternative per OSWER Directive 9355.3-01, "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA."
Prioritized Data Use(s)	Preliminary Engineering Design/Evaluation of Alternatives The purpose of geotechnically testing the soil samples is to provide a preliminary engineering estimate of the geotechnical structural stabilility of the EWMF study area. The following matrix (on the next page) exhibits the tests designated (•) for stability-specific engineering analysis purposes.
Appropriate Analytical Level	II, III
Constitutents of Concern	Geotechnical - Not Applicable
Level of Concern	Geotechnical - Not Applicable
Required Detection Limits	Geotechnical - Not Applicable
Number of Samples	No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to meet the geotechnical, geologic/hydrogeologic, and risk assessment activity objectives. 18 shallow borings will be placed using hollow-stem auger drilling techniques. It is estimated that two Shelby tubes per boring will be collected for geotechnical laboratory testing. The balance of the samples collected will be for chemical, radiological, and geochemical analysis.

TABLE 2 (continued)
MATRIX - GEOTECHNICAL PRIORITIZED DATA USES

Test Type	Test designation	Structural Stability Analyses (Short- and Long-Term)		
		Seismic and liquefaction potential	Foundation settlement	Bearing capacity
Water content determination	ASTM[a] D2216-90	•	•	•
Atterberg limits	ASTM D4318-84	•	•	•
Grain-size distribution with hydrometer analysis	ASTM D422-63	•	•	•
Triaxial consolidated undrained ($\overline{CU}$) compression test with pore measurements	EM1110-2-1906 (USCOE)[b]	•		•
Permeability (falling head)[c] (constant head)[d]	EM1110-2-1906 (USCOE) ASTM D2434-68	[e]	[e]	[e]
One-dimensional consolidation	ASTM D2435-90		•	
In situ soils density determination	EM 1110-2-1906 (USCOE)	•	•	•
Specific gravity determination	ASTM D854-83	•	•	•
Standard Penetration Test	ASTM D1586-84	•		

[a] American Society for Testing and Materials
[b] U.S. Army Corps of Engineers
[c] Soils having a permeability of less than 10^{-4} cm/s
[d] Permeability of granular soils
[e] Estimates of infiltration characteristics for hydrogeologic modeling.

laboratory testing will be undertaken. The geotechnical borings and tests will include standard penetration tests; triaxial (cū), one-dimensional consolidation; and general geophysical parameters such as moisture content, permeability (kv), and grain size distribution. The investigation will focus on geologic and geotechnical structural stability by examining seismic and liquefaction potential, erosional processes, bearing capacity, and long-term load-induced foundation settlements as part of the EWMF RI/FS siting report. The data will be used to evaluate EWMF against the FS criteria of short- and long-term effectiveness and permanence, as well as implementability. In addition, radiological and chemical samples will be collected from these borings to assist in identifying potentially contaminated excavated soil exposed during the EWMF construction activities. These soils may require placement within the waste facility, thereby affecting its physical dimensions and engineering requirements.

3.3 Geochemical Programmatic Needs

The programmatic needs discussion presented in this section elaborates on the contents of DQO Table 3, which provides a summary of the level of detail and data quality required to support this technical activity.

Pathway analyses must be conducted to demonstrate that the EWMF will properly isolate low-level radioactive waste and/or mixed waste from the environment and human receptors. For this evaluation, site-specific data will be collected and analyzed to support pathway modeling activities.

Geochemical data needed are as follows:

- Characterization of the glacial overburden for particle size, CEC, TOC, mineralogy, porosity, and permeability
- Information on the chemical interaction between waste leachate and the glacial overburden and/or engineered barriers
- Contaminant adsorption ratios obtained from batch sorption tests with waste leachate and site-specific soils

Particle size and permeability data will be obtained from the geologic and geotechnical data collection efforts. Therefore, the data needs for geochemical analysis are CEC, TOC, mineralogy, composition of leachate derived from treated waste, and contaminant adsorption ratios. TOC and CEC

TABLE 3
DATA QUALITY OBJECTIVES FOR THE RI/FS DETAILED ANALYSIS OF THE EWMF AS AN ON-PROPERTY WASTE DISPOSAL ALTERNATIVE - GEOCHEMICAL

	Geochemical	
Activity	Total Organic Carbon (TOC)	Cation Exchange Capacity (CEC)
Objectives	Quantify the organic content of soil samples	Characterize the cation exchange capacity of soil samples
Prioritized Data Use(s)	The purpose of this test is to acquire data to evaluate the adsorption ratios for organic contaminants.	The purpose of this test is to estimate the capability of the soil to retard metals in solution.
Analytical Levels	III	III
Constituents of Concern	TOC	Not Applicable. This test determines the exchange capacity of a soil sample.
Level of Concern	Not Applicable.	Not Applicable
Required Detection Limit	Specified in QAPP, Section 4	1 milliequivalent per 100 grams
Number of Samples	23 soil samples TOTAL SAMPLES = 23	23 soil samples TOTAL SAMPLES = 23

TABLE 3 (continued)

	Geochemical			
Activity	Modified ANSI-16.1 Leach Test	Batch Sorption Test	X-Ray Diffraction Analysis (XRD)	Polarized Light Microscopy (PLM)
Objectives	Characterize the chemistry of leachate that may migrate from the EWMF.	Determine adsorption ratios of contaminants of concern on site soil and clay barriers.	Characterize the mineralogy of site soil and clay barrier particles that are less than 125 microns.	Characterize the mineralogy of site soil particles that are greater than 125 microns.
Prioritized Data Use(s)[a]	The purpose of this test is to obtain a leachate composition that will be used to estimate source terms in the fate and transport model required for risk assessment.	The purpose of this test is to obtain sorption data that will be used to calculate retardation coefficients for the fate and transport model.	Mineralogic analysis is required to assist in the evaluation of the retardation of contaminants in soils and clay barriers.	Mineralogic analysis is required to assist in the evaluation of the retardation of contaminants in soils and clay barriers.
Appropriate Analytical Levels	IV, V	V	V	V
Constituents of Concern	pH, alkalinity, Cl, F, NH_4^+, NO_3^-, PO_4^{-3}, SO_4^{-2}, total organic carbon, Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Hg, K, Mg, Mo, Mn, Na, Ni, Pb, Sb, Se, Si, V, Zn, ^{137}Cs, ^{237}Np, ^{238}Pu, $^{239,240}Pu$, ^{226}Ra, ^{228}Ra, ^{90}Sr, ^{99}Tc, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, $^{235,236}U$, ^{238}U	Ag, As, Ba, Be, Cs, Cd, Co, Cr, Cu, Hg, Mo, Ni, Np, Pb, Pu, Ra, Sb, Se, Sr, Tc, Th, U, V, Zn	Not applicable. This test determines the mineralogy of a sample.	Not applicable. This test determines the mineralogy of a sample.

TABLE 3 (continued)

	Geochemical			
Level of Concern	Not applicable. Concentrations obtained from leach test will be modified by the fate and transport model prior to arriving at the receptor for risk assessment.	Not applicable. The sorption test is conducted to evaluate the retardation of contaminants along the flow path.	Not applicable to naturally occurring minerals.	Not applicable to naturally occuring minerals.
Required Detection Limit	Specified in QAPP, Section 4.	Prior to the start of testing, Brookhaven National Laboratory will submit a QA laboratory manual and a vendor source evaluation will be performed to establish compliance with the RI/FS QAPP, Level 5, requirements.	A mineral will be detected if it comprises at least 5 percent by volume of the sample.	A mineral will be detected if it comprises at least 1 percent by volume of the sample.
Number of Samples[b]	An OU 1 waste pit composite mixed with 3 different cement formulations. TOTAL SAMPLES = 3	3 soil samples TOTAL SAMPLES = 3	20 soil samples TOTAL SAMPLES = 20	20 soil samples TOTAL SAMPLES = 20

[a] The geochemical tests/analyses will evaluate the effectiveness of waste containment by the EWMF.

[b] No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to support fate and transport groundwater modeling activities. Each of the 20 selected split-spoon samples (see Section 4.3.2) will yield the following samples for analysis; (1) TOC, (1) CEC), (1) XRD, and (1) PLM.

measurements will be obtained from standard laboratory methods. Mineralogic analysis will be conducted using the techniques of x-ray diffraction and polarized light microscopy (details in Appendix A). Leachate derived from treatability tests on Operable Unit 1 wastes will be characterized by conducting a modified ANSI/ANS-16.1 leach test (see Appendix A). Batch sorption tests proposed to obtain adsorption ratios are discussed in the same appendix. Due to the size and configuration of the study area (Figure 1) and the lack of a final EWMF design, 23 samples representing the distinct and dominant soil types (Section 4.3.2) will be needed to ensure that adequate characterization has been achieved.

3.4 Risk Assessment Programmatic Needs

The programmatic needs discussion presented in this section elaborates on the contents of DQO Tables 4 and 5, which provide a summary of the level of detail and data quality required to support this technical activity.

For the purposes of the detailed analysis of alternatives, the risk assessment will evaluate the overall protection of human health and the environment during construction, maintenance, operation, closure, and postclosure for the EWMF. The risk assessment process involves the following activities (EPA 1989):

- Characterization of potential exposure settings
- Identification of exposure pathways
- Estimation of human intakes of potential constituents
- Calculation of doses and risks from those intakes

This sampling plan is intended to address the data needs for the first two steps of the process, which are site specific. Since the FS risk assessment evaluates incremental risk above background, the study area must be characterized before the construction of the EWMF is initiated (the baseline case) and any potential risks associated with the baseline must be assessed and documented. Since the environmental media in the study area are covered under Operable Unit 5 of the FEMP site, the data obtained during the RI for Operable Unit 5 will serve as the database for the EWMF study area baseline risk assessment and are not part of this SAP's DQOs.

