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# OPERABLE UNIT 2 TREATABILITY STUDY WORK PLAN FOR FLYASH/LIME SLUDGE STABILIZATION VOLUME 1 OF 2 OCTOBER 1993

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# OPERABLE UNIT 2 TREATABILITY STUDY WORK PLAN FOR FLYASH/ LIME SLUDGE STABILIZATION

**FERNALD ENVIRONMENTAL MANAGEMENT PROJECT**
**FERNALD, OHIO**

**VOLUME 1 OF 2**

**OCTOBER 1993**

**U.S. DEPARTMENT OF ENERGY**
**FERNALD FIELD OFFICE**

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# 1.0 INTRODUCTION

The Feed Materials Production Center, renamed on August 23, 1991 and hereinafter called the Fernald Environmental Management Project (FEMP), is a contractor-operated federal facility where pure uranium metals were produced for the U.S. Department of Energy (DOE) between 1951 and 1989. The FEMP site is located on 1050 acres in a rural area of Hamilton and Butler counties approximately 18 miles northwest of Cincinnati, Ohio. The production area is limited to an approximate 136-acre tract near the center of the FEMP site. The communities of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the site (Figure 1-1).

This Work Plan describes the activities necessary to complete a treatability study for mixing coal ash and lime sludge to produce a low permeability product which can be used as backfill. The coal ash to be used originated from the coal boiler which produced steam heat for the Feed Materials Production Center. This coal ash was land disposed in two locations on site. These areas are referred to as the Inactive Flyash Pile and the Active Flyash Pile. The lime sludge originated from the water treatment process which generated process water for the facility. The lime sludge was land disposed in two adjacent areas, the North Lime Sludge Pond and the South Lime Sludge Pond.

## 1.1 PROJECT HISTORY

On March 9, 1985, the U.S. Environmental Protection Agency (EPA) issued a Notice of Noncompliance to DOE identifying EPA's major concerns over potential environmental impacts associated with the FEMP's past and present operations. On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) pertaining to environmental impacts associated with the FEMP was signed by DOE and EPA. The FFCA was entered into pursuant to Executive Order 12088 (43 FR 47707) to ensure compliance with existing environmental statutes and implementing regulations such as the Clean Air Act, the Resource Conservation and Recovery Act (RCRA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

The 1986 FFCA was amended by a Consent Agreement under Sections 120 and 106(a) of CERCLA (Consent Agreement) to divide the site into five operable units to more effectively manage the ongoing CERCLA investigations. The Consent Agreement was signed on April 9, 1990 and became effective on June 29, 1990.

