U-003-303.15

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TREATABILITY STUDY WORK PLAN FOR OPERABLE UNIT 1 REMEDY DESIGN LABORATORY STUDIES VITRIFICATION PART 1A: WORK PLAN NOVEMBER 1992

01/07/93

DOE-FN/EPA
DOE-0772-93
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WORK PLAN

TREATABILITY STUDY WORK PLAN FOR OPERABLE UNIT 1

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDY DESIGN LABORATORY STUDIES

VITRIFICATION

Part 1A: WORK PLAN

GTS DURATEK/CATHOLIC UNIVERSITY OF AMERICA

NOVEMBER, 1992

U.S. DEPARTMENT OF ENERGY

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LIST OF ACRONYMS/ABBREVIATIONS

AA	Atomic Absorption
ALARA	As Low As Reasonably Achievable
ANSI/ASME	American National Standards Institute/American Society of Mechanical Engineers
ARAR	Applicable or Relevant and Appropriate Requirement
ASTM	American Society for Testing of Materials
CCHP	Catholic University Chemical Hygiene Program
CCMSM	Catholic University Chemical Material Safety Manual
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CUA	The Catholic University of America
DCP	Direct Current Plasma
DOE	Department of Energy
DQO	Data Quality Objectives
EPA	Environmental Protection Agency
FEMP	The Fernald Environmental Management Project
FERMCO	Fernald Environmental Management Company of Ohio
FFCA	Federal Facilities Compliance Agreement
GTS	General Technical Services
HCS	Hazard Communication Standard
HEPA	High Efficiency Particulate Air
HF	Hydrofluoric Acid
IAEA	International Atomic Energy Agency
IC	Ion Chromatography
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
LCS	Laboratory Control Samples
MCC	Materials Characterization Center
NBS	National Bureau of Standards
NOX	Oxides of Nitrogen
NQA	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCT	Product Consistency Test
PNL	Pacific Northwest Laboratory
QA/QA	Quality Assurance/Quality Control
QAPjP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SEM-EDX	Scanning Electron Microscope-Energy Dispersive Spectrometer

LIST OF ACRONYMS/ABBREVIATIONS (continued)

SOP	Standard Operating Procedure
SOX	Oxides of Sulfur
S/V	Surface/Volume
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Content
VSL	Vitreous State Laboratory
WEMCO	Westinghouse Environmental Management Company

LIST OF ELEMENTS:

Al	Aluminum
Ag	Silver
As	Arsenic
B	Boron
Ba	Barium
Ca	Calcium
Cd	Cadmium
Cr	Chromium
Fe	Iron
Ge	Germanium
Hg	Mercury
K	Potassium
Li	Lithium
Mg	Magnesium
Mn	Manganese
Ni	Nickel
P	Phosphorus
Ra	Radium
Si	Silicon
Sr	Strontium
Tc	Technicium
Ti	Titanium
U	Uranium
Th	Thorium
Zr	Zirconium

SECTION 1.0 PROJECT DESCRIPTION

1.0 Project Description

The Fernald Environmental Management Project (FEMP) is a federal facility formerly for the production of pure uranium for the U.S. Department of Energy (DOE). Production at the contractor-operated facility ended in 1989. The site is now dedicated to environmental restoration. The FEMP is located on 1050 acres in a rural area approximately 20 miles northwest of downtown Cincinnati, Ohio. On July 18, 1986, a Federal Facilities Compliance Agreement (FFCA) was jointly signed by the U.S. Environmental Protection Agency (U.S. EPA) and DOE to ensure that human health and environmental impacts associated with past and present activities at the FEMP are thoroughly investigated so that appropriate remedial actions can be assessed and implemented. The FEMP is currently operating under a consent agreement of which the FFCA is a part. A Remedial Investigation/Feasibility Study (RI/FS) has been initiated to develop these remedial actions.

The FEMP was divided into five operable units to facilitate remediation. Operable Unit 1 consists of the Waste Pits 1 through 6, the Clearwell, and the Burn Pit. Radioactive waste, consisting of naturally occurring radionuclides left over from uranium ore processing, and various chemicals were stored in this operable unit. The waste in the pits, the Clearwell, and soil surrounding and between the pits are to be remediated.

Both in situ and removal alternatives have been proposed as remedial actions. Removal options are expected to include some of the contaminated soils surrounding the waste. The total amount of material which may require treatment is approximately 1.4 million cubic yards.

The scope of the laboratory study discussed in this document is the laboratory scale remedy design and process development for the waste in Waste Pits 1 through 6, the Burn Pit, and the Clearwell. This Work Plan was prepared in accordance with EPA's "Guide for Conducting Treatability Studies Under CERCLA" (EPA 1988) and the Fernald RI/FS Sitewide CERCLA Quality Assurance Project Plan (SCQ).

1.1 Purpose

The initial screening of alternatives has been conducted (DOE 1991) for Operable Unit 1 with cement stabilization and vitrification being identified as two potential treatment technologies. To support facilities design and process scale-up detailed process information is required.

This treatability work plan outlines the objectives, procedures, and techniques on conducting laboratory scale process studies of vitrification for Waste Pit 5 of Operable Unit 1. Waste pit 6 and Clearwell sludges will also be analyzed for vitrification characteristics but no process studies will be

performed. Characterization and process studies on the other waste pits will be performed subsequently and will be based on the results of this study.

The data, described in the Treatability Study Work Plan for Operable Unit 1, Oct. 1991 was developed as part of the work performed for the remedy screening and remedy selection. This data will be the basis for the remedy design vitrification work. Preliminary formulations and compositional ranges, developed in these studies comprise the starting point for the test matrix in this program. These preliminary formulations will be refined and a data base of process information developed to support remedial design during the bench- and pilot-scale studies. The data resulting from this process study will be considered in support of the FS if available.

1.2 Background Information

1.2.1 Site Description

A variety of chemical and metallurgical processes were utilized at the FEMP for the manufacture of uranium products. During the manufacturing process, uranium compounds were introduced into the FEMP processes at several points. Impure starting materials were dissolved in nitric acid, and the uranium purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating converted the nitrate solution to uranium trioxide (UO_3) powder. This compound was reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal was produced by reacting UF_4 and magnesium metal in a refractory-lined vessel. This primary uranium metal was then remelted with scrap uranium metal to yield a purified uranium ingot.

From 1953 through 1955, the FEMP refinery processed pitchblende ore from the Belgian Congo. Pitch-blend ore contains all daughter products of the uranium decay chains and is particularly high in radium. No chemical separation or purification was performed on the ore before its arrival at the FEMP. Beginning in 1956, the refinery feedstock consisted of uranium concentrates (yellowcake) from Canada and the United States. Canadian concentrates were not processed after 1960. In the production of these concentrates, most of the uranium daughters had been removed. However, radium-226 (Ra-226) and thorium-230 (Th-230) remained in the yellowcake in amounts that varied with the process.

Small amounts of thorium were processed at the FEMP on several occasions from 1954 through 1975. Thorium operations were performed in the metals fabrication plant, the recovery plant, the special projects plant, and the pilot plant. The FEMP currently serves as the thorium repository for DOE and maintains long-term storage facilities for a variety of thorium materials.

Large quantities of liquid and solid waste were generated by the various operations at the FEMP. Before 1984, disposal of solid and slurried waste

from FEMP processes was in the on-property waste storage area. This area, which is located west of the production facilities, includes six low-level radioactive waste storage pits, burn pit and a clearwell; two earthen-bermed concrete silos containing K-65 waste that are high-specific activity and low-level radium-bearing residues resulting from the pitch-blend refining process; one concrete silo containing metal oxides (raffinate solids disposed of in the pits are similar to those initially dried and pneumatically transferred to that silo) and one unused concrete silo; two lime sludge ponds; and a sanitary landfill. The waste storage area is addressed under Operable Units 1, 2, 3, and 4.

An inactive fly ash disposal area and an active fly ash pile, addressed under Operable Unit 2, are located approximately 3000 feet south-southeast of the waste storage area. One pile remains active for the disposal of fly ash from the FEMP coal-fired boiler plant. Fly ash from this area will be tested in the Operable Unit 1 treatability studies. An area between and adjacent to the fly ash areas, known as the Southfield, is believed to be the disposal site for construction debris and possibly other types of solid waste from FEMP operations. The Southfield is also being addressed as a solid waste unit under Operable Unit 2.

1.2.2 Operable Unit Description

The waste pits consist of Pits 1 through 6, the Burn Pit, and Clearwell (Figure 1-1). They are numbered chronologically in their order of construction. Pits 3 and 5 are referred to as "wet" because they received waste in mostly slurry form.

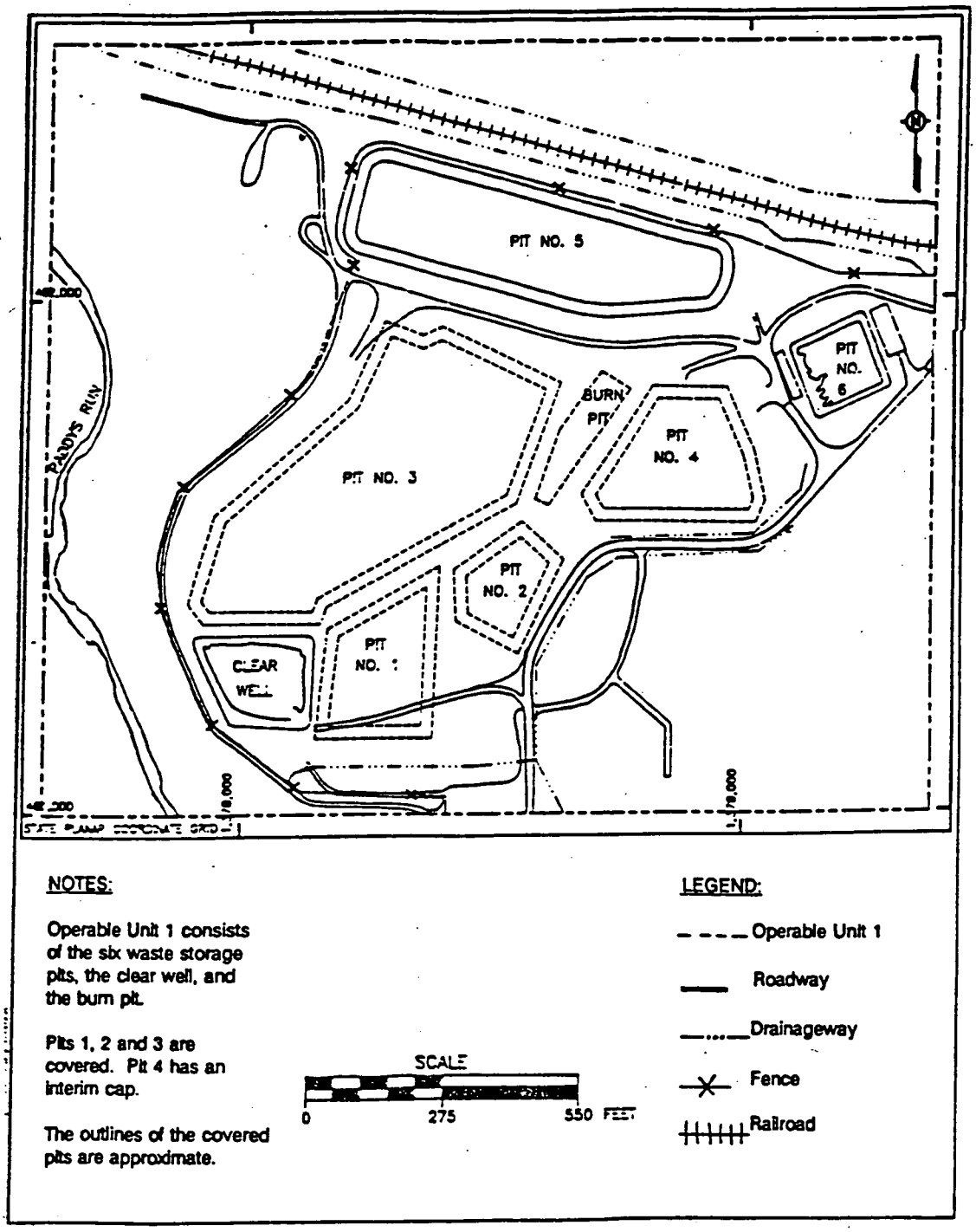
Pits 1, 2, 4, and 6 are referred to as "dry" because they received mostly dry solid waste from trucks. Table 1-1 describes the characteristics of the waste pits and provides an approximate inventory of stored waste based on the limited amount of available historical information.