TABLE 4
DATA QUALITY OBJECTIVES FOR EWMF RISK ASSESSMENT - CHEMICAL

Activity	Surface Soil Samples
Objectives	General: Determine the need for site dust control measures to provide short-term protection during construction of the EWMF. Specific: Determine the impact of fugitive dust emissions from the study area during construction.
Prioritized Data Use(s)	Evaluation of alternatives: The purpose for analyzing soil samples is to obtain an estimation of the potential airborne concentrations of chemicals both in the vapor phase and the particulate form resulting from the soil excavation required to construct the EWMF. The data will be used as input data to an air dispersion model for the risk assessment evaluation of the detailed analysis of the EWMF alternative.
Appropriate Analytical Levels	III, IV
Constituents of Concern	Full HSL to document potential chemical constituents in the study area. (See Attachment 1)
Level of Concern	See Attachment 1
Required Detection Limit	See Attachment 1
Number of Samples	No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to meet the chemical risk assessment activity objectives. Surface soil samples will be collected at 5 geologic and 18 geotechnical boring locations by compositing the first six inches of soil. These samples will represent surface soils that may be disturbed during construction. No subsurface soil samples will be taken for chemical analysis, unless HNu field screening indicates the presence of volatile organics during geotechnical and geologic borehole installation. TOTAL SAMPLES = 23

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ATTACHMENT 1
CHEMICALS IN SURFACE SOILS

Constituents of Concern	Level of Concern: RfD-Based Cleanup Level, Soil[a] (mg/kg)	Level of Concern: CSF-Based Cleanup Level, Soil[b] (mg/kg)	Contract Required Detection Limits[c] (mg/kg)
Inorganics			
Aluminum			20
Barium	4.00E+03		20
Cadmium	8.00E+01		0.5
Cobalt			5
Copper			2.5
Lead[d]	5.60E+01		0.5
Magnesium			500
Manganese	8.00E+03		1.5
Nickel	1.60E+03		4
Silver	2.40E+02		1
Uranium	2.40E+02		
Cyanide	1.60E+03		
Organics			
1,1,2,2-Tetrachloroethane		3.50E+00	0.005
1,1,1-Trichloroethane	7.20E+03		0.005
1,1-Dichloroethane	8.00E+03		0.005
1,1-Dichloroethene	7.20E+02	1.17E+00	0.005
1,2-cis-Dichloroethene	8.00E+02		0.005
1,2-trans-Dichlorethene	1.60E+03		0.005
2-Butanone	4.00E+03		0.01
2-Methylnaphthalene			0.33
4-Methyl-2-pentanone	4.00E+03		0.01
Acenaphthene	4.80E+03		0.33

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Constituents of Concern	Level of Concern: RfD-Based Cleanup Level, Soil[a] (mg/kg)	Level of Concern: CSF-Based Cleanup Level, Soil[b] (mg/kg)	Contract Required Detection Limits[c] (mg/kg)
Anthracene	2.40E+04		0.33
Aroclor-1254[e]		9.09E-02	0.16
Aroclor-1260[e]		9.09E-02	0.16
Benzene		2.41E+01	0.005
Benzo(a)anthracene			0.33
Benzo(a)pyrene		6.09E-02	0.33
Benzo(b)fluoranthene			0.33
Benzo(g,h,i)perylene			0.33
Benzo(k)fluoranthene			0.33
Benzoic Acid	3.20E+05		1.6
Bis(2-ethylhexyl) phthalate	1.60E+03	5.00E+01	0.33
Carbon Disulfide	8.00E+03		0
Chlorobenzene	1.60E+03		0.005
Chloroform	8.00E+02	1.15E+02	0.005
Chrysene			0.33
Di-n-butyl Phthalate	8.00E+03		0.33
Dibenzo(a,h)anthracene			0.33
Dibenzofuran			0.33
Ethylbenzene	8.00E+03		0.005
Fluoranthene	3.20E+03		0.33
Fluorene	3.20E+03		0.33
Beta-Hexachlorocyclohexane		3.89E-01	0.008
Indeno(1,2,3-cd)pyrene			0.33
N-nitrosodiphenylamine		1.43E+02	0.33
Naphthalene	3.20E+02		0.33

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Constituents of Concern	Level of Concern: RfD-Based Cleanup Level, Soil[a] (mg/kg)	Level of Concern: CSF-Based Cleanup Level, Soil[b] (mg/kg)	Contract Required Detection Limits[c] (mg/kg)
Pentachlorophenol	2.40E+03	5.83E+00	0.16
Phenanthrene			0.33
Phenol	4.80E+04		0.33
Pyrene	2.40E+03		0.33
Tetrachloroethene	8.00E+02	1.37E+01	0.005
Trichloroethene		6.36E+01	0.005
Xylenes (total)	1.60E+05		0.005

[a]Remedial Action Objective (RAO) for a noncarcinogen in soil calculated from: Cleanup Level = (Reference Dose [RfD] *Body Weight)/(Intake *Absorption Factor for an intake of 0.2 grams/day for a 16 kg child and an absorption factor of 1.) Federal Register, 7/27/90, Vol. 55, No. 145, p. 30870.

[b]RAO for a carcinogen in soil calculated from: Cleanup Level = (Risk Level *Body Weight *Assumed Lifetime)/(Cancer Slope Factor [CSF]) for a soil intake of 0.1 grams/day for a 70 kg adult/70 year lifetime exposure. The risk level used was 1E-6, the absorption exposure duration was 70 years. Health Effects Assessment Summary Tables (HEAST) (EPA 1991).

[c]Medium Contract Required Detection Limit.

[d]Lead RfD from Marcus 1986.

[e]RfDs and CSFs listed for Aroclors 1242, 1248, 1254, and 1260 are for total polychlorinated biphenyls (PCBs).

TABLE 5
DATA QUALITY OBJECTIVES FOR EWMF RISK ASSESSMENT - RADIOLOGICAL

Activity	Surface Soil Samples	Subsurface Soil Samples
Objectives	General: Determine the need for site dust control measures to provide short-term protection during construction of the EWMF. Specific: Determine the impact of fugitive dust emissions from the study area during construction.	General: Determine the need for site dust control measures to provide short-term protection during construction of the EWMF. Specific Determine the impact of fugitive dust emissions from the study area during construction.
Prioritized Data Use(s)	The purpose of analyzing surface soil samples is to ascertain the concentrations of radiological contaminants in the surface soil. This information will be used to estimate the potential airborne concentrations of contaminants in these soils and as input data to an air dispersion model for the risk assessment evaluation of the detailed analysis of the EWMF alternative.	The purpose of analyzing subsurface soil samples is to ascertain the concentrations of radiological contaminants in the soil during excavation and construction operations. This information will be used to estimate the potential airborne concentrations of contaminants in these soils and as input data to an air dispersion model for the risk assessment evaluation of the detailed analysis of the EWMF alternative.
Appropriate analytical levels	III, IV	III, IV
Constituents of concern	Full radiological to document potential radiological constituents in the study area. (See Attachment 2)	Total uranium and gamma spectral analysis to document potential radiological constituents in the study area. (See Attachment 2)
Level of concern	Radiological: See Attachment 2.	Radiological: See Attachment 2.
Required detection limit	See Attachment 2	See Attachment 2

TABLE 5 (Continued)

Activity	Surface Soil Samples	Subsurface Soil Samples
Number of samples	No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to meet the radiological risk assessment activity objectives. Surface soil samples will be collected at 5 geologic and 18 geotechnical boring locations by compositing the first six inches of soil. These samples will represent surface potentially excavated during construction. TOTAL SAMPLES = 23	No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to meet the radiological risk assessment activity objectives. Subsurface soil samples will be collected at 5 geologic and 18 geotechnical boring locations by sampling soils at mid-stratum of the glacial overburden. These samples will represent subsurface soils potentially excavated during construction. TOTAL SAMPLES = 23* *In the event perched water is encountered prior to attaining mid-stratum depth, the subsurface soil sample will be collected at the perched water elevation only.

Activity	Surface Gamma Survey
Objectives	1) Locate areas containing elevated levels of radionuclides to verify radiological surface soil samples collected from the geologic and geotechnical borings are representative of the study area. 2) Preliminary identification of how much topsoil in the study area must be treated as contaminated material during construction. 3) Provide information to be used to assess information on the short-term hazards to construction workers from areas emitting elevated levels of gamma radiation.
Prioritized Data Use(s)	The surface gamma survey will provide information on the flux of gamma radiation emanating from contaminated soils within the study area. These samples will be used to estimate worker doses, and to estimate the areal extent of contaminated surface soil which must be moved during construction of the facility. The survey will also support selection of surface soil sampling locations.
Appropriate Analytical Levels	I, II
Constituents of Concern	Radionuclides emitting gamma radiation.
Level of Concern	20 μR/h (2 x background).
Required Detection Limit	5 μR/h (0.5 x background).
Number of Samples	No specific measurement point has been determined to be a critical point. However, the specified measurement points are required as part of an overall program to meet the radiological risk assessment objectives. Surface gamma radiation will be measured at the intersections of the lines of an established survey grid. TOTAL SAMPLES = 0 TOTAL MEASUREMENTS = 1500

ATTACHMENT 2
RADIONUCLIDES IN SURFACE SOILS (INHALATION PATHWAY ONLY)

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Constituents of Concern - Radionuclides	Level of Concern: Risk-Based (10^{-6}) Proposed Remediation Goals[a] (pCi/g)	Contract Required Detection Limits (pCi/g)	FEMP Background[b] (pCi/g)
Strontium-90	175	0.5	0
Technetium-99	1200	0.9	0
Ruthenium-106	22	1	0
Cesium-137	515	0.2	0
Lead-210	5.8	2	~1
Polonium-210	3.6	2	~1
Radium-224	8.2	2	1
Radium-226	3.3	0.3	1
Radium-228	15.	0.5	1
Actinium-227	0.12	0.3	0.06
Protactinium-231	0.24	0.5	0.06
Thorium-228	0.13	0.6	1
Thorium-230	0.32	0.6	1.4
Thorium-232	0.32	0.6	1
Uranium-234	0.36	0.6	1.4
Uranium-235	0.39	0.6	0.06
Uranium-238	0.41	0.6	1.4
Neptunium-237	0.28	0.6	0
Plutonium-238	0.23	0.6	0
Plutonium-239	0.24	0.6	0

[a]Assuming a lifetime risk of cancer incidence of 1×10^{-6}, a dust loading of 0.0002 g/m^3 and an inhalation rate of 20 m^3/day for 70 years, using slope factors from HEAST (EPA 1991). The values represent the incremental risk above background radionuclide concentrations.