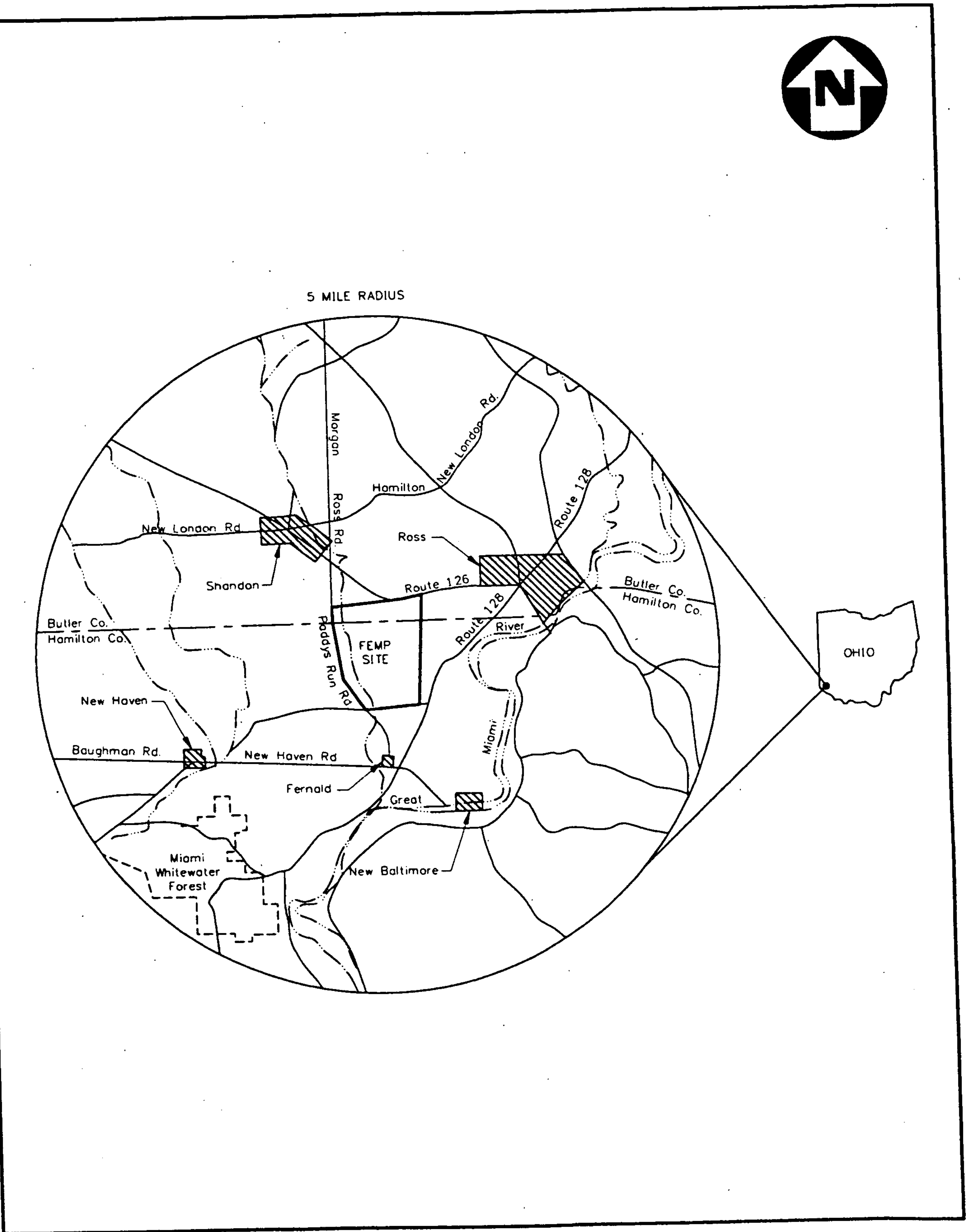



FIGURE 1-1

FIVE MILE RADIUS MAP
FERNALD ENVIRONMENTAL
MANAGEMENT PROJECT
FERNALD, OH

HALLIBURTON NUS
*Environmental Corporation*

000008

The five operable units are shown in Figure 1-2 and defined as follows:

- Operable Unit 1 - Waste Pit Area
- Operable Unit 2 - Other Waste Units
- Operable Unit 3 - Production Area
- Operable Unit 4 - Silos 1 - 4
- Operable Unit 5 - Environmental Media