Waste Pit 1, constructed in 1952, was excavated into an existing clay lens and has a capacity of 33,676 cubic yards. The waste material that

was placed in the waste pit consisted primarily of neutralized waste filter cakes, production plant sump cakes, depleted slag, scrap graphite, contaminated brick, and sump liquor. Although the majority of the waste was dry solids, decant pipes were constructed through the west berm. These pipes were rarely used. The quantity of uranium placed in the pit is estimated at 52,000 kilograms (kg). Waste Pit 1 was closed in 1959, backfilled, and covered with clean fill dirt. Surface water runoff is diverted to the Clearwell before being discharged to the Great Miami River.

Waste Pit 2 was constructed in 1957 and lined with a compacted on-property native clay layer. Waste Pit 2 received primarily dry, low-level radioactive waste consisting of neutralized filter cakes, sump cakes, depleted slag,

FIGURE 1-1 OPERABLE UNIT STUDY AREA



contaminated brick, sump liquor, and concentrated raffinate residues. As with Pit 1, decant pipes were installed through the west berm. The pit holds approximately 18,478 cubic yards of waste that contain approximately 1,206,000 kg of uranium and approximately 400 kg of thorium. The waste pit was covered with clean uncontaminated fill and graded to direct surface drainage to the Clearwell for subsequent discharge to the Great Miami River. Waste Pit 3 was constructed in 1959 by excavating into the underlying clay lens and placing a layer of clay along the pit walls. This pit was the first "wet" pit built for the purpose of settling solids from wet waste streams. The pit received wet waste streams consisting of lime-neutralized radioactive raffinate from the recovery plant and the general sump and slag leach residue, filter cakes, fly ash, and lime sludges. The principal waste contained in Pit 3 is lime-neutralized radioactive raffinate concentrate. The pit contains an estimated 237,053 cubic yards of waste, including 129,000 kg of uranium and 400 kg of thorium. The pit was retired in 1977, and clean fill was placed over the waste. Surface water runoff from the mounded pit cover is diverted to the Clearwell before discharge to the Great Miami River.

Waste Pit 4 was constructed in 1960 and used until May 1986. This pit was constructed in a similar manner as Pit 3 with a liner consisting of two feet of compacted clay on the sides and bottom. Waste Pit 4 received process residues, filter cakes, slurries, raffinates, graphite, noncombustible trash, and asbestos. The pit contains an estimated 53,706 cubic yards of waste (23 percent of Pit 3) but has more than 3 million kg of uranium and 61,800 kg of thorium. Between May 1981 and April 1983, Pit 4 also received 10,681 kg of low-level radioactive waste containing barium chloride salt. The pit is covered with an interim Resource Conservation and Recovery Act (RCRA) cover at the present time and is no longer in service.

TABLE 1-1 ESTIMATED WASTE STORAGE INVENTORY IN OPERABLE UNIT 1*

Waste Pit	Estimated Waste Quantity (cu yd)	Depth (ft)	Contents	Estimated Radioactive Material (kg)	Construction	Operational Period	Current Status
Pit No. 1	33,676	17	Neutralized waste filter cakes, graphite, brick scrap, sump liquor and cakes, depleted slag	Uranium - 52,000	Excavated in clay lens and lined with clay	1952-59	Covered with clean fill dirt
Pit No. 2	18,478	13	Dry low-level radioactive wastes: neutralized waste filter cakes, sump liquor and cakes, brick, scrap, depleted slag	Uranium - 1,206,000 Thorium - 400	Lined with a compacted on-site native clay layer	1957-64	Covered with clean fill dirt

Waste Pit	Estimated Waste Quantity (cu yd)	Depth (ft)	Contents	Estimated Radioactive Material (kg)	Constructio n	Operation -al Period	Current Status
Pit No. 3	237,053	27	Lime neutralized raffinate concentrate, slag leach residues, filter cakes, fly ash, and lime sludge	Uranium - 129,000 Thorium - 400	Excavated into clay lens and lined with clay along the pit walls	1959-77	Covered with clean fill dirt
Pit No. 4	53,706	24	Process residues, trailer cakes, slurries, raffinates, depleted graphite, asbestos, nonburnable trash, barium chloride	Uranium - 3,000,000 Thorium - 61,800	Same as Pit No. 3	1960-86	Interim RCRA cap
Pit No. 5	98,841	30	Solids from neutralized raffinate, slag leach slurry, lime sludge, arsenic	Uranium - 50,309 Thorium - 17,000	Lined with 60 mil Royal-Seal EPDM elastomeric membrane	1968-87	Uncovered

Waste Pit	Estimated Waste Quantity (cu yd)	Depth (ft)	Contents	Estimated Radioactive Material (kg)	Construction	Operation-al Period	Current Status
Pit No. 6	11,556	24	Depleted slag, sump green salt, process residue, filter cake	Uranium - 843,142	Same as Pit No. 5	1979-85	Uncovered
Burn Pit	9074	20	Reactive chemicals, pyrophoric chemicals, oils, combustible wastes, scrap iron, wood, tin cans, ashes, and gravel	Unknown	Excavated in clay Excavated clay used to line Pits 1 and 2	1957-86	Backfilled
Clearwell	5008	27	Clear process effluents and surface runoff	Unknown	Lined with clay	1959	In use

TABLE 1-1 ESTIMATED WASTE STORAGE INVENTORY IN OPERABLE UNIT 1a (continued)

* information generated by WEMCO, Weston, and Dames & Moore.

Waste Pit 5 was constructed in 1968 and operated from 1968 to 1987. The pit was lined with a 60-mil-thick elastomeric membrane. As with Pit 3, this waste pit received liquid waste slurries from the refinery and the recovery plant, including neutralized raffinate settled solids, slag leach slurry, sump slurries, and lime sludge. The waste volume consists of approximately 98,841 cubic yards, containing 320,309 kg of uranium and 17,000 kg of thorium. From 1983 to February 1987, when it was taken out of service, Pit 5 received only clear decant from the general sump, filtrate from the recovery plant, or nonradioactive slurries, such as blowdown from the boiler plant and water treatment plant.

Waste Pit 6 was constructed in 1979 and operated until 1985. Pit 6 was constructed in the same manner as Waste Pit 5 and lined with a similar synthetic liner. Fine-grained solid waste, including green salt, filter cakes, and process residues containing elevated levels of uranium, have been stored in the pit. Until March 1987, rainfall that had collected in the pit was pumped to Waste Pit 5 for settling before discharge via the Clearwell. Since then, collected rainfall is pumped to the Biodenitrification Surge Lagoon. The current waste volume is approximately 11,556 cubic yards, which consists of 843,142 kg uranium. The capacity of Waste Pit 6 has not been reached; however, the pit is currently retired.

The Burn Pit was constructed in 1953 as a site to excavate clay to line Waste Pits 1 and 2. Beginning in 1957, the resulting excavation was used to dispose of laboratory chemicals and to burn combustible materials, including pyrophoric and reactive chemicals, oils, and other low-level contaminated combustible materials. The current waste volume is estimated to be 9,074 cubic yards. The actual inventory of materials or chemicals that were disposed of in the Burn Pit is unknown. The boundaries of the Burn Pit are no longer discernible from the covered Pit 4.

The Clearwell receives surface runoff from the waste pit area, and was originally constructed as part of Pit 3. The Clearwell was used until March 1987 as a final settling basin before discharge to the Great Miami River via the FEMP National Pollutant Discharge Elimination System (NPDES) discharge point. The Clearwell still receives decanted water from Pit 5, and surface water runoff from Pits 1,2, and 3. Presently the Clearwell is estimated to contain 1,546,265 gallons of water.

1.2.3 Nature and Extent of Contamination

The remedial investigation (RI) data and data from previous studies show that releases to the environment from Operable Unit 1 have occurred. The surface soils, the glacial overburden, and the groundwater beneath the waste pits are contaminated. The principal environmental concern associated with Operable Unit 1 is contaminant migration and transport in surface water and groundwater. Radionuclides and chemicals of potential concern to be evaluated in the RI are listed in Table 1-2. Additional compounds have been analyzed under an additional sampling program completed in 1992. Contaminants of

concern from this sampling effort will be incorporated in the OU1 RI scheduled to be submitted in May 1993.

Waste Pit Contents

The contents of the waste pits were sampled under the Characterization Investigation Study (CIS) program conducted by Roy F. Weston in 1986 (Weston 1987). Data from the CIS sampling program indicate that the concentration of uranium-238 (U-238) was relatively high in Pits 2, 4, and 6 with concentrations ranging between 53 and 17,900 picoCuries/gram (pCi/g), 509 and 15,800 pCi/g, and 12,500 and 18,700 pCi/g, respectively. Samples from the Burn Pit contained the lowest uranium concentrations, which ranged from 22 to 454 pCi/g. Pits 3 and 5 contained higher concentrations of Th-230 than the other pits with concentrations ranging from 15 to 21,900 pCi/g and 3080 to 20,200 pCi/g, respectively. The Clearwell and Pit 5 contained higher concentrations of Ra-226 than the other pits with concentrations ranging between 22 to 458 and 235 to 999 pCi/g, respectively.

Results from the CIS for the inorganic chemical analysis show that all pit residues had elevated concentrations of aluminum, calcium, iron, and magnesium. Pits 3 and 5 had elevated concentrations of arsenic with a maximum concentration of 3049 parts per million (ppm) in Pit 3. Vanadium was present in all pits with concentrations ranging up to 9696 ppm in Pit 3. Pits 2, 3, 6, and the Burn Pit had elevated lead concentrations. These ranged from detection limits to 613 ppm that was found in Pit 3. Pits 3 and 5 and the Clearwell had elevated mercury concentrations. These ranged from detection limits to 4.0 ppm, which was found in Pit 3 and the Clearwell. Pits 4, 6, and the Burn Pit had the higher silver concentrations that measured 444, 158, and 506 ppm, respectively. Pit 4 had fluoride and barium with concentrations ranging from 47,812 ppm to 124,576 ppm and from 444 to 6669 ppm, respectively.

Results from the organic chemical analysis identified the presence of polychlorinated biphenyls (PCBs) in Pits 1 through 6 and the Burn Pit. The PCBs most frequently detected were Aroclor-1254, Aroclor-1248, and Aroclor-1260. The concentrations of PCBs in the waste storage area ranged from detection limits to 10.0 ppm with Pit 1 containing the highest concentrations. Various organic chemicals found in other storage areas outside Operable Unit 1 were also detected in individual pits. In Pit 1, chrysene and phenanthrene were detected and ranged in concentration up to 0.51 and 2.3 ppm, respectively. In Pits 1 and 2, 4,4'-DDT was detected in concentrations ranging up to 1.6 and 1.4 ppm, respectively. In Pit 4, tetrachloroethane was detected at 30.0 ppm. In Pit 6, a concentration of 29.0 ppm 1,1,2,2-tetrachloroethane was detected.

TABLE 1-2 RADIONUCLIDES AND CHEMICALS OF POTENTIAL CONCERN FOR OPERABLE UNIT 1

Note: These contaminants of concern were identified in the OU 1 Draft RI which is currently being revised to incorporate data from the 1992 sampling and analysis efforts. The revised listing will be incorporated in the RI report to be submitted in May 1993.