[b]All fission products and transuranics are assumed to be zero. Ra-226, Th-232, and U-238 concentrations are from Myrick et al. (1983). All daughter nuclides are assumed to be in equilibrium with their long-lived progenitors. Natural isotopic ratios are assumed for uranium.

The data needs for the risk assessment are dependent upon the exposure pathways that have been identified for the study area. An exposure pathway describes the mechanism by which an individual or population may be exposed to constituents of concern associated with the site. For the detailed analysis of alternatives, these pathways will be considered in terms of two specific objectives: short-term effectiveness and long-term effectiveness and permanence.

The individuals or populations identified as being at potential risk for all of the exposure scenarios are the workers and the nearby residents. However, for purposes of this sampling plan, it is assumed that exposures to workers are short-term and are minimized by use of protective clothing. It is expected that the most significant route of exposure during the construction phase will be the potential exposure to airborne constituents. It is assumed that other potential exposure pathways (such as direct contact and ingestion of contaminated water or soil) will be negligible due to institutional controls, but risk from these pathways will be evaluated to confirm this. The on-going air monitoring program conducted at the FEMP is sufficient to characterize the radiological air quality. The monitoring and meteorological data, in conjunction with additional soil analyses, will be used to model potential airborne exposures. Soil samples will be collected during the installation of the geologic and geotechnical borings described in this sampling plan. The samples will be analyzed for both radiological and chemical parameters and will supplement data obtained under the Operable Unit 5 sampling plan.

The purpose for analyzing soil samples is to obtain an estimation of the potential airborne concentrations of chemicals, both in the vapor phase and particulate form, resulting from the soil excavation required to construct the EWMF. Neither surface soil nor subsurface soil results alone will be sufficient to estimate the average concentration of constituents in the construction zone.

The evaluation of long-term effectiveness and permanence of the EWMF will consider risks associated with the hypothetical failure of the facility. The significant exposure pathways for nearby residents are expected to be the potential contamination of air, groundwater, and soil, depending on the nature of the release. The data for estimating airborne exposures will be based upon information regarding the treated waste that is stored in the facility, the characteristics of the facility, and meteorological data from the FEMP air monitoring program. Groundwater and soil data from the Operable Unit 5 RI database and parameters from the geologic and geochemical investigations in this work plan will be used as inputs to fate and transport models of waste materials in the event of leakage or failure.

Pathways involving surface waters and sediments per se do not exist in the study area. The jurisdictional wetland located in the northern part of the study area does not ordinarily contain standing water. For these reasons, it is impractical to obtain data on surface water and sediment contamination in the study area. However, potential impacts of EWMF construction and operation on surface water, including wetlands, will be evaluated in the EWMF Siting Report.

3.5 RI/FS - EIS Programmatic Needs

The programmatic needs discussion presented in this section elaborates on the contents of DQO Table 6, which provides a summary of the level of detail and data quality required to support this technical activity.

The construction of an on-property EWMF for the storage or disposal of FEMP wastes would be a major federal action requiring documentation of environmental impacts under NEPA. This documentation is also necessary to meet CERCLA requirements for evaluating environmental impacts of proposed remedial actions and will be included in the RI/FS-EIS.

The environmental impacts of EWMF construction (i.e., fugitive dust or runoff) could potentially extend to areas adjacent to the boundaries of the FEMP. Although habitats within FEMP boundaries have been extensively characterized, off-property areas have not been examined. To adequately document potential impacts (e.g., impacts on wetlands), an ecological characterization of off-property areas within 1000 feet of the study area will be conducted.

Construction may require disturbance or removal of the deciduous woodland and the pine plantation on the north side of the FEMP. These activities could mobilize radionuclides taken up by trees into the environment. Removal and disposal of the trees could therefore pose risks to ecological receptors (animals and plants) in adjacent areas if there has been significant accumulation of radionuclides by trees. However, radionuclide levels in trees on the FEMP have not been measured. Therefore, 32
sampling for radionuclides is necessary to characterize potential ecological risks. Additional analysis

TABLE 6
DATA QUALITY OBJECTIVES FOR THE RI/FS DETAILED ANALYSIS OF THE EWMF AS AN ON-PROPERTY WASTE DISPOSAL ALTERNATIVE - RI/FS-EIS

ACTIVITY	ECOLOGICAL (RI/FS - EIS)
Objectives	1) Characterize habitats and ecological receptors in off-property areas potentially subject to the impacts of fugitive dust emissions and storm water runoff from the EWMF construction, operation, and closure. 2) Evaluate potential environmental impacts and ecological risks of removal and disposal of trees (if shown to be contaminated) from the EWMF study area.
Prioritized Data Use(s)	The purpose of this data-gathering effort is to develop the technical information necessary to evaluate the potential environmental impacts of construction, operation, and closure of an EWMF in order to comply with CERCLA and NEPA requirements.
Appropriate Analytical Levels	II, III, IV
Constituents of Concern	Total Uranium (HSL metal analyses to be performed during preliminary remedial design stage dependent on the results of the surface soil chemical analyses)
Level of Concern	See Level of Concern, DQO for Surface Soils: Radiological
Required Detection Limits	See Required Detection Limits, DQO for Surface Soils: Radiological
Number of Samples[a] 3 3	1) Two replicate samples for radionuclide analysis will be collected from each of 9 trees at the same location as those used for surface soil sampling. Sampling will be restricted to the wooded portion of the study area, west of the northeast access road on the FEMP. TOTAL SAMPLES = 18. 2) An off-property ecological characterization survey will cover an area consisting of a 1000-foot-wide zone parallel to the EWMF study area boundary. Experienced field biologist will note general habitat types, dominant plant species, approximate species abundances and canopy heights. The locations of potential wetlands indicators such as hydric soils, hydrophytic vegetation, or wetlands hydrology will be noted as areas where formal wetlands delineation may be required.

[a]No specific sample has been determined to be a critical sample. However, the specified samples are required as part of an overall program to meet the ecological activities objectives.

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for inorganic chemicals would be proposed if these constituents are found in soils at concentrations sufficient to have acute and chronic toxic effects to trees or other ecological receptors. Construction activities would disturb large areas of surface soils with consequent potential impacts of fugitive dust on ecological receptors. Although surface soils in portions of the study area have been analyzed for radionuclides, data on potential chemical constituents do not exist. Sampling of surface soils for radiological and chemical constituents is therefore necessary for characterizing the potential risks of construction to ecological receptors.

Pathways of potential concern with respect to ecological receptors are as follows:

- Shallow Groundwater
  - Uptake by deeply rooted plants
  - Indirect exposure via food chain uptake

- Soils
  - Uptake of constituents from soils by plants
  - Dermal exposure and direct radiation
  - Incidental ingestion by animals
  - Exposure by surface water runoff during construction and groundwater leaching
  - Indirect exposure via food chain uptake

No permanent surface water features exist in the study area and therefore will not be evaluated as a transport mechanism for exposure of ecological receptors.

4.0 SAMPLING STRATEGY

Unless specifically modified by this addendum, all activities will be governed and conducted in accordance with the appropriate portions of the "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Work Plan Requirements," including:

- Volume I - Sampling Plan
- Volume II - Health and Safety Plan
- Volume IV - Data Management Plan
- Volume V - Quality Assurance Project Plan (QAPP)

Batch sorption tests will be conducted by Brookhaven National Laboratories (BNL), Long Island, New York. Prior to the start of testing, BNL will submit a quality assurance laboratory manual and a vendor source evaluation will be performed to establish compliance with the RI/FS QAPP requirements.

4.1 Geologic/Hydrogeologic Sampling Strategy

The strategy of this SAP is to support risk assessment efforts in identifying potential fate and transport mechanisms as they relate to the geologic conditions of the study area. This will be achieved by the construction of eight groundwater monitoring wells at five locations; five of the wells will be screened in the glacial overburden (1000 series) and three at the water table interface of the Great Miami Aquifer (2000 series).

Sampling and logging of the subsurface materials will be performed by a field geologist during drilling activities. Using split-spoon samplers, soil samples will be continuously collected ahead of the casing as the boring is advanced. At those locations where two monitoring wells are to be installed, soil samples will be collected from the 2000-series wells only; the 1000 series will be installed without collecting soil samples.

Monitoring wells will be installed in each geologic borehole in accordance with the procedures listed in the RI/FS Work Plan, Volume 5, Section 5.3. During the installation of each monitoring well, a field geologist will record all field measurements and well-construction information. Upon completion, each well will be developed to ensure it is clear of fines and sediment and the readings for pH, specific conductance, and temperature are stable per the RI/FS QAPP requirements. Water levels will be monitored monthly thereafter.

Hydraulic conductivity tests will be performed on the 1000-series wells to provide additional hydrogeologic information from the glacial overburden. The tests will be conducted as slug tests, eliminating the need for disposal of the potentially contaminated groundwater generated by pump testing. These tests will be conducted per the procedures in the RI/FS Work Plan, Volume 5, Section 5.6. Furthermore, it is believed that the groundwater yields associated with the glacial overburden will be inadequate for a pump test.

4.1.1 Geologic/Hydrogeologic Sampling Locations

As previously stated, the sampling plan is designed to collect hydrogeologic information on the glacial overburden and upper regional aquifer in the study area. Since some monitoring wells were installed during previous site activities or will be installed under other monitoring programs, only eight wells will be installed at the five locations illustrated in Figure 3 and listed in Table 7.

The wells at each location will provide the hydrogeologic information required to support the fate and transport modeling, as well as provide surface and subsurface soil samples for chemical and radiological analyses. Groundwater sampling, if required, will be performed as part of the Operable Unit 5 RI field data collection activities.

4.1.2 Geologic/Hydrogeologic Sample Collection and Analysis

Using a cable-tool drill rig and standard two-inch split-spoon samplers, soil samples will be continuously collected as each boring is advanced. At those location where two monitoring wells are to be installed, soil samples will only be collected from the 2000-series wells; the 1000-series wells will be installed without collecting soil samples. A field geologist will describe and classify all of the soil samples based on their color (Munsell Soil Color Chart), texture (Unified Soil Classification System), estimated water content, and depth from land surface. The samples will be collected using standard 24-inch split-spoon samplers in accordance with the American Society of Testing and Materials (ASTM) method D1586-84. If during drilling, split-spoon samples become impossible to acquire due to penetration resistance, then the geologist will log and sample the drill cuttings.