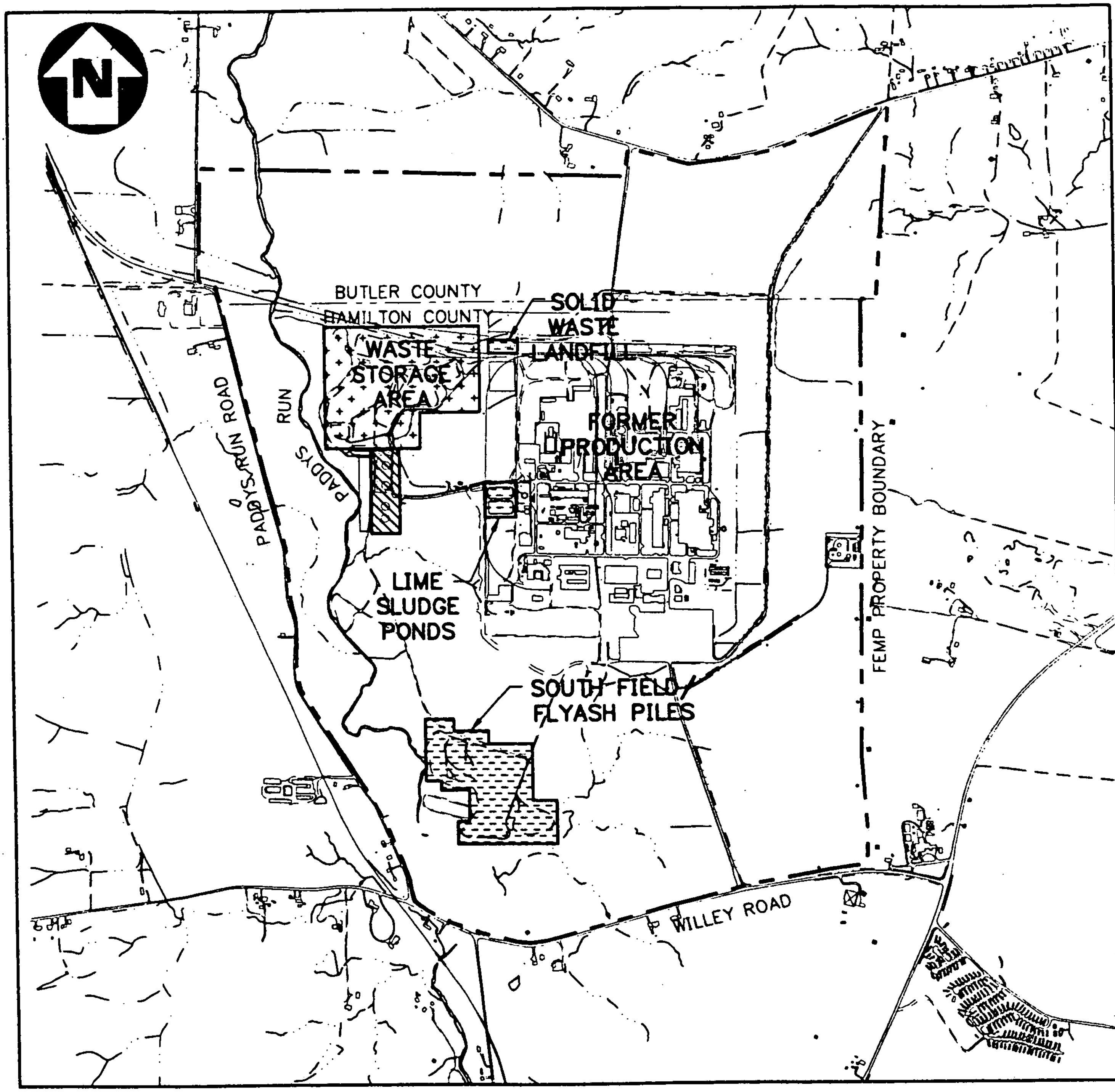
The Consent Agreement was itself amended the next year to revise the schedules for completing the RI/FS for the five operable units. This Amended Consent Agreement was signed on September 20 and became effective on December 19, 1991.

## 1.2 DESCRIPTION AND HISTORY OF FEED MATERIALS PRODUCTION CENTER

The U.S. Atomic Energy Commission (AEC), predecessor to DOE, established the FEMP for processing uranium and its compounds from natural uranium ore concentrates and recycled recoverable residues for government needs. This integrated production complex began operations in conformance with AEC Orders in the early 1950's. In 1951, National Lead Company of Ohio (now NLO Inc.) entered into contract with the AEC as Operations and Management Contractor. This contractual relationship continued with AEC, and subsequently with DOE, until January 1, 1986. Westinghouse Materials Company of Ohio, a wholly owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities of the site operations and facilities for a minimum of five years. In 1991 Westinghouse renamed this subsidiary the Westinghouse Environmental Management Company of Ohio (WEMCO).

Uranium production peaked in 1960 at approximately 10,000 metric tons per year. A product decline began in 1964, to a low in 1975 of about 1230 metric tons per year. In 1981 the FEMP production levels significantly increased, and there was a rapid staff buildup in many areas for several years. In the summer of 1989, production ceased and plant resources were focused on environmental cleanup. In June 1991, the FEMP was officially closed as a federal production facility.