ENVIRONMENTAL MEDIA: WASTE PIT		
Radionuclides	**Inorganics**	**Organics**
U-234	Arsenic	Acenaphthene
U-235/236	Barium	Anthracene
U-238	Beryllium	Benzo(a)anthracene
Th-228	Cadmium	Benzo(b)fluoranthene
Th-230	Chromium	Benzo(k)fluoranthene
Th-232	Cobalt	Benzo(g,h,i)perylene
Pu-238	Copper	Benzo(a)pyrene
Pu-239/240	Lead	Chrysene
Tc-99	Magnesium	Ethyl benzene
Sr-90	Manganese	Fluoranthene
Np-237	Mercury	Fluorene
Cs-137	Nickel	Indeno(1,2,3-cd)pyrene
Ra-226	Selenium	2-methylnapthalene
Ra-228	Silver	Naphthalene
Pb-210	Thallium	Pentachlorophenol
	Vanadium	Phenanthrene
	Zinc	Phenol
		Pyrene
		Toluene
		Xylenes
		Acetone
		2-butanone

ENVIRONMENTAL MEDIA: WASTE PIT		
Radionuclides	**Inorganics**	**Organics**
		PCBs (Aroclors-1242, 1248, 1254, 1260)
		DDT
		Ethyl parathion
		Methyl parathion
		Bis(2-ethylhexyl)phthalate
		Di-n-butyl phthalate
		Di-n-octyl phthalate
		Chloroform
		Methylene chloride
		1,1,1-trichloroethane
		Trichloroethene

ENVIRONMENTAL MEDIA: GROUNDWATER		
Radionuclides	**Inorganics**	**Organics**
U-234	Aluminum	Butyl benzyl phthalate
U-235	Arsenic	Di-n-butyl phthalate
U-238	Barium	1,1-dichloroethane
Total uranium	Copper	1,1,1-trichloroethane
Th-228	Magnesium	Trichloroethene
Th-230	Manganese	Toluene
Th-232	Molybdenum	Acetone

ENVIRONMENTAL MEDIA: GROUNDWATER		
Radionuclides	**Inorganics**	**Organics**
Tc-99	Nickel	cis-1,2-dichloroethene
Sr-90	Vanadium	2-propanol
Ra-226	Zinc	Tetrachloroethene
Ra-228		2-butanone[a]
Pb-210		Chloroform[a]
		Ethyl parathion[a]
		Methyl parathion[a]
		Phenol[a]
		Methylene chloride[a]

ENVIRONMENTAL MEDIA: SURFACE WATER		
Radionuclides	**Inorganics**	**Organics**
U-234	Aluminum	Bis(2-ethylhexyl) phthalate
U-235	Beryllium	Di-n-butyl phthalate
U-238	Cobalt	
Total uranium	Manganese	
Tc-993	Vanadium	
Ra-226		
Ra-228		
Pb-210		

ENVIRONMENTAL MEDIA: SURFACE SOIL		
Radionuclides	**Inorganics**	**Organics**
U-238	(No data available)	(No data available)
Th-232		
Ra-226		
Pb-210		
U-234	(No data available)	2-butanone[b]
U-235		Carbon disulfide[b]
U-238		Ethyl benzene[b]
Total Uranium		Acetone[b]
Th-228		Xylenes[b]
Th-230		
Th-232		
Tc-99		
Sr-90		
Ra-226		
Pb-210		

ENVIRONMENTAL MEDIA: SEDIMENT		
Radionuclides	**Inorganics**	**Organics**
Total uranium	None	Acetone
Ra-226		Methylene chloride

ENVIRONMENTAL MEDIA: DIRECT RADIATION		
Radionuclides	**Inorganics**	**Organics**
Penetrating radiation	Not applicable	Not applicable

ENVIRONMENTAL MEDIA: AIR		
Radionuclides	Inorganics	Organics
U-238	(No data available)	(No data available)
Th-232		
Ra-226		
Radon		

[a] Chemicals expected to reach aquifer within 500 years based on preliminary fate and transport calculations.

[b] Organic data for surface soil were taken from the one sample available.

Surface Soils
A review of the surface soil data obtained during the CIS (Weston, 1986) program shows that uranium and thorium are the predominant and most widespread radionuclides in the waste pit area. Surface U-238 concentrations are elevated around the perimeter of Pit 6 and east of Pits 1 and 2.

Several locations within the waste pit area had concentrations greater than 35 pCi/g and at some locations as high as 10,900 pCi/g. The majority of sampling locations show Th-232 concentrations to range between 1 and 5 pCi/g. Several locations that are associated with elevated U-238 activity show Th-232 concentrations ranging from 5 to 15 pCi/g. The areal extent of Ra-226 concentrations greater than background levels of 1.5 pCi/g is quite low. The Th-232 levels range between 1 to 5 pCi/g in the majority of the waste storage area surface samples.

Subsurface Soils
A total of 26 subsurface soil samples were collected from various depths from the wells installed within the Operable Unit 1 study area during the RI/FS. These samples were analyzed for a full range Th-228, Th-230, Th-232, U-234, and U-238 were consistently detected in these samples. The concentration range for these radionuclides in pCi/g are: 0.4 to 1210 for Ra-226; <0.5 to 160 for Ra-228; <0.6 to 22.9 for Th-228; <0.6 to 710 for Th-230; <0.6 to 33.1 for Th-232; <0.6 to 112 for U-234; and <0.6 to 320 for U-238.

Surface Water
Surface water samples were collected at 12 locations along drainageways within Operable Unit 1. Data from this RI sampling program, as well as data from previous studies, indicate the presence of radionuclides in the storm water

runoff from the waste pits. Most of the radionuclides are present at background concentrations. Total uranium concentrations range from 54 to 9318 micrograms/liter (ug/L). Concentrations of U-234 and U-238 in two samples exceed the DOE-Derived Concentrations Guide (DCG) limit of 500 and 600 pCi/L, respectively. These samples contained 597 and 653 pCi/L of U-234 and 2840 and 2506 pCi/L of U-238. Radium and thorium concentrations in all the samples were well within the DOE guidelines. Radium and thorium were not detected in any surface water samples with the exception of a single sample, which had a radium level of 6.1 pCi/L. Thorium was not detected in any samples.

Sediments

No sediment samples were collected within Operable Unit 1 during the RI. However, several drainage ditches within Operable Unit 1 were sampled during the CIS program. Review of the CIS data indicates widespread uranium contamination in most of the drainage ditches. A sample from a drainage ditch that flows parallel and adjacent to the south berm of Pit 5 contained U-238 activity concentrations ranging from 46 to 728 pCi/g. The radium and thorium concentrations were low in all the drainageway samples, with the concentrations ranging from nondetectable to slightly greater than detection limits (approximately 1 pCi/g). A shallow drainage ditch flowing north and south over the Burn Pit area contained U-238 activity concentrations ranging from 170 to 408 pCi/g. A minor drainage ditch flowing east of Pit 4 contained U-238 activity concentrations ranging from 96 to 746 pCi/g.

Groundwater

The perched groundwater in the glacial till overburden is contaminated with uranium as a result of leaking waste pits. A sample from a well in this region contained 15,330 ug/L of total uranium. Many other wells contained high concentrations of uranium greater than 1000 ug/L. All the wells that contain high concentrations of uranium are located in the east central part of the waste storage pits. Leakage from the waste pits is suspected of being the source of contamination in the eastern groundwater plume. Contaminants from the heavily contaminated overburden have infiltrated into the Great Miami Aquifer from the perched groundwater zones as evidenced by uranium levels of up to 218 ug/L found in deeper wells.

Biological Resources

The investigation of biological resources conducted during the RI determined that there is uptake of radionuclides by both plants and animals within the FEMP. Total uranium concentrations in samples of vegetation collected within the Operable Unit 1 study area ranged from 1.8 to 31.3 pCi/g. Results from background uranium concentrations obtained from macro-invertebrate (taken from the vicinity of Paddy's Run, north of the FEMP) have been reported as nondetectable. This site is upstream of the FEMP. At another site just above the confluence of Paddy's Run and the Great Miami River, uranium concentrations in a bluegill sample ranged from below detection limits of 1.8 to 3.7 pCi/g.

1.2.4 Remedial Action Objectives

Remedial action objectives (RAOs) are medium-specific cleanup goals for protecting human health and the environment. They address the contaminants of concern as well as exposure routes and receptors identified in the baseline risk assessment. The primary purpose of RAOs is to ensure site-wide compliance with:

- Chemical-specific ARARs and to be considered (TBC) guidelines
- U.S. EPA guidance for risk to public health from hazardous chemicals
- Regulatory standards for control of radiation and radioactivity in the environment.

The remediation objectives for Operable Unit 1 typically cover all constituents of concern(radiological and chemical) that contribute to a reasonable maximum exposure (RME) scenario. RAOs were developed based on chemical-specific and radionuclide-specific ARARs. The media for which RAOs were developed included: air, soils, sediments and surface water, groundwater, and pit waste.

1.2.5 EPA Guidance

The U.S. EPA's "Guide for Conducting Treatability Studies Under CERCLA" outlines a three-tiered approach to conducting treatability studies for a Superfund site. The original interpretation of the approach can be seen in Figure 1-2.

The remedy evaluation phase of the RI/FS, in accordance with proposed revised EPA guidance, may require a maximum of three tiers of treatability testing:

- Remedy screening
- Remedy selection
- Remedy design

The terminology of this approach has been revised to reflect Figure 1-3. This illustrates these three levels of treatability testing and how this design process compares with these requirements. The three levels of treatability testing are divided into pre-Record of Decision (ROD) and post-ROD studies. The remedy screening and remedy selection testing are pre-ROD studies, and the remedy design studies are post-ROD. However, due to the large scale of this OU 1 remediation project, remedy design studies are being initiated prior to the ROD to allow sufficient time for process scale up and design in order to meet the 15 month post-ROD "sustained remediation criterion."

Pre-ROD treatability studies provide the critical performance and cost data needed to (1) evaluate all potentially applicable treatment alternatives and (2) select an alternative for remedial action based on the nine RI/FS evaluation criteria. The detailed analysis of alternatives phase of the RI/FS

follows the development and screening of alternatives and precedes the actual selection of a remedy in the ROD.

During the detailed analysis, all remedial alternatives are evaluated based on nine RI/FS evaluation criteria. These criteria are as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

These criteria are described in detail in "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA."

Remedy screening is the first step in the tiered approach. Its purpose is to determine the feasibility of a treatment alternative for the contaminants/matrix of interest (Figure 1-3). These tests are typically conducted under conditions that are favorable to the technology. These small-scale studies are designed to provide a qualitative evaluation of the technology and are conducted with minimal levels of Quality Assurance/Quality Control (QA/QC). Tests conducted under this tier are generic in nature (not vendor specific). If the feasibility of the treatment cannot be demonstrated, the alternative should generally be screened out at this time.

The remedy selection tier of the treatability study program is designed to determine whether a treatment alternative can meet the operable unit's cleanup criteria and at what cost (Figure 1-3). The purpose of this tier is to generate the performance and cost data necessary for remedy evaluation in the detailed analysis of alternatives phases of the Feasibility Study (FS). The cost data developed in this tier should support costs estimates of +50 percent/-30 percent accuracy. The performance data will be used to determine if this technology will meet ARARs or cleanup goals. Remedy selection studies are typically small-scale, incorporating generic tests using bench- or pilot-scale equipment in either the laboratory or field. The study costs are higher than those encountered in the remedy screening tier and require longer durations to complete. The levels of QA/QC are moderate to high because the data from these studies will be used to support the ROD.

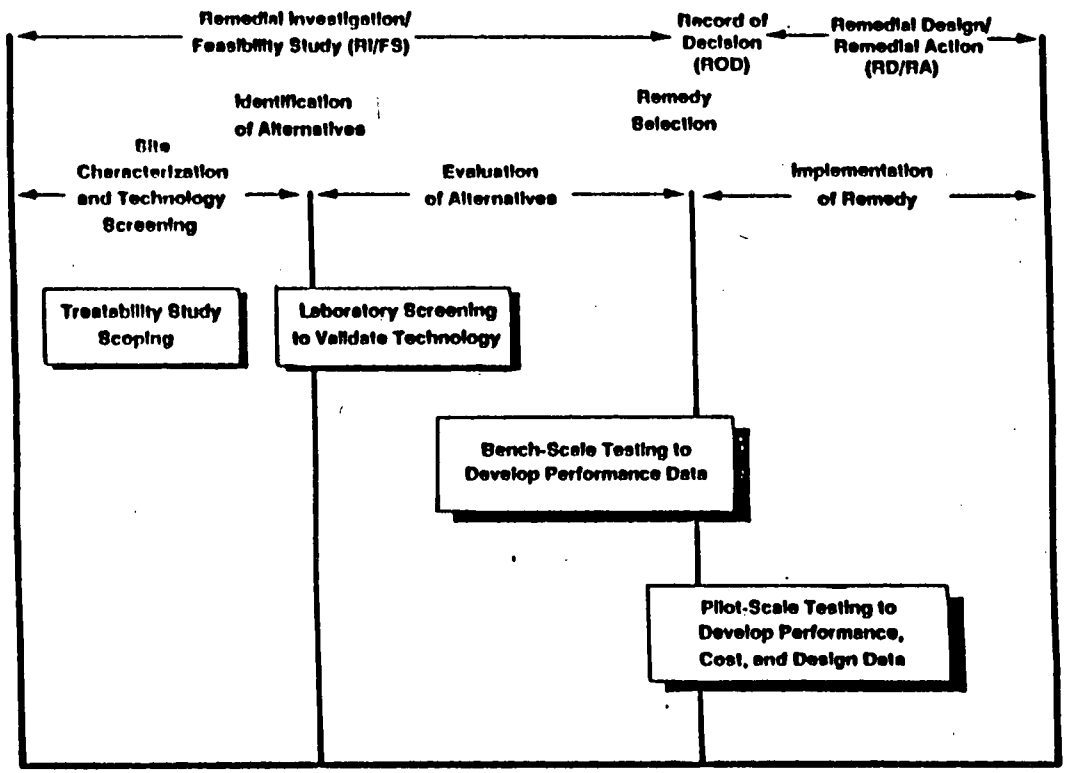
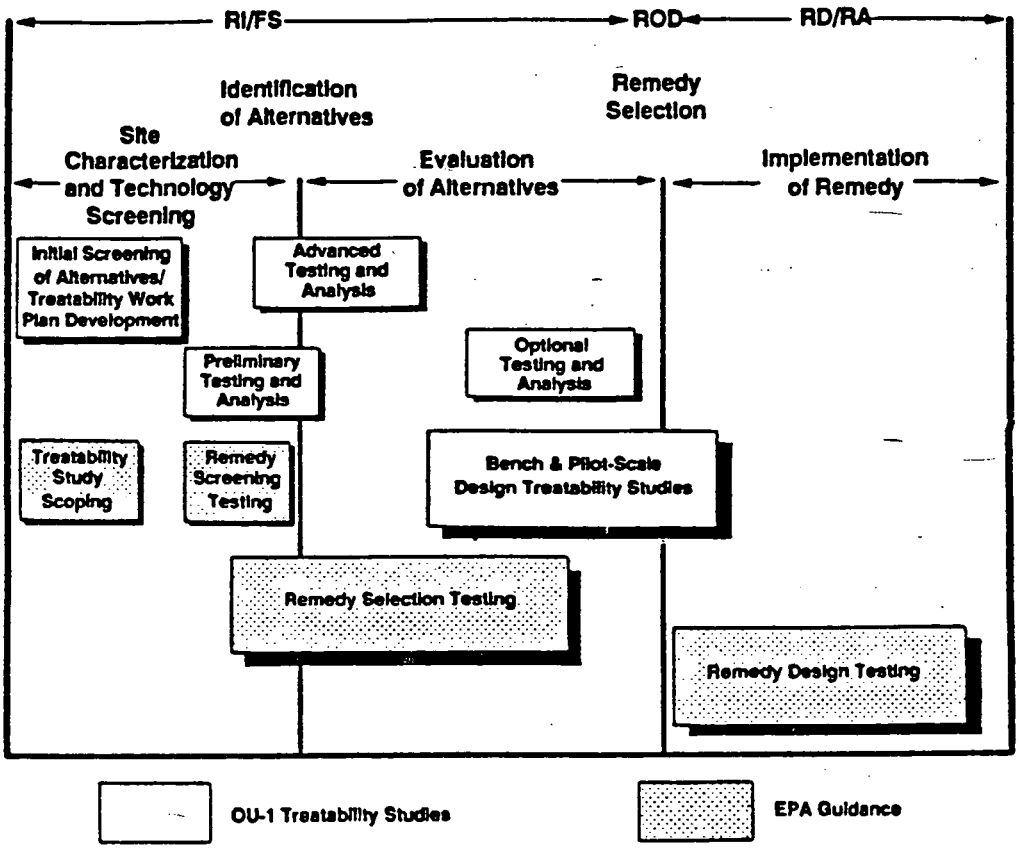