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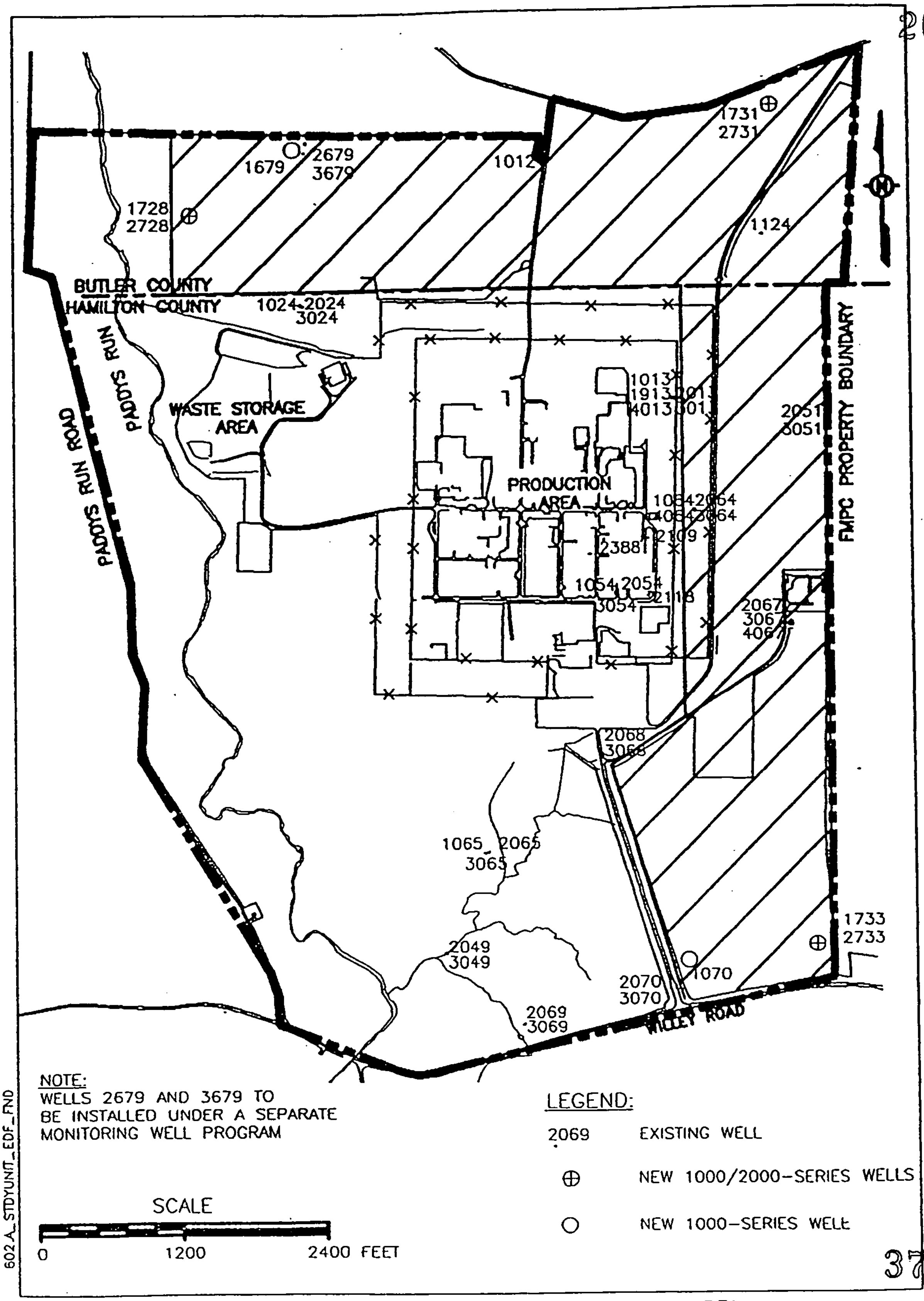

FIGURE 3. NEW WELL LOCATIONS – EWMF STUDY AREA

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TABLE 7

ESTIMATED DEPTHS OF NEW MONITORING WELLS
(See Figure 3 for Well Locations)

New Well Number	Estimated Depth (feet)
1728	35
2728	50
1731	30
2731	45
1733	40
2733	70
1070	35
2070[a]	103[b]
3070[a]	151.5[b]
1679	30
2679[c]	45[c]
3679[c]	120[c]

[a] Existing well
[b] Actual Depth
[c] To be installed under a separate monitoring program

Each sample will undergo radiological and volatile organic field screening. If any soil samples exceed the field screening criteria of a sustained reading greater than 5 ppm on the HNu for at least 10 seconds, the sample that exhibits the highest reading from each boring will receive full HSL analysis.

The soil samples will be used to characterize the geologic and hydrogeologic properties of the glacial overburden and upper regional aquifer, as well as providing needed samples for geotechnical, chemical, and radiological characterization studies.

Each newly installed well will be developed and water levels in both the new and existing wells will be monitored. Hydraulic conductivity (slug) testing will be performed on the 1000-series wells installed as part of this SAP per the RI/FS Work Plan.

4.2 Geotechnical Sampling Strategy

Geotechnical boring locations were selected so that the entire study area can be better characterized for FS engineering evaluation purposes. Soils data is very limited for the RI/FS database and will be used to better understand the topography and the soil engineering characteristics. This information, along with the eight borings from the hydrogeologic investigation, will provide a better understanding of the variability of the subsurface soils beneath the study area.

4.2.1 Geotechnical Boring Locations

Figure 4 shows the locations of the borings. A total of 18 borings will be drilled to a point sufficiently above the overburden/aquifer interface to avoid leakage from any perched zones into the aquifer. If perched water is encountered in any geotechnical boring, drilling will cease and the boring will be abandoned per RI/FS Work Plan, Volume 5, Section 5.2. The boring will be relocated and reinitiated based on the discretion of the field geologist/geotechnical engineer and the EWMF RI/FS program manager. It is expected the average borehole depth will be 30 feet. If bedrock is encountered, the borehole will be extended five feet to confirm its presence. Drilling will be conducted using standard hollow-stem auger drilling techniques.

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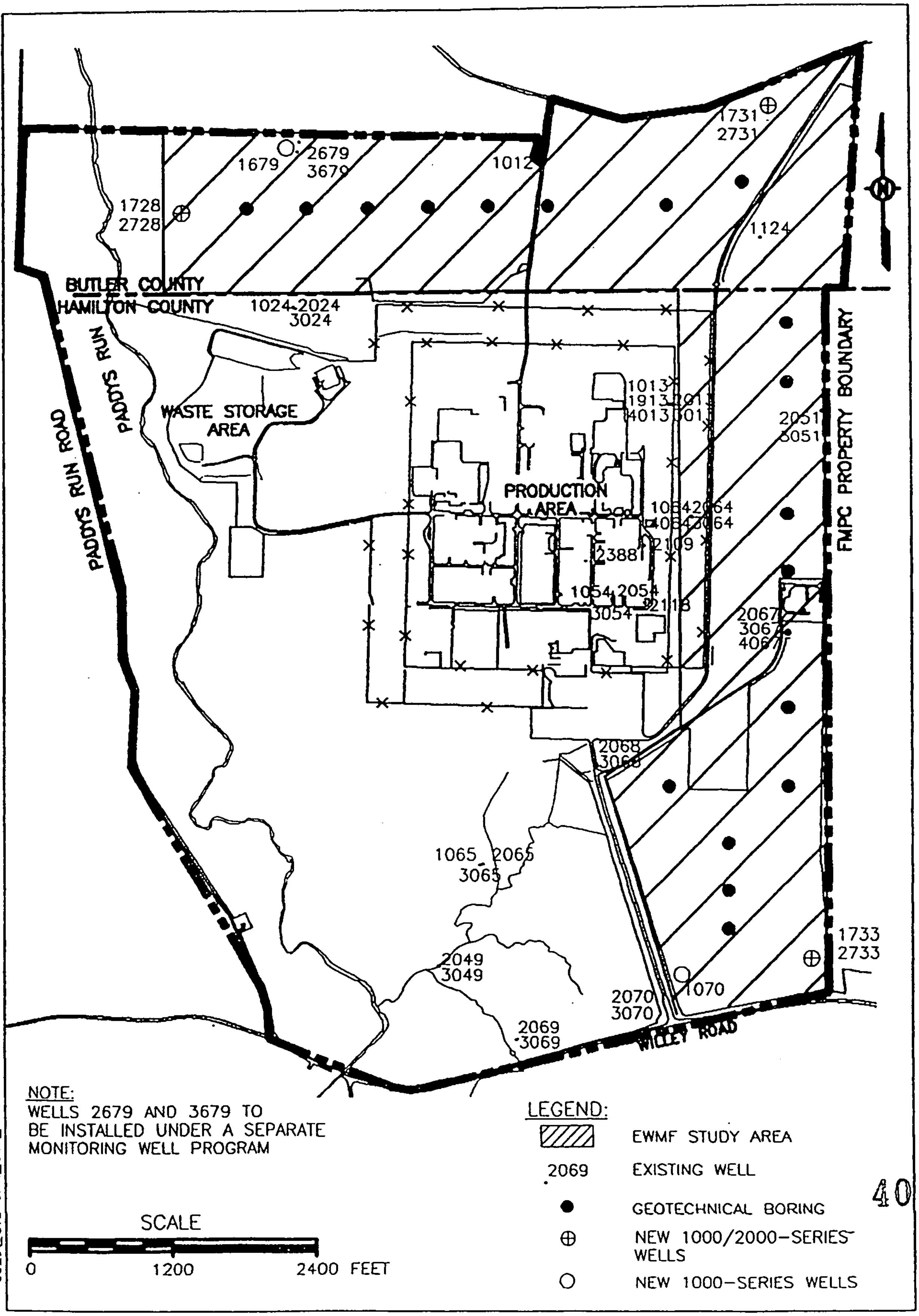

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FIGURE 4. GEOTECHNICAL BORING LOCATIONS – EWMF STUDY AREA

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4.2.2 Geotechnical Sample Collection and Analysis

Disturbed samples will be collected at five-foot intervals using standard 24-inch split-spoon samplers, where appropriate, according to ASTM D1586. A three-inch outside diameter thin-walled Shelby tube (ASTM D1587) will be hydraulically driven in advance of the auger to collect selected undisturbed samples when cohesive material is encountered. It is estimated that two Shelby tubes per boring will be taken at approximate depths of one-third and two-thirds within the glacial overburden thickness for a total of 36 Shelby tubes (see Figure 5). Rock coring will be conducted with NWT-size core barrel or equivalent and be in accordance with ASTM D2113. Based on noticeable soil property differences and field experience, a field geotechnical engineer or geologist will select appropriate samples during drilling. All borings will be abandoned per the RI/FS Work Plan, Volume 5, Section 5.2.