A variety of chemical and metallurgical processes were used at the FEMP for the manufacture of uranium products. During the manufacturing process, high-quality uranium compounds were introduced into the FEMP processes at several points. Impure starting materials, containing uranium, were dissolved in nitric acid. Solvents were then used to extract impurities from the nitric acid which produced a uranyl nitrate solution. Evaporation and heating converted the uranyl nitrate solution to




NOTE:

OPERABLE UNIT 3 INCLUDES ALL BUILDINGS, PIPELINES, AND ABOVEGROUND STRUCTURES IN THE FORMER PRODUCTION AREA. OPERABLE UNIT 5 INCLUDES GROUNDWATER, SURFACE WATER, SOILS, SEDIMENTS, FLORA AND FAUNA IN THE REGIONAL AREA AS WELL AS THE FORMER PRODUCTION AREA.

LEGEND:

- OPERABLE UNIT 1
- OPERABLE UNIT 2
- OPERABLE UNIT 4

0 1500 3000
SCALE IN FEET

0010 FIGURE 1-2

OPERABLE UNITS
SITE PLAN
FERNALD, OH

HALLIBURTON NUS
*Environmental Corporation*

uranium trioxide (U03) 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. Various uranium metalworking processes were also housed on the FEMP.

From 1953 through 1955, the FEMP refinery processed pitchblende ore from the Belgian Congo. Pitchblende ore contains all progeny products of uranium decay and is particularly high in radium content. No chemical separation or purification was performed on the ore before its arrival at the FEMP. Beginning in 1956, the refinery feed stock consisted of uranium concentrates (yellow cake) from Canada and the United States. Canadian concentrates were not processed after 1960. In the production of these concentrates, most of the uranium progeny had been removed. However, radium-226 (Ra-226) remained in the yellow cake in amounts that varied with the process. Small amounts of thorium were produced 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.

## 1.3 SITE DESCRIPTION AND HISTORY OF OPERABLE UNIT 2, OTHER WASTE AREAS

Operable Unit 2, referred to as Other Waste Units, consists of:

- Solid Waste Landfill
- Lime Sludge Ponds
- Active Flyash Pile
- Inactive Flyash Pile
- South Field

These areas were used for the storage/disposal of sanitary waste, spent lime sludge, flyash, and construction rubble. For the purposes of this Treatability Study Work Plan, only the Lime Sludge Ponds, Active Flyash Pile, and the Inactive Flyash Pile will be discussed.

### 1.3.1 Lime Sludge Ponds

The Lime Sludge Ponds are located immediately west of the former production area as shown in Figure 1-3. A north-south railway is located along the western boundary of this waste area and access roads lie to the north and east. On the southern boundary, a portion of the K-65 slurry line,