FIGURE 1-2 THE ROLE OF TREATABILITY STUDIES IN THE RI/FS AND RD/RA PROCESS

Source: Guide for Conducting Treatability Studies Under CERCLA. Interim Final

FIGURE 1-3 RELATIONSHIP OF THE OPERABLE UNIT 1 TREATABILITY STUDIES TO THE RI/FS PROCESS



In the remedy design tier treatability study, detailed scale-up, design, performance, and cost data are generated to implement and optimize the selected remedy (Figure 1-3). Remedy design studies are performed, usually as part of the remedy implementation. These studies are performed with the purpose of generating detailed, scale-up design and cost data; they require moderate levels of QA and are vendor-specific. Due to the large scope of this project the remedy design portion of this tiered approach is divided into three levels. More in-depth laboratory studies are required to provide process design information for scaleup and bench scale. The study outlined in this treatability plan will focus on optimizing process parameters which are not developed as a part of remedy screening and remedy selection studies performed under the Treatability Study Work Plan for Operable Unit (OU) 1, October 1991.

SECTION 2.0 REMEDIAL TECHNOLOGY DESCRIPTION

Several remediation technologies are being considered for the Operable Unit 1 RI/FS. These alternatives have been described in detail in the Department of Energy report "Initial Screening of Alternatives for Operable Unit 1, Task 12 Report, January 1991."

2.1 Summary of Alternatives

In addition to the no-action alternative, seven distinct remedial action alternatives were developed for Operable Unit 1. These alternatives are briefly described in the following sections.

Alternative 0 - No Action

The no-action alternative provides no remediation of any sort and simply leaves the waste pits in their present condition.

Alternative 1- Nonremoval, Slurry Wall, and Cap

The first nonremoval alternative for Operable Unit 1 is intended to isolate the waste from the environment and to minimize the generation and release of contaminated leachate to the underlying Great Miami Aquifer. This alternative includes removing and treating any standing water, installing subsurface flow control measures, building a closure cap, and providing storm water runoff and run-on control measures. The subsurface flow control measures combine a slurry wall, subsurface drains, and a temporary groundwater extraction system.

Alternative 2 - Nonremoval, Physical Stabilization, Slurry Wall, and Cap

The second nonremoval alternative for Operable Unit 1 is identical to Alternative 1 with the addition of a waste stabilization step. The purpose of this additional process is to promote the compaction (densification) of the waste to minimize both the potential for long-term settlement and the release of contaminated waste pit water into the underlying till. The need for continuing maintenance of the cap due to settling will be correspondingly reduced.

Alternative 3 - Nonremoval, In Situ Vitrification, and Cap

Because a waste immobilization step has been incorporated into the nonremoval scenario, this alternative is similar to alternative 2. However, this solidification/stabilization step specifies that a vitrification technology be used rather than physical stabilization technologies. A second important difference: the subsurface control measures are not included in this alternative. It is reasoned that the resultant vitrified mass precludes the future release of contaminated water from the waste.

Alternative 4 - Removal, Waste Treatment, and On-Property Disposal

The alternatives for Operable Unit 1, which include removing the waste material, are intended to completely eliminate the waste source from its current location above the Great Miami Aquifer and to obviate future problems

through the treatment and disposal of the wastes. This alternative utilizes technologies that include removing and treating the standing water, removing the waste, waste segregation and treatment, and on-property disposal. The waste treatment portion of this alternative retains two distinct process options: cement stabilization and continuous vitrification. Treatment of residual water will be handled by the existing FEMP wastewater treatment facility and the FEMP advanced wastewater treatment facility. If any pretreatment is necessary, it will consist of waste segregation/separation.

Alternative 5 - Removal, Waste Treatment, and Off-Site Disposal
This alternative is identical to alternative 4 except that the treated and packaged waste is to be transported to and disposed of at an approved off-site location.

Alternative 6 - Waste Removal, Treatment, On-Property Disposal, and Cap
This alternative, like alternative 4, addresses the removal and treatment of the waste pit caps (or standing surface water on those pits without caps) and pit wastes from each of the waste pits including the Burn Pit and the Clearwell. However, in this alternative, the contaminated soils that make up and surround the pits will be left in place and fitted with a closure cap. The treated and packaged waste is to be housed on site in an engineered waste management facility.

Alternative 7 - Waste Removal, Treatment, On-Property Disposal, Soil Treatment, and Cap
This alternative is identical to Alternative 6, except that the soil in the pits will be treated by in situ technologies following the excavation of the waste materials.

The following alternatives were removed from further consideration during initial screening of alternatives because of concerns about technology implementability and reliability:

- Alternative 1 Nonremoval - Slurry Wall and Cap
- Alternative 2 Nonremoval - Physical Stabilization, Slurry Wall, and Cap
- Alternative 3 Nonremoval - In Situ Vitrification and Cap
- No treatability testing is planned for alternatives 1, 2, or 3.

SECTION 3.0 TEST OBJECTIVES

3.1 Data Quality Objectives

The process treatability study described in this work plan will be performed by GTS Duratek/Catholic University of America (CUA) Vitreous Sate Laboratory in Washington, D.C.. The data generated for this study by the Duratek/CUA Vitreous State Labortory will be of the following types:

- Physical and Chemical Characterization Data;
- Process Measurements (Rates, physical parameters such as temperatures,)
- Product Characterization Data such as viscosity, conductivity, leachate analysis)

The acquired data are intended to assess whether the immobilization of the hazardous/radioactive components in the vitrified form has been achieved and if the product is leach resistant while remaining a good processable material. Both specialized (nonstandard), and nonspecialized procedures are followed.

In accordance with CERCLA Guide, and FEMP Sitewide CERCLA Quality Assurance Project Plan (SCQ) we define our Data Quality Objectives (DQO) using the following Analytical Support Levels (ASLs):

Level A (Qualitative Field Analysis)
Field screening or analysis with portable instruments; measurements carried out in the field for rapid qualitative analysis such as for the presence or absence of radioactive isotopes.

Level B (Semi-Quantitative/Quantitative and Qualitative Analyses)
Provides more quality control checks than level A. Methods include standard methods, such as America Society for Testing of Materials (ASTM) procedures or modified procedures of the standard procedures. The QA/QC requirements depend on intended data use.

Level C (Quantitative with Fully Defined QA/QC)
Routine analyses performed in the Analytical Laboratory; well-defined QA/QC applied; Data package does not contain raw instrument output but does include summaries of QA/QC sample results. VSL-prepared procedures used. Analyses require a rigid, well-defined protocol.

Level D (Confirmational with Complete QA/QC and Reporting)
Analysis as in level C but with an additional package of all raw instrumental data. Since raw data is included, validation may take much longer time than in the case of level C.

Level E (Non-Standard)

Analyses by non-standard protocols that often require method development or adaptation. Methods developed and procedures specially prepared by VSL. QA/QC, data quality, and method limitations are specified for each method. The ASLs for the work to be performed in this study are listed on Table 3-1, 3-2, and 3-3. The VSL-SOPs referenced here are included in Appendix A of this document. Table 3-1 lists the characterization methods to be used for material from Pits 5,6 and the Clearwell. Table 3-2 details the methods to be used to analyze glass from crucible melts and mini-melter runs using Pit 5 sludge. Table 3-3 details process measurements which will be made during crucible melts and mini-melter runs.

TABLE 3-1 CHARACTERIZATION OF WASTE SAMPLES

Number of Samples	Matrix	Study/Method	Procedure	Objective/ Intended Use	ASL
5	Sludge; solid	Density (wet/as-received)	ASTM D854	Feed system development	B
5	Sludge; solid	Density (Dry)	ASTM D854	Feed system development	B
5	Sludge; solid	Particle Size Distribution	ASTM D4211 and D422	Feed system development	B
> 5	Solution	Chemical Composition (Inorganics)/DC-Plasma	VSL-SOP	To quantify components affecting glass/melt properties	E
> 5	Solution	Anions/Ion Chromatography	VSL-SOP	To quantify components affecting glass/melt properties	E
> 5	Solution	Radionuclides ICP-MS	VSL-SOP	To determine radionuclide constituents	E
> 5	Sludge; solid	Radionuclides/γ-Spectroscopy	VSL-SOP	To determine radionuclide constituents	E

Number of Samples	Matrix	Study/Method	Procedure	Objective/ Intended Use	ASL
> 5	Solution	Total Organic Content/ TOC-Analyzer	VSL-SOP	Impact of organics on glass redox	E
5	Sludge; solid	Thermogravimetric Analysis	VSL-SOP	To determine weight loss vs. temperature	E

TABLE 3-2 CHARACTERIZATION OF VITRIFIED PRODUCTS

Number of Samples	Matrix	Study/Method	Procedure	Objective/ Intended Use	ASL
> 5	Solution (dissolved glass)	Chemical composition/ DCP,ICPMS,IC	VSL-SOP	To confirm chemical composition	E
≥ 20	Glass	Temperature/ thermocouples	VSL-SOP	To obtain measure of leachability	E
≥ 20	Glass	Leach resistance/TCLP	EPA-TCLP	To obtain measure of leachability	B
≥ 20	Glass	Crystal content SEM-EDX	VSL-SOP	To determine extent and type of devitrification	E
≥ 20	Glass melt	Viscosity/rotating spindle	VSL-SOP	To determine melt viscosity vs. temperature	E
≥ 20	Glass melt	Electrical conductivity/ AC bridge	VSL-SOP	To determine melt conductivity vs. temperature	E
≥ 3	Glass	Redox state/ Mossbauer spectroscopy	VSL-SOP	Effect of Redox State on glass properties	E

TABLE 3-3 LAB-SCALE PROCESS MEASUREMENTS

Number of Samples	Matrix	Study/Method	Procedure	Objective/ Intended Use	ASL
> 5	Feed slurry	Flow rate/metering pump	VSL-SOP	To determine feed rate to melter	B
≥ 20	Glass melt	Temperature/ thermocouples	VSL-SOP	To determine melt pool temperature in various locations	B
≥ 20	Glass melt	Current & voltage/ ammeters, voltmeters	VSL-SOP	To determine power input to glass melt	B
≥ 20	Glass	Glass output/balance	VSL-SOP	To determine glass production rates	B
≥ 5	Off-gas	Off-gas composition/ specific absorption tubes, sampling train-ICPMS; DCP	VSL-SOP	To determine concentratio ns of selected components in off-gas stream	E
≥ 5	Off-gas	Off-gas flow rate/flow meter; thermocouple	VSL-SOP	To determine flow rate for calculation of emission rates	B

SECTION 4.0 EXPERIMENTAL DESIGN AND PROCEDURE

4.1 Selection and Procurement of Candidate Wastes

The potential contaminants of concern are being identified in preparation of the RI. The objective of the present study is to develop process information for vitrification of OU 1 pit wastes and the possibility of using soils and fly ash as vitrification process additives. The study is intended to delineate the compositional range that meets the combined requirements of leach resistance and processability. Samples from Pit 6 and the Clearwell will be characterized for vitrification properties only. Vitrification crucible melts and mini-melter testing will focus exclusively on Pit 5 sludge. The other pit wastes will be addressed in future work dependent on the outcome of this study. Flyash and FEMP site soils will be investigated as sources of silica to permit vitrification of the pit sludges and thereby study the possibility of integrating the site waste streams synergistically to reduce the overall volume after treatment and reduce the amount of chemical additives required.