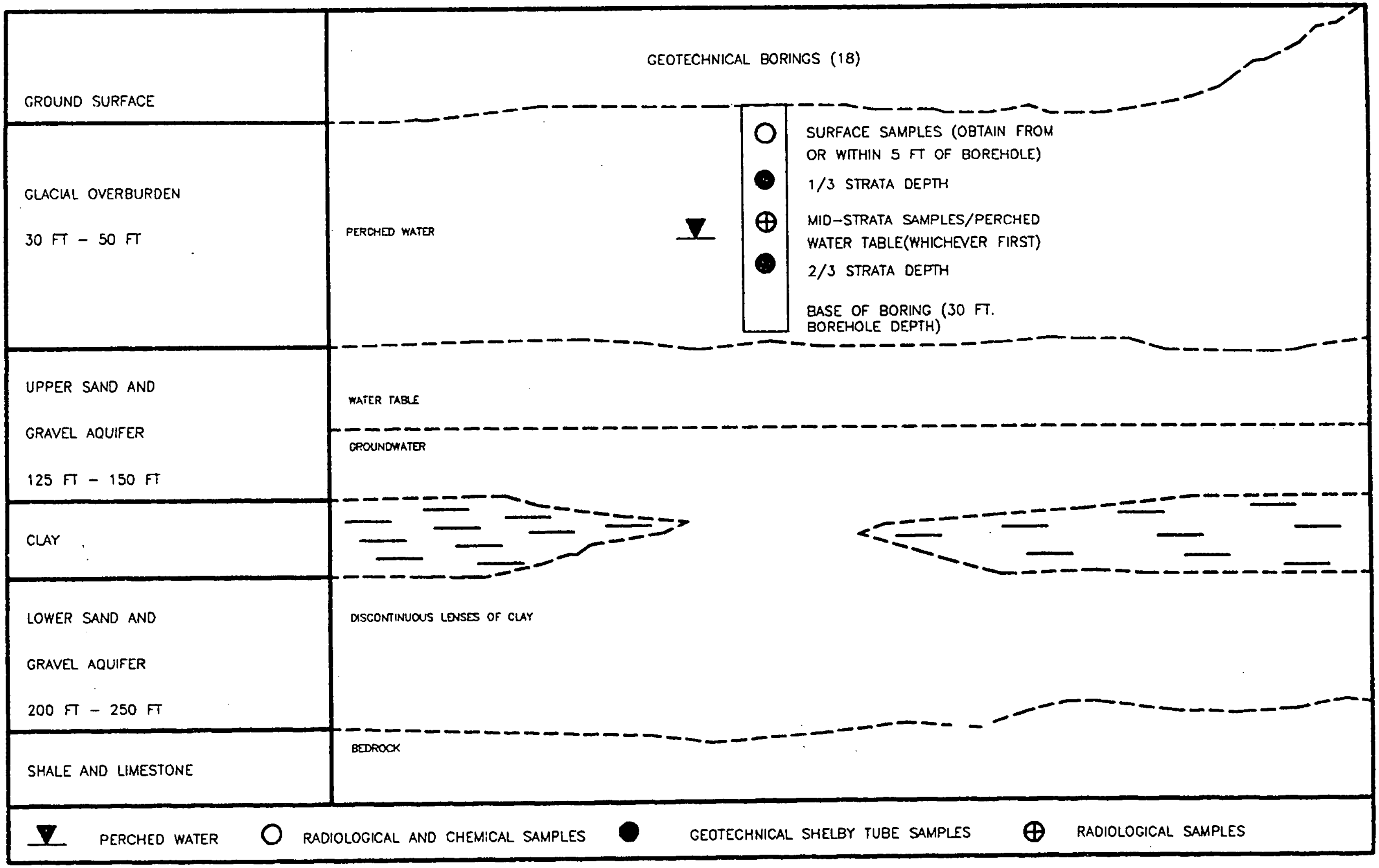
The selected soil samples from the geologic and geotechnical drilling operations will be shipped to an approved laboratory for analysis. The remaining soil samples and rock cores will be archived for future reference and examination, if needed. The type of test, type of sample, and estimated number of tests are shown in Tables 8 and 9.

For the purposes of determining preliminary sample quantities, it is assumed that from the estimated 36 Shelby tubes, the field technician will select 10 representative cohesive soil samples (i.e., Shelby tubes) for undisturbed laboratory analysis. It is further estimated that the following split-spoon samples will be selected by the field technician:

- 3 split-spoon soil samples per geotechnical boring (54)
- 4 split-spoon soil samples per each of 5 geologic boring locations (20)

for a total of 74 disturbed samples. Allowances have also been included for additional disturbed analyses, specifically grain size distribution, to assist in engineering material properties characterization and identify unforeseen subsurface conditions encountered during drilling.

Each sample will undergo radiological and volatile organic field screening. If any soil samples exceed the field screening criteria of a sustained reading greater than 5 ppm on the HNu for at least 10 seconds, the sample that exhibits the highest reading from each boring will receive full HSL analysis. Any soil selected for physical properties (geotechnical) testing that exceeds general licensable



NOTE: GEOCHEMICAL SAMPLES WILL BE OBTAINED FROM THE TOP, MIDDLE, AND BOTTOM OF EACH BORING

FIGURE 5
TYPICAL ANALYTICAL SAMPLING SEQUENCE FOR THE GEOTECHNICAL BORINGS

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TABLE 8

GEOTECHNICAL/PHYSICAL TESTS

Type of Test	Type of Sample	Number of Tests
Water content determination	Undisturbed/ Disturbed	75
Atterberg limits	Undisturbed/ Disturbed	75
Grain-size distribution with hydrometer analysis	Undisturbed/ Disturbed	100
Triaxial consolidated undrained ($\overline{CU}$) compression test with pore measurement	Undisturbed/ Disturbed	10
Permeability	Undisturbed	10
One-dimensional consolidation	Undisturbed	10
In situ soils density determination	Undisturbed	10
Specific gravity determination	Undisturbed/ Disturbed	75

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TABLE 9

GEOTECHNICAL/PHYSICAL PROPERTY TESTS AND THEIR RESPECTIVE CODES

Water content determination	ASTM D2216-90, "Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures," 1991 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
Atterberg limits	ASTM D4318-84, "Standard Test Method for Liquid Limit, Plastic Limit, and Plastic Index of Soils," 1989 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
Specific gravity determination	ASTM D854-83, "Standard Test Method for Specific Gravity of Soils," 1989 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
In situ soils density determination	EM 1110-2-1906, Engineering and Design, Laboratory Testing Manual, Department of the Army.
Grain-size distribution hydrometer analysis	ASTM D422-63, "Particle Size Analysis of Soils," 1989 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
Triaxial consolidated undrained ($\overline{CU}$) compression with pore pressure measurements	EM 1110-2-1906, Engineering and Design, Laboratory Testing Manual, Department of the Army.
One-dimensional consolidation	ASTM D2435-90, "One Dimensional Consolidation Properties of Soil," 1991 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
Permeability of granular soils	ASTM D2434-68, "Test Method for Permeability of Granular Soils (Constant Head)," 1987 Annual Book of ASTM Standards Vol. 04.08 Soil and Rock; Building Stones; Geotextiles.
Permeability of cohesive soils (falling head)	EM 1110-2-1906, Engineering and Design, Laboratory Testing Manual, Department of the Army.

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quantities (radiation levels) must be sent to a geotechnical laboratory licensed to receive radiological material.

Analytical testing for physical properties will be conducted under the appropriate ASTM standards and laboratory procedures using qualified geotechnical laboratory technicians and properly calibrated apparatus which meets ASTM D3740-80, "Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction."

4.3 Geochemical Sampling Strategy

The field sampling and subsequent analyses conducted under this work plan addendum will address only the geochemistry of the study area soils and waste leachate interaction. All soil samples will be obtained from the geologic and geotechnical borings. The waste and/or waste leachate and preliminary constituent analysis will be provided by sampling and treatability programs proposed by Operable Units 1, 2, and 4 with Operable Units 3 and 5 providing waste source characterizations. The procedures referenced in this section appear in Appendix A of this work plan.

4.3.1 Geochemical Locations

Surface and subsurface soil samples that are needed to characterize the mineralogical, physical, and geochemical properties of natural barrier material will be obtained from geologic and geotechnical boring locations as described in Sections 4.1.1 and 4.2.1.

4.3.2 Geochemical Sample Collection and Analysis

Samples will be collected using a 24-inch split-spoon sampler with stainless steel liners. Samples will be obtained from the top, middle, and bottom intervals within the glacial overburden of each geotechnical boring and five geologic boring locations. Of 69 samples, a total of 20 samples will be analyzed for CEC, TOC, and mineralogy (see Appendix A for petrographic and x-ray diffraction techniques required for mineralogic analysis). The 20 samples will represent the 10 distinct soil types in the EWMF acreage (USDA 1980, 1982) and a minimum of two samples of each soil type will be obtained. Additionally, three samples are required so that each dominant soil type will be available for batch sorption tests. All samples will be archived in a controlled environment and conform to the RI/FS chain-of-custody procedures. The 23 samples selected for analysis are approximately 33 percent 45 of the total number of samples collected for geochemical characterization. The project geochemist will select the archived samples to be analyzed based upon reviewing the boring logs and soil classifications.