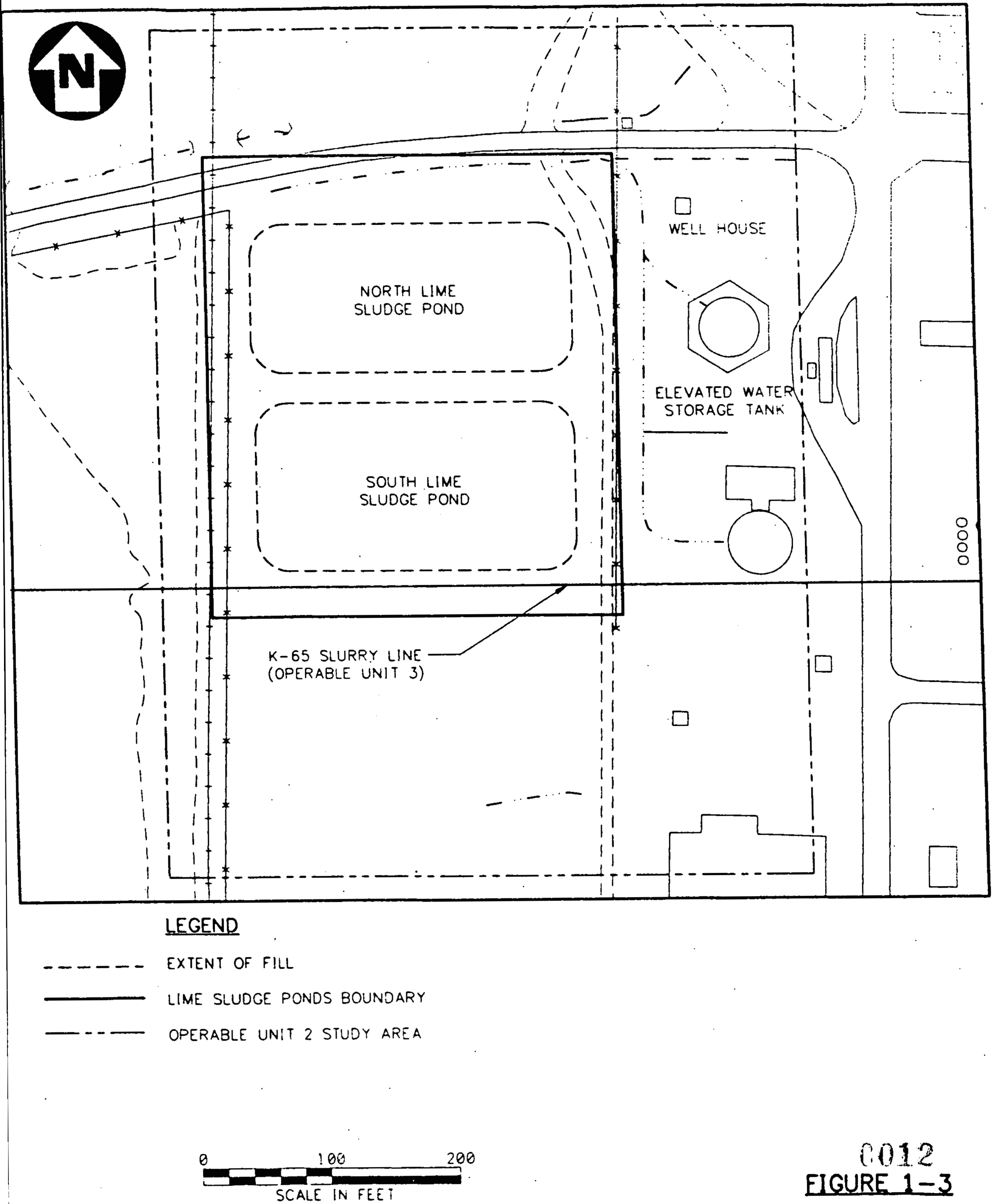



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FIGURE 1-3

LIME SLUDGE PONDS
SITE PLAN
OPERABLE UNIT 2, FERNALD, OH

HALLIBURTON NUS
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which is considered under Operable Unit 3, lies in a covered concrete trench. Generally, the topography in the vicinity of the ponds slopes very gently to the west.

The North Lime Sludge Pond is an unlined pond with dimensions of approximately 125 by 225 feet. The North Lime Sludge Pond began operations in 1984 and is still active at present. The residual lime sludge is estimated to have an average depth of 5.3 feet. Typically, the pond contains free standing water above the lime sludge, with the depth depending on precipitation and plant operations. Often, water collects in the western portion of the pond which is the topographic low of the pond.

The South Lime Sludge Pond is a dry, unlined pond with dimensions of approximately 125 by 225 feet. The South Lime Sludge Pond began operations in 1952 which continued until 1964. The residual lime sludge has an estimated average depth of 11.2 feet. Currently, the South Pond is now overgrown with grass and shrubs.

Lime sludge which was disposed in the North and South Ponds was generated from three waste streams. These waste streams originated from the (1) water plant operations, (2) coal pile storm water runoff, and (3) boiler plant blowdown.

The waste stream from the water plant operations originates from a water softening process which consists of lime addition to precipitate calcium and magnesium salts. Aluminum sulfate is also added in the softening process to induce colloid entrapment and charge neutralization. Approximately one cubic yard of lime sludge is generated and pumped from the water softening clarifiers to the General Sump on a daily basis. The existing water softening system has been in operation since the early 1950's and has provided the site with potable water and boiler feed water.