Approximately 50 kg of each of 5 samples (Pit 5, Pit 6, Clearwell, site soil and site flyash) will be delivered to GTS Duratek-VSL/CUA by FEMP. Selection of the samples from the site will be the responsibility of FEMP personnel, while receipt and return of the samples and treatment wastes will be the responsibility of GTS Duratek and its subcontractors, as outlined in the FEMP Waste Acceptance Criteria (WAC).

4.2 Characterization of Wastes

Both physical and chemical characterization of the 5 samples will be performed in this study. The objectives of these characterization studies, intended use, the quality levels desired, and the Analytical Support levels (ASLs) are given in Tables 3-1 (See page 4 of Section 3.0). These characterization studies will provide the data necessary to design the vitrification composition variability study as well as some of the process design parameters for vitrification systems. Sample characterization will include the following studies:

<u>Density:</u>
Sludge, soil, and flyash densities will be determined by weighing a known volume of the sample and determining the weight/volume ratio following the ASTM D854 procedure. Tests will be carried out on wet (as received) samples and oven-dried (110 ± 5°C) for at least 12 hrs samples following ASTM D854.

<u>Particle Size Analysis:</u>
The particle size distribution of each of the samples will be determined by sieving the sludges, soils and flyash according to ASTM procedure. The weight of each fraction will then be measured, and a maximum of 11 fractions will be

collected. Uranium contaminant distributions as a function of particle size will be investigated for the major fractions.

Chemical Analysis:
The chemical composition of each sample will be determined by a variety of techniques (Table 4-1). Each solid sample will first be dissolved in a nitric acid/hydrofluoric acid solution using a microwave dissolution technique and samples of the solution will be subjected to the following analyses.

Cations:
Major inorganic cations such as Na, K, Ca, Mg, Al, Si, and Fe will be determined by DC plasma spectroscopy, and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

Anions:
Major inorganic anions such as F^-, SO_4^-, and NO_3^- will be determined by Dionex ion chromatography.

Radionuclides:
The isotopic radionuclide composition of the samples will be measured using ICP-MS for long lived isotopes in combination with γ-counting spectroscopy.

Organics:
The presence of organics in the samples will be checked by carrying out a total organic carbon (TOC) measurement on each sample using a total organic carbon analyzer.

4.3 Testing to Select Design and Operation Parameters

Activities in this task will be directed toward the development of optimum compositions for vitrification of FEMP pit sludges by making full use of FEMP flyash and soils in the process to reduce the amounts of chemical additives needed and thereby the process costs. The characterization data obtained for the waste samples will be used for selecting the blends used in the vitrification composition variability study. Chemical additives that will be investigated will include (as oxides) Na_2O, B_2O_3, and CaO.

A flow-diagram illustrating the sequential steps in glass preparation and glass characterization is given in Figure 4-1.

4.3.1 Crucible Melts

The composition study will be based on a minimum of 20 crucible melts of about 400 g each. Raw-mix recipe calculations for the feed will be based on previous experience and glass composition-property correlations that have been developed at VSL. The initial test matrix to be used is detailed in Table 4-2. The remaining melt formulations will be determined after results of the

TABLE 4-1 REQUIREMENTS FOR CHEMICAL ANALYSIS OF OU 1 WASTES

Analysis	Level*	Method	Required Precision
CATIONS			
Major (Ca, Mg, Na, Si, etc)	≥ 0.5 wt%	DCP/ICP-MS	± 10%
Minor	0.01-0.5 wt% (100-5000 ppm)	DCP/ICP-MS	± 20%
ANIONS			
Major	≥ 0.5 wt%	IC	± 10%
Minor	0.01-0.5 wt% (100-5000 ppm)	IC	± 20%
RADIONUCLIDES			
	≥ 1 ppb	ICP-MS γ-Spectroscopy	± 20%
TOTAL ORGANICS			
	≥ 100 ppm	TOC analysis	± 20%

* Calculated on a dry basis

initial 10 melts are analyzed. A further essential component is feed-back data from the glass characterization studies which will be used to refine the glass composition study. These small melts will be prepared in clay crucibles at temperatures of between 1100-1250°C (typically around 1150°C) depending on the observed melt behavior. The objectives of this study are to provide a data base on the composition dependence of the key process and product parameters to permit selection of the optimum feed composition under a variety of alternative assumptions and to permit an assessment of the tolerance of these parameters to variations in feed stream composition. The key process parameters include sludge loading, melt viscosity, electrical conductivity, development of secondary phases, and processing temperatures.

Some of the crucible melts will be produced under reducing conditions to

determine the effect of redox state on the glass materials as indicated. The redox state will be determined by wet chemical analysis or Mossbauer spectroscopy using the standard techniques used in the high-level waste vitrification program.

4.3.2 Minimelter:
Two compositions will be selected on the basis of the collected process and leach data, waste loading and additive requirements and used for process demonstrations in a small-scale continuous joule-heated ceramic melter. Approximately 20 kg of glass will be produced in each of these runs at temperatures of around 1150°C. These runs will be used to collect data on processing parameters that cannot be obtained from crucible melts alone. These runs will provide data on processing rates, cold-cap formation, foaming, and off-gas characteristics. Processing rates will be determined in terms of both kg/hr of feed material fed to the melter and kg/hr of glass produced. Cold-cap formation is the accumulation of unmelted feed on top of the glass pool which occurs at high feed rates and ultimately limits the maximum throughput that is achievable. Foaming events will be recorded if they occur together with current process parameter measurements. These include temperature readings, current and voltage readings, and feed rates and concentrations of significant species in the off-gas stream; such species are expected to include oxides of nitrogen (NOX), hydrofluoric acid (HF), and oxides of sulfur (SOX) and volatile metals to be determined based on the sample characterization data. Such data will be necessary for larger-scale demonstrations of vitrification systems.

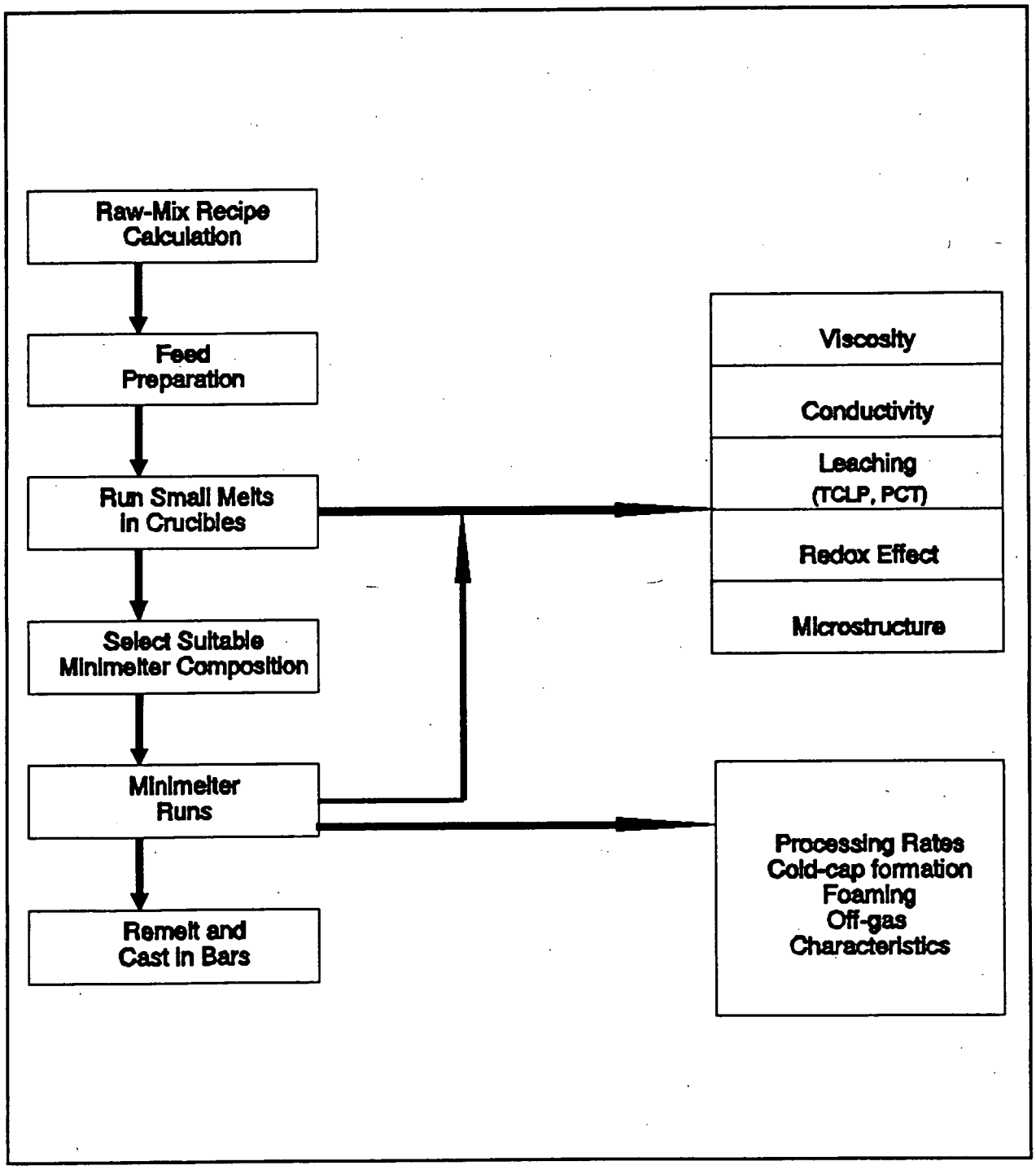


FIGURE 4-1 FLOW DIAGRAM ILLUSTRATING SEQUENTIAL STEPS FOR GLASS PREPARATION AND CHARACTERIZATION.

TABLE 4-2 VITRIFICATION EXPERIMENT MATRIX PRELIMINARY FORMULATIONS

Melt Number	Pit 5 Weight %	Site Soil Weight %	Site Fly Ash Weight %	Na_2O* Weight %	B_2O_3** Weight %
1	40	40	0	10	10
2	50	40	0	5	5
3	60	40	0	0	0
4	70	30	0	0	0
5	80	20	0	0	0
6	40	30	10	10	10
7	40	20	20	10	10
8	50	20	20	10	0
9	50	40	0	10	0
10	60	30	0	10	0

Notes:

(1) All entries are dry weight percent of total batch.

(2) Na_2O and B_2O_3 will be added as the stoichiometrically equivalent quantities of Na_2CO_3 and either B_2O_3 or $Na_2B_4O_5(OH)_4 \times H_2O$ (Borax).

(3) Formulations may be revised as appropriate to reflect data from previous melts and waste characterization studies.

4.3.3 Glass Characterization:
Key product parameters include durability, in terms of both EPA Toxicity Characteristic Leaching Procedure (TCLP) and Product Consistency Test (PCT), modified Materials Characterization Center Test (MCC-3 Test), microstructure, and overall volume reduction. Leachate analysis will be carried out for glass chemical durability testing as outlined in Table 4-3.

EPA TCLP Test:
The TCLP will be performed on glasses produced which indicate good process characteristics. This is a one-day procedure at room temperature (22± 3°C)

and a relatively small ratio of glass surface area to leachant volume.