To obtain intact samples from the split-spoon sampler, four 6-inch stainless steel liners will be used. After the sample is retrieved, each end of the liner will be covered with aluminum foil and sealed with a fitted plastic cap. All samples will be stored in a manner to minimize sample disturbance. All samples not analyzed will be archived until the EWMF final design has been chosen.

4.4 Sampling Strategy in Support of Risk Assessment

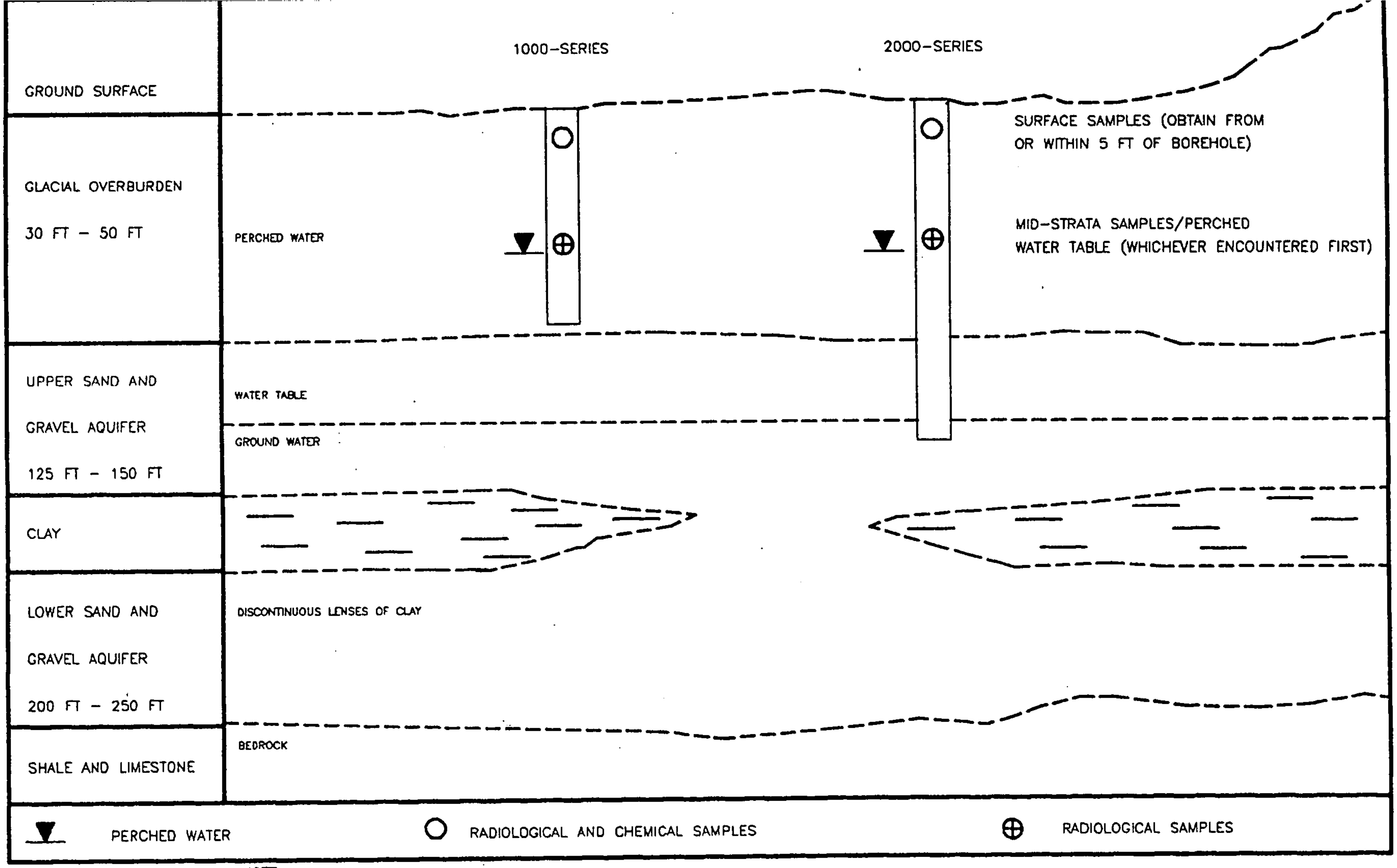
The purpose of these samples is to provide input values for air dispersion calculations. Air dispersion models will be used to determine the impacts of fugitive dust emissions during the construction of the EWMF. Surface and subsurface soil samples will be collected in conjunction with the geologic and geotechnical sampling programs. These samples will represent the three-dimensional volume of soil that may be removed during excavation for site preparation and foundation placement. The soils thereby become available for dispersion. The values from the analytical data and air pathway information from the on-going air quality monitoring program at the Fernald site will be combined to determine the hypothetical reasonable maximum exposure for nearby residents.

4.4.1 Soil Sampling Locations

The sampling locations specified for the geologic and geotechnical investigations (Figures 3 and 4) will be utilized for purposes of the risk assessment. One surface soil sample will be collected at or within five feet of each geologic or geotechnical boring. One subsurface soil sample for radiological analysis will be collected from each boring (Figures 5 and 6). Unless HNu field screening indicates otherwise, no subsurface soil samples for chemical analysis will be collected.

4.4.2 Soil Collection and Analysis

Geotechnical borings will be advanced at 18 locations in the study area as shown in Figure 4. The samples from each of the five well boring locations will be collected from the deepest boring at that location. The eight wells are listed in Table 7 and illustrated in Figure 3. The radiological and chemical surface soil samples will be collected within the first six inches of soil. The radiological 46



NOTE:
GEOCHEMICAL SAMPLES WILL BE OBTAINED FROM THE TOP, MIDDLE, AND BOTTOM OF THE GLACIAL OVERBURDEN
1000-SERIES CONTINUOUS GEOLOGIC SAMPLING
2000-SERIES GEOLOGIC SAMPLING AT EVERY 5 FEET OR LITHOLOGY CHANGES
ALL SAMPLES TO BE COLLECTED FROM DEEPEST BORING AT EACH OF THE FIVE(5) LOCATIONS

FIGURE 6
TYPICAL RADIOLOGICAL AND CHEMICAL SAMPLING SEQUENCE FOR THE GEOLOGIC BORINGS

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subsurface samples will be collected at mid-stratum in the glacial overburden. In the event that perched water is encountered first, the subsurface sample will be collected at the perched water table.

All surface soil samples will be submitted for full radiological and full Hazardous Substance List (HSL) analyses. All mid-stratum samples will be submitted for total uranium and gamma emitter analyses. By analyzing both the surface and subsurface soils a more accurate estimate of the distribution of contaminants in the soils can be derived. The type and number of analyses are summarized in Table 10. Surface soil and subsurface soil sampling will be conducted per the RI/FS Work Plan, Volume 5, Sections 6.4 and 6.6, respectively.

4.4.3 Surface Radiation Field Measurements

Radiation field measurements will be conducted to further characterize the concentration of gamma emitters in surface soils in the study area. Locations for surface radiation measurements will be established according to Section 1.2.1 of the "Remedial Investigation/Feasibility Study: Volume I: Sampling Plan" (March 1988). The RI/FS sampling plan requires 100-foot intervals between sampling locations. The grid will run north to south and east to west, following the state planar coordinate grid system. The results of this walkover survey may influence the location of surface soil sampling by identifying areas requiring further characterization.

4.5 Ecological Assessment Sampling Strategy

The off-property ecological characterization will cover a study area consisting of a 1000-foot-wide zone perpendicular to the study area boundaries (Figure 7). The 1000-foot distance is chosen as a reasonable upper limit for the occurrence of direct, short-term impacts of construction. Indirect and long-term impacts will be included in the NEPA analysis, but do not require additional data. The characterization has two elements. First, soil surveys of Hamilton and Butler counties (USDA 1980, 1982), topographic maps of the FEMP and vicinity, and existing aerial photographs of the FEMP will be examined for indications of wetlands outside the boundaries of the FEMP. These indications include hydric soils, streams, standing water, and wetland areas noted on the Shandon quadrangle topographic map (U.S. Geologic Survey [USGS] 1981). Wetlands within FEMP boundaries have been delineated in the RI/FS database. Aerial photographs and topographic maps will be used to map general habitat types; for example, pasture and deciduous forest. This information will

TABLE 10

RADIOLOGICAL/CHEMICAL LABORATORY ANALYSES

Medium/Location	Required Analyses	No. of Samples	Text Reference Section
Soil (Total samples to be collected: Chemical 23 and Radiological 46)			
Surface samples at geotechnical borings	Full radiological[a] Full HSL[b]	18 18	4.2 Geotechnical Sampling Strategy
Samples at mid-stratum[c] of glacial overburden	Radiological: Total uranium and gamma spectral analysis	18 (estimated)	4.2 Geotechnical Sampling Strategy
Samples at perched water table	Full radiological[a]	18[d] (estimated)	4.2 Geotechnical Sampling Strategy
Surface samples at monitoring well locations	Full radiological[a] Full HSL[b]	5 5	4.1 Geologic/Hydrogeologic Sampling Strategy
Samples at mid-stratum of glacial overburden[c] at monitoring well locations	Radiological: Total uranium and gamma spectral analysis	5 (estimated)	4.1 Geologic/Hydrogeologic Sampling Strategy
Samples at perched water table at monitoring well locations	Full Radiological[a]	5[d] (estimated)	4.1 Geologic/Hydrogeologic Sampling Strategy
Tree Analysis	Total uranium	2 samples @ 9 locations = 18 samples	4.5 Ecological Assessment

[a] Full radiological analysis includes: gamma spectral analysis, isotopic uranium, isotopic thorium, isotopic plutonium, total uranium, Sr-90, Tc-99, Cs-137, Ru-06, Np-237, Ra-226, and Ra-228.

[b] Full HSL analysis includes: HSL inorganics, HSL volatiles, HSL semi-volatiles, and HSL pesticides/PCBs.