The waste stream from the coal pile storm water runoff control system consists of storm water runoff collected from the coal pile. Storm water runoff from the coal pile is collected in the storm water retention basin which is a small unlined pond. The solids in the basin are allowed to settle and the water is decanted to tanks 6 and 7 of the General Sump as needed.

The waste stream from the boiler plant blowdown consists of backflush water from the boilers at the coal plant. The boilers are backflushed to prevent scale build-up. This waste stream is sent to tanks 6 and 7 of the General Sump.

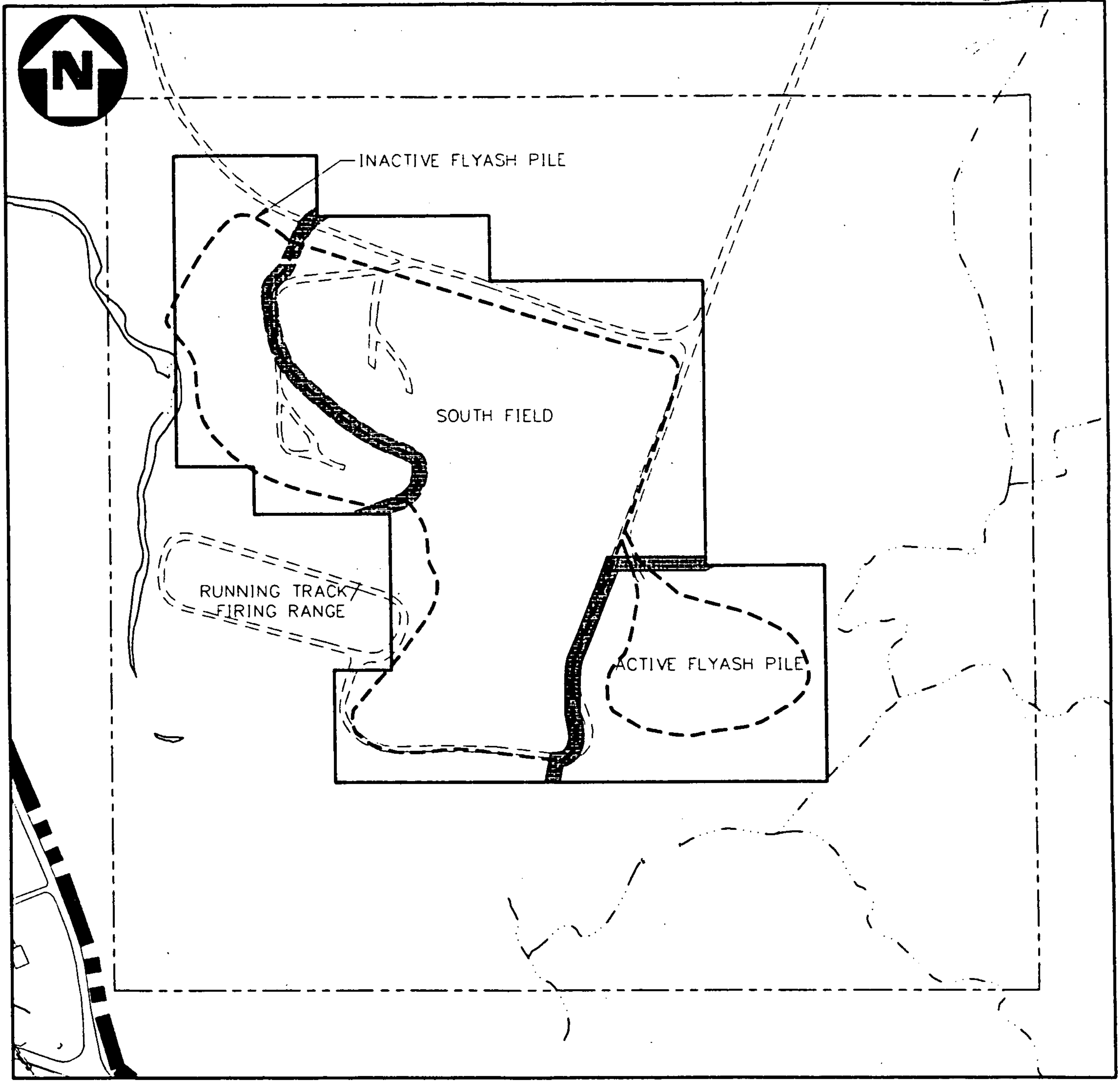
Currently, sludge from the above three sources is allowed to accumulate in the General Sump for approximately two weeks. While there, the sludge is circulated through Treatment Tanks 6 and 7, where it is partially de-watered. Polymers are also added to induce sludge thickening. At the end of two weeks, the resultant slurry of approximately 20,000 gallons is pumped to the North Lime Sludge Pond. Over time, the solids in the slurry settle by gravity and the remaining decant is pumped from the pond back through the General Sump (Tank 14), where it is tested. Based on the analytical results, the water is discharged to the Great Miami River via Manhole 175 or treated as required prior to discharge. Current estimates indicate that 19,700 cubic yards of lime sludge were disposed in the lime sludge ponds.