PCT:
The Savannah River Product Consistency Test (PCT) is the present standard test for high-level waste glasses. This test is significantly more aggressive than TCLP and is run for a nominal duration of 7 days. PCT tests on FEMP glasses will be performed at room temperature (22± 3°C) and will be sampled at 7, 28, 56, and 180 days to acquire data on the long-term durability of these glasses. The final report will include 7-day PCT data on all glasses, data extending to 180 days on at least eight glasses, and data extending to 56 days on at least fifteen glasses.

TABLE 4-3 LEACHATE ANALYSES FOR GLASS CHEMICAL DURABILITY TESTING

Test	Analyte	Method	Required Detection Limits	Required Precision
TCLP	Ag, As, Ba, Cd, Cr, Hg, Pb, Se	DCP/ICP-MS	Per EPA-TCLP	± 10%
PCT (Standard)	B, Si, Na, Al, Ca, Cr, Fe, K, Li, Mg, Mn, Ni, P, Sr, Ti, U, Zr	DCP	1 ppm	± 10%
	Ph	Glass Electrode	NA	± 0.1
PCT (Selected Samples)	^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, ^{235}U, ^{238}U, ^{226}Ra, ^{99}Tc	ICP-MS	1 ppb	± 20%
	Ag, As, Ba, Cd, Cr, Hg, Pb, Se	DCP/ICP-MS	1 ppm	± 10%

At least two of the most promising glasses will also be subjected to PCT testing at 90°C to make full contact with the substantial data base on high-level waste glass performance. This data may be utilized in supporting waste acceptance decisions.

Melt viscosity and electrical conductivity:
These are both key processing parameters and will be determined as functions of temperature up to 1300°C. Melt viscosity will be measured using a Brookfield rotating spindle viscometer, and electrical conductivity will be measured as a function of frequency using a Hewlett Packard Signal Analyzer to permit extrapolation to zero frequency.

Microstructure:
The homogeneity of the glasses will be determined by microstructural analysis using Scanning Electron Microscope-Energy Dispersive Spectrometer (SEM-EDX) techniques. At least two of the most promising glasses will be subjected to heat treatments before microstructural analysis in order to detect any secondary phases that might form over likely melter residence times and temperatures which might adversely affect processability.

From the data collected, a range of optimal compositions will be identified, and the requirements for additives such as glass formers or fluxing agents will be determined. However, the composition development program will make full use of any suitable FEMP materials included in this study that would result in cost savings for the vitrification process. Throughout these efforts, maximum loading of the raffinate pit sludge per glass volume will be considered a critical parameter.

4.4 Process Design and Comparative Analysis

4.4.1 Process Design

The data obtained from the crucible melts and minimelter runs will help provide the technical and economic basis for scale-up studies for OU 1 vitrification. The technical assessment will include an analysis of the effect of glass composition on key glass properties (viscosity, electrical conductivity, and leach resistance) and, therefore, the likely achievable waste loadings that are consistent with processability and leach resistance constraints.

Preliminary waste form criteria for the vitrified material will be developed based on the data obtained, and the model studies and assessments performed. The process assessments performed and the preliminary waste form criteria developed will be documented in the required reports described in Section 2.6.

4.4.2 Implementation

Implementation requirements and logistics will be assessed. The effects of meeting the As Low As Reasonably Achievable (ALARA) and shielding requirements on the melter design and construction, special handling systems, fugitive emissions control will be incorporated in this evaluation. Both technical and cost considerations will be incorporated into the development and assessment of the implementation requirements.

SECTION 5.0 EQUIPMENT AND MATERIALS

The major operations to be performed at VSL include soil and sludge analysis and characterization, glass melting, standard leach tests on the vitrified product, analysis of the materials and leachates, and end-product characterization. The equipment that will be used for these studies is listed in Table 5-1.

A Joule-heated ceramic minimelter is available at VSL that has a capacity of about 6 liters and is capable of producing glass on a continuous basis at a rate of about 0.5 kg/hr. It is slurry fed and can permit both nitrate feeds and radioactive feeds. It has been used to develop uranium- and thorium-loaded glasses in a small-scale simulation of the vitrification process for high-level nuclear waste at the West Valley Nuclear Facility. Other features of the melter include lid heaters that allow operation with either a hot or cold top and an off-gas system incorporating an oil scrubber and a 3-stage High Efficiency Particulate Air (HEPA) filter assembly.

TABLE 5-1 LIST OF EQUIPMENT PLANNED TO BE USED FOR VITRIFICATION STUDIES FOR OU-1 WASTES

EQUIPMENT/INSTRUMENT	APPLICATION
Glove Box	Radioactive sample preparation
ASTM Sieves	Particle size analysis
Flask, balances, ram	Density determination
Sandbath, microwave	Sample sludge dissolution for analysis
DC-Plasma Spectrometer	Inorganic analysis
Dionex Ion Exchange Chromatograph	Anion analysis
Dohrmann Toc-Analyzer	Total organics analysis
Inductively Coupled Plasma-Mass Spectrometer	Radionuclide analysis
Ge-γSpectrometer with Marrinelli beaker	Gamma counting
Deltech Furnace, clay crucibles, platinum spindles and graphite casting molds; temperature and power measuring devices, heaters	Prepare crucible melts

EQUIPMENT/INSTRUMENT	APPLICATION
Joule-heated continuous ceramic melter	Continuous melting (vitrification)
Viscometer, furnace	Viscosity measurements
Conductivity measuring (Hewlett Packard bridge furnace) Device	Conductivity measurements
Scanning Electron Microscope with Energy Dispersive Analyzer	PCT Tests
Rotary Agitator, zero-headspace extraction vessel, pH meter, oven	TCLP Tests

Up to 1 kg quantities of glass will also be melted in platinum or ceramic crucibles in the extensive batch melting laboratory at VSL. Standard glass characterization techniques, including viscosity, conductivity and microstructure determination using SEM-EDX will also be performed at VSL.

The radioactive material handling laboratory will receive the FEMP samples. In this Nuclear Regulatory Commission (NRC) licensed laboratory, gloveboxes and other appropriate safety features are present in order to comply fully with the requirements of the Catholic University of America Radiation Safety Manual (Appendix B). Standard laboratory equipment including ovens, balances, sieves, and additional equipment for physical characterization of the samples, are available.

The analytical laboratory at VSL will be used to dissolve and analyze soil, sludge, flyash and glass samples. Facilities in this laboratory include a microwave oven for acid solubilization of solid samples, ion chromatography equipment, Direct Current Plasma (DCP), Atomic Absorption (AA), and inductively coupled plasma-mass spectrometers (ICP-MS) that can provide a complete analysis of the inorganic components of the samples. It was shown in the analysis of Fernald wastewater at VSL that the ICP-MS is capable of detecting radionuclides, such as U, Th and Pu in the parts per trillion range. The analytical laboratory at VSL produces more than half a million data points per year. Modern radioactive counting equipment is also available in the laboratory for analysis of low levels of the radionuclides. Analysis of the leachate solutions will be carried out in the analytical laboratory.

SECTION 6.0 SAMPLING AND ANALYSIS

Waste Pits 5 and 6 were sampled in December- January 1991-92. Samples were taken from several different locations within Waste Pit 5. Pit 5 samples were considered composite samples. Details of this sampling effort may be found in the Sampling Plan for Pits 5, 6 and Clearwell, December 1991.

A 5 gallon container of Clearwell residues, a 5 gallon container of Pit 6 material, 15-20 5 gallon containers of site soil, 2-5 gallon containers of site flyash and a 55 gallon drum of Pit 5 material were shipped to VSL.

All containers were visually inspected upon arrival. The Pit 5 material as received was highly stratified and had about 25% of the total volume as free water. Beneath this distinct layer of light brown, red, and brown sludges could be discerned. The bottom layer was a dark grey crusty material. The sludge was homogenized for approximately 1 1/2 hrs and a homogeneous light brown sludge was formed. The grey crusty bottom layer was completely incorporated in this mix. Three samples were taken from this mixture after further successive intervals of 15 minutes of mixing. These samples will be independently analyzed in order to assess the homogeneity of the mixture.

The Pit 6 sample also contained a significant amount of standing water, estimated at about 20 % of the total sample volume. The standing water was dark green while the solids were dark grey. Mixing again produced a homogeneous sludge, although the material did contain several chunks of material ranging in size up to about 2 cm which did not incorporate into the sludge. Three samples were taken for subsequent analysis.

All samples for the crucible studies and mini-melter runs were taken from the 55 gallon drum of Pit 5 sludge. The sludge was homogenized completely prior to taking of samples for treatment. Sample sizes will vary dependent on the required volume for testing.

Soils and flyash were also homogenized prior to analysis and use in testing. Procedures for preparation of soil samples are included in the specific ASTM or VSL test procedure in Table 3-1.

Specific procedures for sampling of vitrified product are incorporated within the VSL Standard Operating Procedures. QC required samples are also specified within these individual procedures. These procedures are currently being extensively revised to comply with the approved Sitewide CERCLA Quality Assurance Project Plan (SCQ), September 1992. The SCQ details specific QA/QC requirements for the Analytical Support Levels A through E. These requirements will be incorporated in the revised procedures. The revised procedures will be incorporated in Appendix A of this Work Plan as they become available.

SECTION 7.0 DATA MANAGEMENT

7.1 Data Management

The data for every test and experiment carried out in the laboratory are immediately logged into the appropriate databooks, then signed and dated by the responsible operator. The databooks are reviewed, signed and dated by the project manager, or other assigned laboratory notebook reviewer, once per month.

In areas where large amounts of data are generated (in particular, leach resistance, composition analysis and thermal analysis), data are stored on floppy disks, with back-up disks prepared. Printouts of processed data are filed in appropriately labeled binders or pasted into laboratory notebooks. Processed data provide the basis for the preparation of tables and graphs for use in summaries, internal reports, and progress reports.

Project-specific laboratory notebooks will be maintained for this project in each laboratory. All raw data measurements and general observations will be recorded in these notebooks. These laboratory data books are subjected to periodic QA surveillances.

Data validation details will comply with the FEMP sitewide SCQ. All of the experimental work to be carried out will adhere to the following guidelines:

- Verification of all numerical results
- calculations are checked and recalculated
- All test results will be reviewed by experienced laboratory/project manager.
- All required instrumental calibrations will be carried out under guidance from QA officer.
- All technical personnel will be suitably trained and qualified before conducting the laboratory work.
- Computer programs used to process raw instrumental data will be appropriately verified and validated.
- Blanks, spiking, and duplicating of analyses will be carried out as required routinely for all analytical work.

A system for the control of documents is utilized to assure that all documents and changes to documents are reviewed and approved prior to use.

7.2 Internal Quality Control Checks and Data Validation

Internal QC checks are performed to verify the quality of measurements of the laboratory analysis.

- Laboratory Control Samples (LCS), such as reference standards

National Institute of Standards and Technology (NIST) certified) or a control matrix spike with analytes representative of target analytes, calibrated against NIST certified standard is used. LCS results are compared to established control limits for accuracy and bias to determine useability of data.

- A method blank (e.g., reagent blanks, preparation blank) is a volume of the analyzed matrix to which reagents used in sample processing are added in the same volumes or proportions required by the method. Method blanks are submitted to the full analytical procedure and used to assess background contamination levels in the laboratory. Guidelines are established for acceptance or rejection of analytical data based on the level of contamination in the blank.

- Data validation, data acceptance, and data accuracy are discussed in the analytical and leach test procedure sections.

7.3 Materials Control

The laboratory's administration office monitors the inflow of purchased items. Incoming chemicals and equipment are checked to assure conformance with purchase orders, specifications and requirements. Controls are established to assure that only correct and accepted items are used or installed. Identification is maintained either on the items or in documents traceable to the items. Specific procedures appropriate for each item as stated in manufacturer instructions or other applicable documents are followed for handling and storage of all items.

Certifications supplied with purchased equipment are reviewed. Certifications must record serial number, date, signature, master standards, and traceability of equipment. Purchase order records are maintained in the central files.

A records index is set up in the central files. The index locates information covering the administrative, technical, and experimental areas of the research project. All records are reviewed for completeness and legibility prior to storage.

The central files also contain information on calibration schedules. The calibration schedule specifies the method, frequency and accuracy requirements for listed measuring equipment used in activities affecting quality. At stated periods, equipment is calibrated either externally or according to written procedures and adjusted to maintain accuracy within the specified limits.

7.4 Sample Custody

Mixed waste samples received at VSL for treatment research purposes are

handled and documented as required by 40 CFR 261.4 (f) in order to be exempted from the treatment, storage, and permitting requirements under RCRA. The following compliances satisfy these requirements:

1) VSL notifies the Housing and Environmental Regulation Administration of the Government of the District of Columbia whenever new treatability studies are initiated.

2) CUA/VSL has an EPA identification number: DCD 980 204 879.