[c] Samples will be collected mid-stratum in the event that the perched water table is not encountered.

[d] The number is based upon the maximum borings to be installed in the study area. Samples will only be collected if the perched water table is encountered

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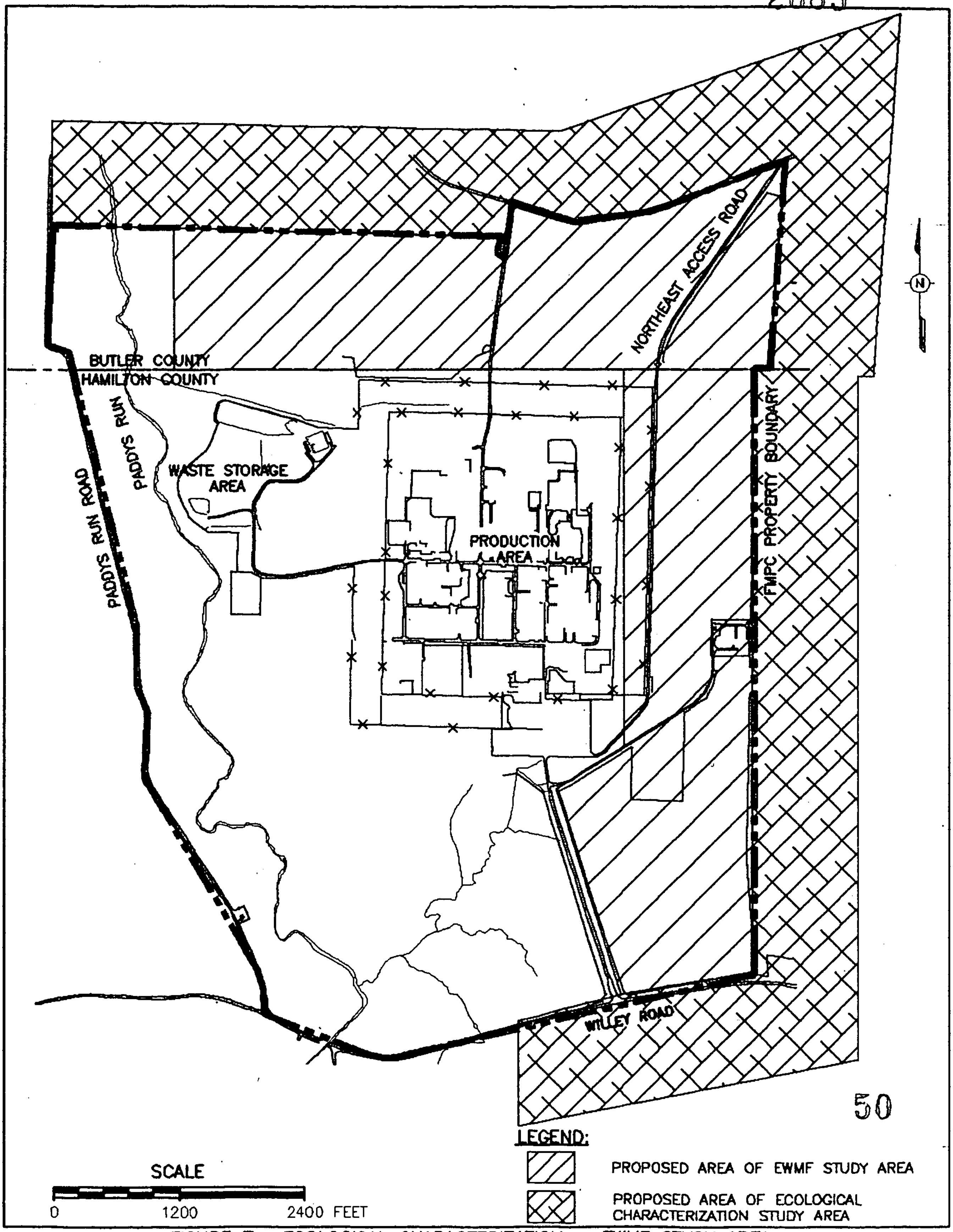

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FIGURE 7. ECOLOGICAL CHARACTERIZATION – EWMF STUDY AREA

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be combined with that provided for the FEMP by Facemire et al. (1990) to produce a habitat map for the combined study area. Soil surveys will also be checked for soil map units associated with prime agricultural lands, an additional concern for NEPA analyses of potential impacts of EWMF construction.

The second element of the off-property ecological characterization, to be conducted in the spring or early summer, is a walkover survey of the properties deemed critical for the successful completion of the survey (Figure 7). Experienced field biologists will note general habitat types, dominant plant species, approximate species abundances, and canopy height. During this walkover, mammals, birds, and herpetofauna, or signs of them (e.g., scat, tracks, or nests) will be noted. Biologists will overturn rocks and fallen trees, etc., to look for reptiles and amphibians, as well as look in drainages for amphibians. The locations of potential wetlands indicators such as hydric soils, hydrophytic vegetation, or wetlands hydrology will be noted as areas where formal wetlands delineation may be required.

4.5.1 Biota Sampling Locations

Two replicate samples for radionuclide analysis will be collected from nine trees at the same locations as those used for surface soil radiological and chemical sampling, choosing the specified tree nearest to the boring. Sampling of trees will be restricted to the wooded portion of the EWMF study area, west of the northeast access road on the FEMP. The referenced boring locations are the eight geotechnical borings and Well 1728 shown in Figure 4.

4.5.2 Biota Sample Collection and Analysis

Each tree sampled will be identified as to species. Two samples from each tree containing both twig and leaf tissue will be removed with scissors at a height of approximately five feet above the ground or the lowest twig and leaf tissue available. Sampling of twig and leaf tissue, which are more commonly sampled than other plant tissue (Garten 1980; Landeen and Mitchell 1986), will allow comparison of FEMP concentrations with those in trees from other contaminated and noncontaminated sites. The minimum tree size to be sampled is four inches in diameter. All sampling, quality assurance, and decontamination procedures will follow the Biological Resources Sampling Plan from the RI/FS Work Plan. Both samples from each location will be analyzed for total uranium because uranium is the most abundant and widely distributed contaminant at the FEMP. A third sample will be collected for inorganic chemical analyses if the results of soil sampling indicate that plant uptake could pose a significant ecological or health hazard. The analyses are summarized in Table 10.

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REFERENCES

American Nuclear Society, 1986, "Measurement of the Leachability of Solidified Low-level Radioactive Wastes by a Short-Term Test Procedure," ANSI/ANS-16.1-1986, ANS, La Grange Park, IL.

American Society for Testing and Materials, 1988, "Water (I)," Sec. 11, Vol. 11.01, Annual Book of ASTM Standards, ASTM, Philadelphia, PA.

Facemire, C.F., S.I. Guttman, D.R. Osborne and R.H. Sperger, 1990, "Biological and Ecological Site Characterization of the Feed Materials Production Center," FMPC - SUB 018, prepared for Westinghouse Materials Company of Ohio, Cincinnati, OH.

Garten, C.T., 1980, "Comparative Uptake of ^{234}U, ^{239}U, ^{241}Am and ^{244}Cm by Boxelder Trees (Acre negundo) Inhabiting a Contaminated Tennessee Floodplain," Health Physics, Vol. 339, Pages 332-334.

Landeen, D.S. and R.M. Mitchell, 1986, "Radionuclide Uptake by Trees at a Radwaste Pond in Washington State," Health Physics, Vol. 50, Pages 769-774.

Logan, T.J. and R.H. Miller, 1983, "Background Levels of Heavy Metals in Ohio Farm Soils," Research Circular 275, Ohio State University, Columbus, OH.

Marcus, W.L., 1986, "Lead Health Effects in Drinking Water," Toxicity and Industrial Health, 2:4 pp. 363-407.

Myrick, T.E., B.A. Berven and F.F. Haywood, 1983, "Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S.," Health Physics, Vol. 45, pp. 631-642.

U.S. Army Corps of Engineers, 1952, "Report of Foundation Investigation, Feed Materials Production Center, Fernald, Ohio," COE, Ohio River Division Laboratories, Mariemont, OH.

Shacklette, H.T. and J.A. Boerngen, 1984, "Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States," U.S. Geological Survey Professional Paper 1270.

U.S. Dept. of Agriculture, Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, and Ohio Agricultural Research and Development Center, 1980, "Soil Survey of Butler County, Ohio," USDA, ODNR, and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Agriculture, Soil Conservation Service, Ohio Dept. of Natural Resources, Division of Lands and Soil, and Ohio Agricultural Research and Development Center, 1982, "Soil Survey of Hamilton County, Ohio," USDA, ODNR and Ohio Agricultural Research and Development Center, n.p.

U.S. Dept. of Energy, 1988, "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Work Plan Requirements," Revision 3, DOE, Oak Ridge Operations Office, Oak Ridge, TN.

REFERENCES
(Continued)

U.S. Environmental Protection Agency, 1991, "Health Effects Assessment Summary Tables, FY - 1991," OERR 9200.6-303(91-1), EPA, Washington, DC.

U.S. Environmental Protection Agency, 1990, "Method 1311 Toxicity Characteristic Leaching Procedure (TCLP)," Code of Federal Regulations, Title 40, Part 261, Appendix II, EPA, Washington, DC.

U.S. Environmental Protection Agency, 1990, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Code of Federal Regulations, Title 40, Part 264, EPA, Washington, DC.

U.S. Environmental Protection Agency, 1989, "Risk Assessment Guidance for Superfund: Human Health Evaluation Manual Part A, Interim Final," EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1989, "Risk Assessment Guidance for Superfund: Volume II, Environmental Evaluation Manual," EPA/540/1-89/001, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," EPA/540/G-89/004, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1987, "Data Quality Objectives for Remedial Response Activities, Development Process," EPA/540/G-87/003, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Nuclear Regulatory Commission, 1990, "Licensing Requirements for Land Disposal of Radioactive Waste," Code of Federal Regulations, Title 10, Part 61, NRC, Washington, DC.

Wolery, T. J., 1983, "EQ3NR, A Computer Program for Geochemical Aqueous Speciation-Solubility Calculations: User's Guide and Documentation," UCRL-53414, Lawrence Livermore National Laboratory, Livermore, CA.