### 1.3.2 Active Flyash Pile

The Active Flyash Pile disposal area is located about 3000 feet southwest of the FEMP's former production area as shown in Figure 1-4. The pile has received ash waste since the mid-1960's. Estimates established for inclusion in the Operable Unit 2 Remedial Investigation indicate that 69,000 cubic yards of ash have been disposed in this area. The pile has a surface area of approximately 2.1 acres with an exposed working surface gently sloped downward in a northerly direction, and steeply-sloped sides (greater then 45 degrees) on its eastern and southern ends. Ash pile thickness ranges from 3 to 40 feet.

The coal ash in the Active Flyash Pile was generated from the FEMP's two fired boilers. The FEMP has relied on boiler-produced steam for heat, laundry facility operation and to support uranium metal production.

Coal combustion at the FEMP generates approximately 7 tons of ash waste per day during the fall/winter and approximately 3 tons per day during the spring/summer. Ash waste is comprised of approximately 70% bottom ash which is collected below the boilers. Precipitator ash collected from pollution control devices and flyash removed from the middle levels of the boiler comprise the remaining 30% of the ash waste. Until recently, ash waste had been loaded into dump trucks and transported to the Active Flyash Pile disposal area. As of December 1, 1992 newly generated ash is disposed of in a licensed off-site disposal facility.




LEGEND

- EXTENT OF FILL
- FLYASH/SOUTH FIELD BOUNDARY
- BOUNDARY BETWEEN FLYASH PILES AND SOUTH FIELD
- OPERABLE UNIT 2 STUDY AREA

0 300 600
SCALE IN FEET

0015

FIGURE 1–4

**ACTIVE/INACTIVE FLYASH PILES**
**SITE PLAN**
**OPERABLE UNIT 2, FERNALD, OH**

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MB 8/10/93 AVERT1 PLOT320 DWG300

### 1.3.3 Inactive Flyash Pile

The Inactive Flyash Pile is located approximately 2000 feet southwest of the former FEMP production area and covers approximately 3.1 acres. This area is shown in Figure 1-4.

The Inactive Flyash Pile formerly received flyash and bottom ash from boiler plant operations starting in 1951. It has been inactive since the mid-1960's and is covered with soil and natural vegetation. The total quantity of ash disposed in this area has been estimated at 61,450 cubic yards. Materials such as building rubble, concrete, asphalt, steel rebar and asbestos containing transite were also discarded in this area. These materials are visible at the surface along the Inactive Flyash Pile's western and southern edge.

## 1.4 SUMMARY OF EXISTING WASTE CHARACTERIZATION DATA

The following sections provide a summary of the pertinent information from the previous investigations. The summary is provided separately for each sub-unit.

### 1.4.1 Lime Sludge Ponds

Results for sampling conducted to support the characterization of the Lime Sludge Ponds are provided in the Draft Remedial Investigation Report for OU2 (See RI, OU2, Volume 1, October 1991). Pertinent information has been summarized in Appendix A.

Geotechnical samples indicate that the dry density of surface media is 47 $lb/ft^3$ in the North Pond and 45 to 50 $lb/ft^3$ in the South Pond. The average percent solids, by weight, is estimated to be approximately 50% for the North Pond and the South Pond.