3) The quantity of "as received" hazardous waste that is subjected to initiation of treatment in all treatability studies in any single day is less than 250 kg.

4) The quantity of "as received" hazardous waste that is stored at the laboratory does not exceed 1000 kg, including 500 kg of soils, water, or debris contaminated with acute hazardous waste or 1 kg of acute hazardous waste.

5) No more than one year has elapsed since the generator or sample collector shipped the sample to the laboratory.

6) The treatability study does not involve either placement of hazardous waste on the land or open burning of hazardous waste.

7) VSL maintains records showing compliance with the treatment rate limits and the storage time and quantity limits for three years following completion of each study.

8) VSL keeps a copy of the treatability study contract and all shipping papers for three years from the completion date of each treatability study.

9) VSL submits an annual report to the Housing and Environmental Regulation Administration of the Government of the District of Columbia. This report summarizes the treatability studies conducted during the previous year and provides the estimates on the number of studies and the amount of waste to be used in treatability studies during the current year.

10) VSL returns all unused samples to the generator, including any treatability study residues.

11) VSL shall notify the Housing And Environmental Regulation Administration of the Government of the District of Columbia when treatability studies are no longer planned.

In addition to the above compliances for mixed waste samples, VSL also

complies with Nuclear Regulatory Commission (NRC) licensing and storage/safety requirements for the radioactive samples. The Radiation Safety Director of CUA monitors the safety and handling requirements of the radioactive samples. Each shipment of radioactive samples from FEMP for this work will be contingent upon a review at FEMP to establish consistency of the current VSL NRC license with the current VSL inventory of radioactive materials. Sample custody for samples packaged and shipped from the FEMP are governed by FEMP sample custody procedures per the SCQ. A sample custody form accompanies each sample shipped to CUA. The custody forms are signed by the CUA RSO and returned to the FEMP.

- Three types of formats are used for the mixed waste sample handling and chain-of-custody documentation at CUA. Form A contains the particulars of the sample receipt, storage and initial transfer to the laboratory (Figure 7-1). Form B documents the daily sample treatment activity (Figure 7-2). Form C contains the sample return/shipment particulars (Figure 7-3).

- A chain-of-custody record is initiated at the time of the arrival (Form A, Figure 4-1) of the sample for treatability study. VSL assigns an identification number for the sample identifying the project. This identification number shall be used on all daily log statements (Form B). When transferring the possession of samples, the individuals relinquishing and receiving will sign and enter the date on the form.

- The Project Manager has the responsibility for ensuring that the samples received are transferred to the appropriate laboratory supervisor who in turn will ensure that the daily sample treatment activity is properly logged in by the technical personnel.

- The Project Manager shall inspect the sample consignment as soon as it arrives at VSL. In cases in which any breakage, tampering or discrepancy is observed, the project manager shall promptly contact the shipper for clarification.

- All sample documentation shall be sent to the Quality Assurance Officer (QAO) by the Project Manager/laboratory supervisor for compliance verification. The QAO shall ensure that the documentation is suitably indexed and archived in the central files of the VSL.

- The Project Manager shall ensure that all unused samples are shipped back to the sender in compliance with the requirements of WEMCO's WAC; the details are documented in Form C. The laboratory supervisor, in consultation with the project Manager shall ensure that all residues, treated waste samples and contact wastes are returned to the sender.

7.5 Compliance Verification

Periodic documented surveillances and an annual audit are performed to verify conformance of items or activities with established procedures. Recommendations are promptly made if corrective action is required. In the case of significant conditions adverse to quality, the situation is immediately reported to the appropriate level of management. Follow up inspections are carried out to verify implementation of the corrective action.

Tests to verify conformance of an item with specified requirements and to demonstrate that items perform satisfactorily in service are carried out in accordance with detailed sequential procedures. Characteristics to be tested and test methods to be employed are specified. Test results are documented and their conformance with acceptance criteria evaluated. Items which do not conform with specified requirements are appropriately identified to prevent inadvertent installation and use. Non-conformances are documented and promptly resolved. Appropriate corrective action is identified and implemented to prevent recurrence. Copies of all non-conformances will be sent to FEMP with data packages.

Records of personnel working on the appropriate research projects are contained in the central files. Such records include the dates each person worked on the research projects and, in the case of technical personnel, their qualification, training, indoctrination, and assessment.

Specific QA procedures designed to meet this basic QA program have been developed and implemented. Changes in procedures are being continuously monitored and the written procedures updated as required. This task has been assigned to the QA Officer who is also responsible for the implementation of the program. However, the Co-Director of the laboratory is ultimately responsible for the establishment and enforcement of the QA program as it applies to the research projects.

FIGURE 7-1 VSL FORMAT FOR HAZARDOUS/MIXED WASTE SAMPLE SHIPMENTS

Vitreous State Laboratory
Hazardous/Mixed Waste Sample Receipt and
Chain-of-Custody Record
(Form A)

Date Received:

Project:

Received From:

Waybill Number:

Sample Particulars

Sender's Code/ ID	VSL ID Code	Container Description	No. of Containers	Weight in each Container	Total Weight	Condition of Package	Description of Sample

Samples Stored at:
Samples Intended for/
transferred to: _____
Remarks
Sample Received

Sample Received

Lab notebook/log ref. _____ Lab Supervisor _____ Lab Supervisor _____ Lab Supervisor

Samples Returned:

Lab notebook/log ref. _____ Lab Supervisor _____ Lab Supervisor _____ Lab Supervisor

_____ Project Manager _____ QAO

FIGURE 7-2 VSL FORMAT FOR DAILY SAMPLES HANDLING ACTIVITY FOR HAZARDOUS/MIXED WASTES

Vitreous State Laboratory
Daily Removal/Treatment Record of Hazardous/Mixed
Waste Samples and Chain-of-Custody
(Form B)

Receipt Record Page No.:
Project:

Date	VSL ID #	Quantity Remove from Storage	Quantity Used/ Treated	Quantity Returned to Storage	Balance in Custody	Where Used	Treated/ Disposed

Lab Supervisor/Project Manager

FIGURE 7-3 VSL SAMPLE CHAIN OF CUSTODY RECORD FOR HAZARDOUS/MIXED WASTE

Vitreous State Laboratory
Hazardous/Mixed Waste Sample Shipment Record
(Form C)

Date Dispatched:
Project
Shipped to:
Waybill no:
Shipment Particulars

ID/Code #	Container Description	No. of Containers	Weight in Each Container	Total Weight	Description of Sample

Receipt Record Doc. No.

Remarks:

_____

_____ QAO

SECTION 8.0 DATA ANALYSIS AND INTERPRETATION

8.1 Vitrification Process Parameters

Process parameters including sludge loading, processing rate, melt viscosity, electrical conductivity, development of secondary phases, and processing temperatures will be investigated and reported.

8.2 Effectiveness of Waste Form

The results of the PCT and TCLP leach tests will be used to evaluate the long-term effectiveness of each waste form. The concentrations of radioactive and hazardous constituents in the leachate may be used as input into geochemical models developed under the RI/FS for establishing risk.

8.3 Data Precision, Accuracy, and Completeness

The following procedures are used to assess data precision, accuracy, and completeness. Calculations of precision, accuracy, and completeness will be used to assess data quality.

Example calculations of precision:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

where

RPD	=	relative percent difference
C_1	=	larger of the two observed values
C_2	=	smaller of the two observed values

Example calculations of accuracy:

$$\%R = \frac{100\% \times (S-U)}{C_{sa}}$$

where

%R	=	percent recovery
S	=	measured concentration in spiked aliquot
U	=	measured concentration in unspiked aliquot
C_{sa}	=	actual concentration of spike added

For calculations of completeness:

$$\%C = 100\% \times \frac{V}{n}$$

where

%C	=	percent completeness
V	=	number of measurements judged valid
n	=	total number of required measurements (per SCQ)

SECTION 9.0 HEALTH AND SAFETY

9.1 Health and Safety Plans

Refer to Appendix.

Appendix B: Radiation Safety Manual

Appendix C: Chemical Materials Safety Manual

SECTION 10.0 RESIDUALS MANAGEMENT

10.1 Vitrified Waste

The project will generate approximately 60 kg of vitrified waste. There may also be waste samples that have not undergone treatment which will be returned to the FEMP. the vitrified waste and associated residual material will be disposed of by GTS Duratek/CUA in compliance with all local state and federal regulations or returned to the FEMP for storage in compliance with the FEMP established Waste Acceptance Criteria.

10.2 Leachate

As a result of TLCP and PCT, 50 liters of liquid waste leachate will be generated. Unused leachate remaining after analysis will be decanted at VSL and mixed in with the feed materials for the minimelter vitrification runs.

SECTION 11.0 COMMUNITY RELATIONS

Treatability studies and community information and involvement activities are required in the CERCLA process. Community relations activities shall be conducted: 1) to support treatability studies in Operable Unit 1 to explain the role of treatability studies in the RI/FS, and 2) to raise the public's confidence in cleanup alternatives and technologies identified in the alternatives screening/analysis process and in the preferred alternative for this operable unit. The Treatability Study Community Relations activities for Operable Unit 1 will comply with the Community Relations Plan (CRP) -- RI/FS and Removal Actions at the DOC FMPC, Fernald, Ohio, August 1990. At a minimum, the following Community Relations activities will be conducted to explain treatability studies for Operable Unit 1.

- Community Meetings - Held a minimum of three times per year to provide status on cleanup issues, and to ensure that interested area residents have a routine public forum for receiving new information, expressing their views and getting answers to their questions. The meetings shall focus on operable unit updates, removal actions, major RI/FS documents, and other appropriate topics. During the July 1991 community meeting, an initial discussion of treatability was held to make the community aware of treatability studies that are underway.

- Publications - RI/FS materials such as progress reports, fact sheets and a community newsletter, *Fernald Site Cleanup Report*, provide updates of CERCLA-related activities at the FEMP and will include information on treatability study activities for this operable unit.

- Presentations to Community Groups - Information about treatability studies for this operable unit shall be included in briefings to community groups in Ross, Crosby, and Morgan townships, and to Fernald Residents for Environment Safety and Health, as appropriate. Also, this information shall be included in presentations to other organizations, as requested.

Key Milestones in treatability studies will be identified and progress reported to the community in these presentations and publications. These milestones include:

- Submittal of work plans to DOE and EPA
- EPA approval of work plan
- Treatability testing
- Treatability testing report submittal

Other activities identified in Section 4 of the CRP may be utilized as appropriate to effectively communicate treatability information to the community. Such activities may include workshops and community roundtables.

SECTION 12.0 REPORTS

12.1 Task 6 - Report Preparation

The following reports will be prepared and submitted to the DOE.

Monthly Reports:
The technical highlights of the work performed during each month will be sent to the FEMP by the 15th day of the following calendar month in a monthly report. These reports will also cover any technical issues which may develop during the course of the work and will describe the progress made in meeting the technical milestones.

Sample Analysis and Characterization:
A report detailing all the data obtained during crucible melts will be prepared and submitted to the FEMP by the end of July 1992.

Interim Report:
An interim report will be prepared by the end of October 1992 which will cover the details to that date on the crucible melts and conditions. A preliminary assessment on vitrification feasibility and operating conditions will also be included based on the data available.

Final Report:
A final technical report will be provided to the FEMP at the conclusion of this study. This report will include full documentation of the technical work, run data, evaluations, assumptions, conclusions, the feasibility study and any issues or questions that may require further resolution.

SECTION 13.0 SCHEDULES

13.1 Deliverables

The contract was signed on February 5, 1992. The following deliverables will be provided to the FEMP from the work under this contract:

Deliverable:	After award of contract	Date
Project Schedule	1 month	March 5, 1992
Procedures and QA Plan	2 months	April 5, 1992
Sample analysis and characterization report	5 months	July 5, 1992
Interim Report	8 months	October 5, 1992
Final Report	12 months	February 5, 1993

13.2 Milestones

In addition to the deliverables listed in Section 3.1 the following technical milestones will be used to monitor progress of the project.

<u>Milestone 1 - 2 months after contract award</u>

COMPLETE PREPARATIONS AND SCOPING STUDY

Deliver procedures and SCQ; receive samples from FEMP; begin sample characterizations; complete three scoping crucible melts on the basis of the best presently available data.

<u>Milestone 2 - 4 months after contract award</u>

COLLECT AND REVIEW DATA TO DETERMINE FIRST MINIMELTER FEED

Complete a further 8 crucible melts; begin review of durability, viscosity, conductivity, and microstructural data to decide feed composition for first minimelter run; complete bulk of sample characterization studies.

<u>Milestone 3 - 6 months after contract award</u>

COMPLETE FIRST MINIMELTER RUN

Complete first minimelter run; complete a further 5 crucible melts; continue glass characterization studies; continue modelling efforts.