Wolery, T. J., 1984, "EQ6, A Computer Program for Reaction-Path Modeling of Aqueous Geochemical Systems: User's Guide and Documentation," Draft, Lawrence Livermore National Laboratory, Livermore, CA.

APPENDIX A

GEOCHEMICAL PROCEDURES

A.1.0 INTRODUCTION

The geochemical procedures described in the following sections specify all required components to support the subsurface constituent pathway analyses for the EWMF site characterization by analyzing the geochemical effects that the waste has on the existing study area soils, as well as natural and engineered barrier materials (e.g., clays, bentonite/sand mixes, and structural concrete).

A.2.0 Modified ANSI/ANS 16.1 Method

Infiltrating precipitation or surface water will react with untreated and treated waste to form a waste leachate. Characterization of this leachate is required to support the EWMF pathway analysis. Leachate characterization will be carried out by running a modified ANSI/ANS-16.1-1986 leach test with cement-treated waste from Operable Unit 1. Operable Unit 1 waste has been selected for this characterization because it represents the largest volume of process-generated waste that may be placed in the EWMF.

Prior to conducting the modified ANSI/ANS-16.1986 leach test, untreated waste will be obtained from each waste pit in Operable Unit 1 and mixed to form a single composite. This composite will be mixed with the cement formulations for Operable Unit 1 proposed treatability studies and cured for 30 days. Based upon the Operable Unit 1 treatability study results, a maximum of three samples will be selected from the stock of composited, cured, cemented waste samples. Specimen preparation, initial leachant, leach vessels, and the ratio of leachant volume to the specimen external surface area will follow the methods outlined in ANSI/ANS-16.1. By using the modified ANSI/ANS-16.1 Method, the initial leaching solution remains in contact with the cemented waste throughout the 90-day leach period, and leachate samples are obtained at 5-, 45-, and 90-day intervals. This modification allows for evaluation of contaminant solubility limits, rather than diffusion coefficients.

The laboratory set up will follow ANSI/ANS-16.1, and each cylindrical waste sample will be placed in deionized water and leached for 90 days. At 5- and 45-day sampling intervals, 100 mℓ of solution will be removed and analyzed for inductively coupled plasma (ICP) metals, pH, and uranium (Table A.1). A complete chemical and radiological characterization of the leachate will be done with the entire solution volume at the end of 90 days (Table A.1).

A.3.0 Petrographic and X-Ray Diffraction Analysis

To obtain data on the mineralogy of natural and engineered barriers, petrographic and X-ray diffraction studies will be conducted with solid samples obtained from well-installation and geotechnical borings in the EWMF acreage and vendor materials, if applicable. Mineralogic data on the barriers are required to support the EWMF pathway analysis.

Petrographic studies will be conducted by examining both horizontal and vertical sections of soil cores and vendor materials, if applicable. All unconsolidated samples will be impregnated with an epoxy resin prior to the preparation of thin sections. One-half of the area of all thin sections will be stained for the identification of K-feldspar and dolomite. Optical microscopy will be used to identify all mineral phases (e.g., clay, calcite, dolomite, quartz, zircon, etc.,) and quantification will be carried out using a point-counting technique (e.g., 50 percent clay, 20 percent calcite, 10 percent dolomite, 8 percent quartz, trace zircon, etc.). If intact soil cores are used in the preparation of thin sections, a point-counting technique also will be used to quantify the porosity of samples.

X-ray diffraction studies will be conducted to identify the minerals in the silt and clay-size fraction of the sample. Samples used for X-ray diffraction studies are sieved to separate the size fraction less than 230 mesh. This size fraction is placed in deionized water that contains a deflocullating agent and ultrasonically agitated to disaggregate the particles. Centrifugation or a settling tube is used to separate the silt fraction (>2 microns) and the remaining clay suspension is decanted into a vacuum filtration system to collect the clay fraction and orient the crystallites parallel to their basal (001) d-spacing. The relative intensity of the principal d-spacing reflection of a clay mineral is used to semi-quantify ($\pm$ 20 percent) the proportion of the clay mineral in a sample. An appropriate calibration standard (e.g., NBS Silicon d-spacing SRM-640b) is run before and after the analysis of the samples to ensure instrument calibration.

Additional tests to characterize the chemical composition of the natural-occurring clay minerals may be requested by the project geochemist if the stoichiometry of the clay minerals becomes important for demonstrating compliance of the EWMF with 10CFR61 and 40CFR264. For instance, X-ray diffraction analysis may reveal that the dominant clay mineral in a sample is montmorillonite; 57
however, the dominant interlayer cation cannot be identified by X-ray diffraction. The interlayer

cation can be important because Na-montmorillonite will ion exchange more readily than Ca-montmorillonite; thus Na-montmorillonite would be a more effective barrier to radionuclide and metal migration. If necessary, a scanning electron microscope (SEM) fitted with energy dispersive spectroscopic (EDS) capabilities can characterize the morphology of each clay mineral and semiquantify the chemical composition of the clay mineral. Characterization by SEM/EDS would allow a definite conclusion to be reached on the dominant interlayer cation in the clay mineral.

A.4.0 Batch Sorption Tests

Constituent adsorption ratios are characterized by reacting waste leachate with all natural and engineered barrier materials. Adsorption ratios for constituents of concern are required to support the EWMF pathway analysis.

To evaluate the sorption isotherm, laboratory adsorption tests will be run over the range of constituent concentrations reported for the waste leachate with barrier materials. Adsorption ratios will be reported in units of volume over mass (e.g., liter/kilogram) and are defined as the mass of the constituent sorbed to the solid (mg/kg) divided by the concentration of the constituent in solution (mg/ℓ). The mass of constituent sorbed to the solid will be calculated from the difference in the concentration between the initial and final solutions, with a correction applied, if needed, to account for adsorption on the surface of the reaction vessel. Adsorption to the surface of the vessel housing the experiment will be evaluated with blank runs containing solution only.

Batch tests will be conducted in duplicate or triplicate with barrier materials and waste leachate. Constituent concentrations in the leachate will be varied by diluting and spiking the leachate with deionized water and spike solutions, respectively. Solution preparation and the batch tests will take place under a controlled atmosphere to maintain in situ pH and Eh conditions. Equilibration time for the adsorption reactions will be determined by preliminary runs, and upon attainment of steady-state conditions the actual testing will begin. The batch tests will not be reversed to evaluate desorption ratios because equilibrium between adsorption/desorption reactions is difficult, and often impossible, to obtain. Disequilibrium between adsorption and desorption ratios is attributed to surface reaction kinetics between the mineral and the adsorbed constituent that result in incorporation of the adsorbed constituent into the mineral structure where it is no longer available for desorption. These conditions 58 produce measured adsorption ratios that are not equal to measured desorption ratios (i.e., adsorption > desorption). Thus, the adsorption ratios estimated by the proposed laboratory batch tests should not be termed distribution coefficients, since equilibrium adsorption/desorption will not be demonstrated.

A.5.0 Evaluating Chemical Degradation of Barriers and Concrete Structures

The chemical degradation of engineered and natural barriers must be evaluated to demonstrate the integrity of the EWMF for a minimum of 500 years (10CFR61.7(a)(2)). This analysis will be carried out by conducting geochemical modeling with data obtained on waste leachate, natural barrier mineralogy, and concrete and bentonite formulations used in engineered barriers.

Geochemical modeling will be conducted with the EQ3NR and EQ6 computer codes (Wolery 1983, 1984) to evaluate dissolution/precipitation reactions that occur as leachate migrates through and reacts with natural and engineered barrier materials. Results from this modeling effort will provide data on the number of moles of each barrier mineral that can be dissolved in the waste leachate and the resulting change in pore volume of the barrier material. The solubility of barrier minerals in waste leachate and changes in porosity and permeability are evaluated with a reaction-path analysis that simulates leachate migration through and reaction with barrier material.

The reaction-path analysis begins by calculating the most stable thermodynamic assemblage of aqueous species (e.g., Mg^{+2}, HCO_3^-, $UO_2(CO_3)_2^{-2}$, etc.,) in the waste leachate. After determining the species present in waste leachate, the minerals in the barrier or structured concrete are added incrementally to the leachate to increase the solution concentrations of those elements present in the mineral (e.g., each mole of calcite dissolved by the leachate results in a one-mole increase in the concentration of Ca^{+2} and CO_3^{-2} in the leachate). This addition process, referred to as titration, simulates the dissolution of barrier material by waste leachate. As the titration proceeds, solubility limits are reached for barrier and secondary (i.e., non-barrier) minerals and they are precipitated from the leachate. When all barrier minerals are saturated in the leachate, the modeling is terminated and the change in pore volume is calculated by summing the molar volume of dissolved minerals and comparing it to the molar-volume sum of precipitated phases. In this manner, changes in porosity (and hence permeability) can be predicted as a function of time.

TABLE A.1

ANALYTICAL SCHEDULE AND PARAMETERS OF INTEREST FOR MODIFIED ANSI/ANS-16.1 LEACH TEST

5 Days	45 Days	90 Days		
pH	pH	pH	^{137}Cs	Eh
Ag	Ag	Ag	^{237}Np	alk
Al	Al	Al	^{238}Pu	Cl
Ba	Ba	As	$^{239,240}Pu$	F
Be	Be	Ba	^{226}Ra	NH_4^+
Be	Be	Ba	^{228}Ra	NH_4^+
Ca	Ca	Be	^{90}Sr	NO_3^-
Cd	Cd	Ca	^{99}Tc	PO_4^{-3}
Co	Co	Cd	^{228}Th	SO_4^{-2}
Cr	Cr	Co	^{230}Th	TOC
Cu	Cu	Cr	^{232}Th	
Fe	Fe	Cu	^{234}U	
Mg	Mg	Hg	$^{235,236}U$	
Mo	Mo	K	^{238}U	
Mn	Mn	Mg		
Na	Na	Mo		
Ni	Ni	Mn		
Sb	Sb	Na		
Si	Si	Ni		
Tl	Tl	Pb		
U	U	Sb		
V	V	Se		
Zn	Zn	Si		
		V		
		Zn		