Milestone 4 - 8 months after contract award

COLLECT AND REVIEW DATA TO DETERMINE SECOND MINIMELTER FEED

Complete a further 5 crucible melts including melts under reducing conditions; begin review of glass characterization data to decide feed composition for second minimelter run; continue glass characterization studies; continue modelling efforts; continue feasibility study/cost estimate.

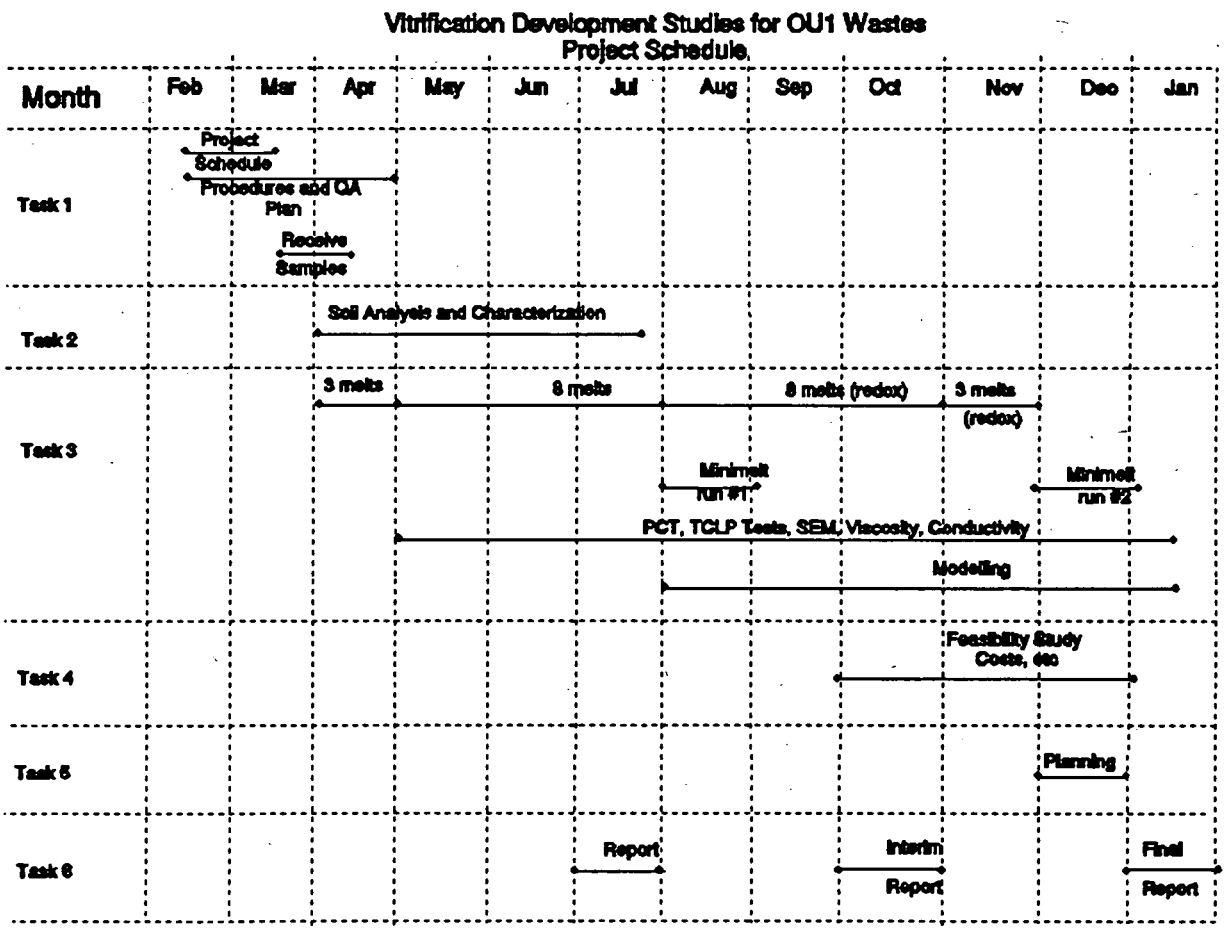
Milestone 5 - 10 months after contract award

COMPLETE SECOND MINIMELTER RUN

Complete second minimelter run; complete remaining crucible melts; complete feasibility study/cost estimates and Phase II planning; continue glass characterization studies; continue modelling efforts.

13.3 Project Schedule
The proposed project schedule is shown in Figure 13-1.

FIGURE 13-1 PROPOSED PROJECT SCHEDULE



SECTION 14.0 MANAGEMENT AND STAFFING

The technical and laboratory activities will be performed by VSL personnel with management coordination by GTS Duratek. The Organization chart of key personnel from GTS-Duratek and VSL/CUA responsible for this project are shown in Figures 14-1 and 14-2.

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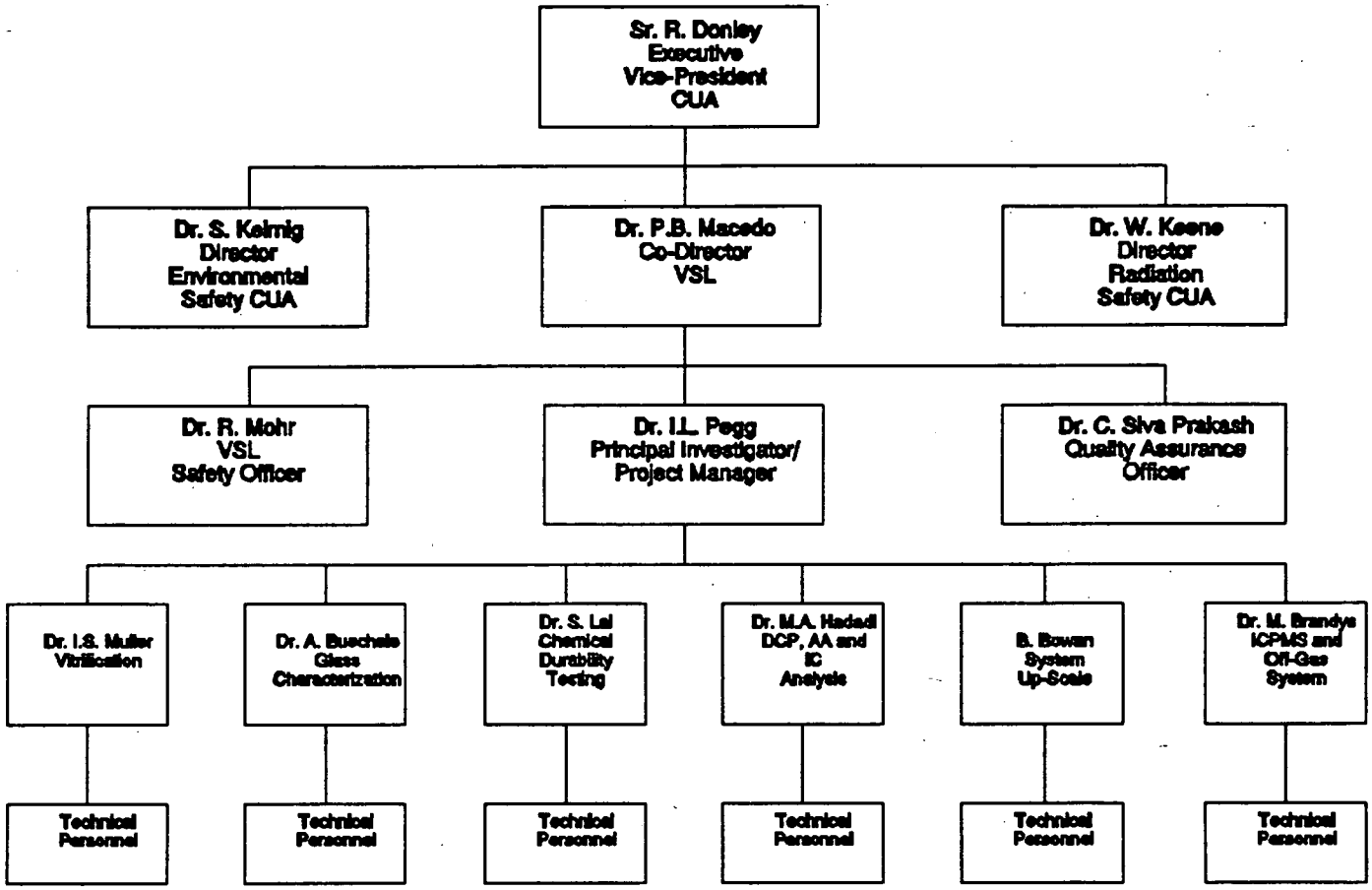
FIGURE 14-1 ORGANIZATION CHART OF VSL-CUA



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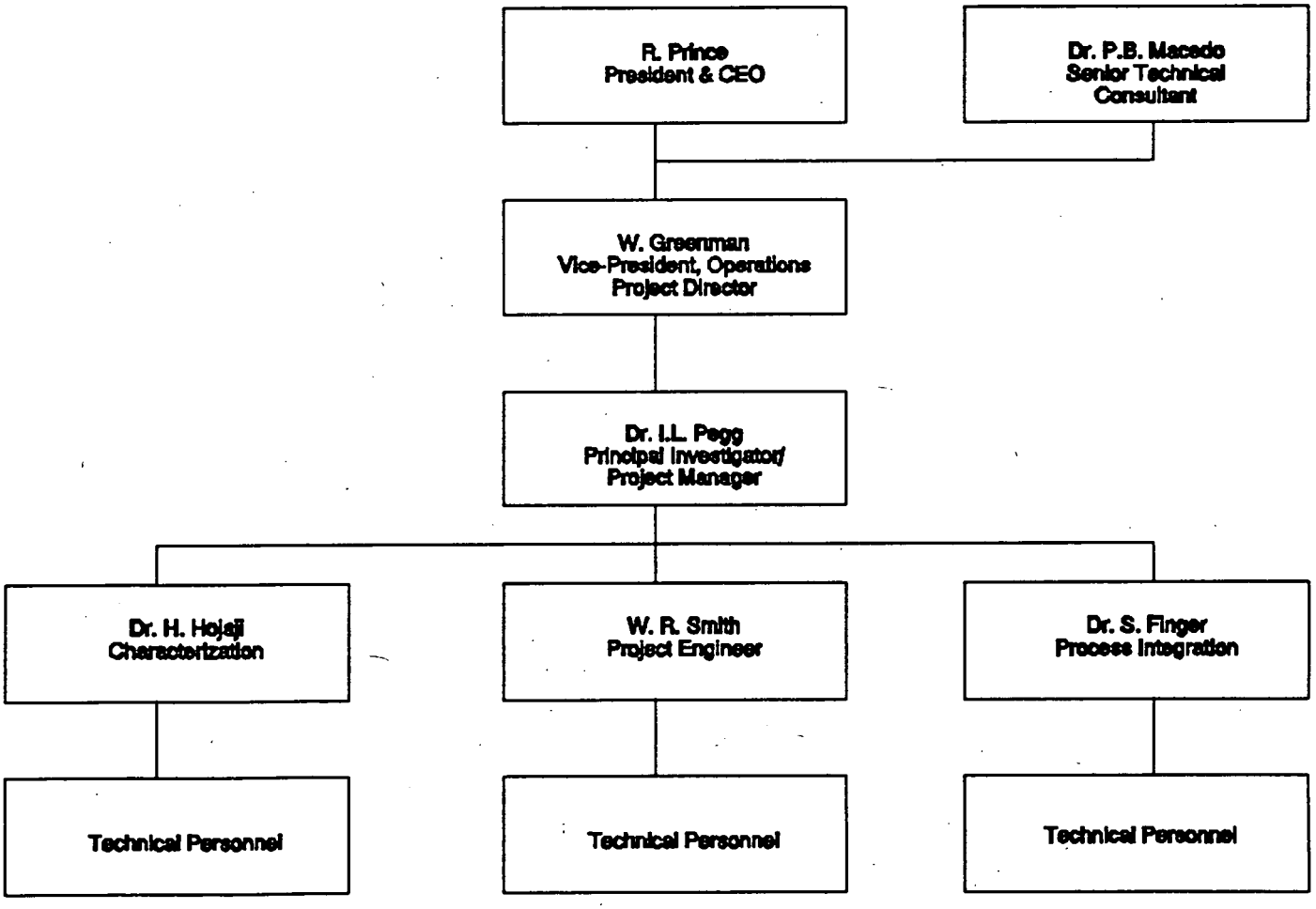
FIGURE 14-2 GTS DURATEK ORGANIZATION CHART FOR FEMP OU 1 VITRIFICATION STUDIES