The surface media samples were tested for radionuclides, VOCs, SVOCs, PCBs, and TCLP RCRA metals. The subsurface samples were analyzed for radionuclides, VOCs, SVOCs, pesticides/ PCBs, dioxins/furans, total uranium, metals, TCLP metals/organic, and TOC. A summary of the preliminary contaminants of concern are provided in Table 1-1.

### 1.4.2 Active Flyash Pile

Results from sampling conducted to support the characterization of Active Flyash Pile are provided in the Draft Remedial Investigation Report for Operable Unit 2 (See RI, OU2, Volume 1, Figures 2-11

TABLE 1-1

PRELIMINARY CONTAMINANTS OF CONCERN FOR LIME SLUDGE PONDS IN WASTE/SOIL – FERNALD, OHIO

| Primary Contaminants | Frequency of Detection | Range of Positive Direction (ppm) | Upper Confidence Level (ppm) |
|---|---|---|---|
| Acetone (1) | 6 of 6 | 0.020 - 0.150 | 0.150 |
| Antimony (1) | 2 of 2 | 20.00 - 22.10 | 22.10[a] |
| Arochlor-1248 (1) | 1 of 1 | 1.2 | 1.2[a] |
| Beryllium (1) | 2 of 2 | .650 - .760 | .760[a] |
| 2-Butanone | 1 of 1 | 1.8 | 1.8[a] |
| Cadmium (1) | 2 of 2 | 2.50 - 4.0 | 4.00[a] |
| Cesium-137 (2) | 2 of 11 | 0.600 - 2.30 (pCi/g) | .544 (pCi/g) |
| Chlordane (1) | 1 of 1 | 1.2 | 1.2[a] |
| Chromium (1) | 2 of 2 | 28.10 - 28.20 | 28.20[a] |
| Lead-210 (2) | 3 of 3 | 12.0 - 44.0(pCi/g) | 44.0[a](pCi/g) |
| Mercury (2) | 2 of 2 | 0.3 | 0.3[a] |
| Methylene Chloride (1) | 7 of 7 | 0.021 - 0.240 | 0.18 |
| Neptunium-237 (2) | 2 of 11 | 2.70 - 4.00 (pCi/g) | 0.38 (pCi/g) |
| Radium-226 (2) | 9 of 10 | 1.10 - 29.4 (pCi/g) | 17.4 (pCi/g) |
| Silver (1) | 2 of 2 | 21.70 - 22.0 | 22.0[a] |
| Strontium-90 (1) | 1 of 8 | 2.20 (pCi/g) | 0.549 (pCi/g) |
| Technetium-99 (2) | 5 of 11 | 4.00 - 91.0 (pCi/g) | 8.32 (pCi/g) |
| Thallium (2) | 1 of 2 | 0.51 | 0.51 |
| Thorium-228 (2) | 11 of 11 | 0.100 - 17.0 (pCi/g) | 17.0 (pCi/g) |
| Thorium-230 (1) | 7 of 8 | 0.500 - 20.0 (pCi/g) | 20 (pCi/g) |
| Uranium-234 (1) | 8 of 8 | 0.866 - 3.10 (pCi/g) | 2.51 (pCi/g) |
| Uranium-235 (1) | 6 of 8 | 0.100 - 0.300 (pCi/g) | 0.238 (pCi/g) |
| Uranium-238 (1) | 8 of 8 | 0.712 - 2.80 (pCi/g) | 2.71 (pCi/g) |

Note: Table is comprised of data from the Draft Remedial Investigation and will be revised based on the additional sampling results.

[a] The maximum detected concentration is substituted if the upper 95% confidence limit on the mean exceeds the maximum detected concentration or if the sample size $\leq 2$.

to 2-14, October 1992). All pertinent analytical data from the OU2 Draft RI is provided in Appendix B.

Borehole log information within the Active Flyash Pile indicate that the pile waste (69,000 cubic yards) is composed primarily of fly and bottom ash, slag fragments and trace amounts of sand, silt and gravel. The bottom ash, comprising 70% of the ash material disposed at the pile, is composed of coarse, dark sand-to-gravel size particles.

Geotechnical samples indicate that approximately 35% of the ash passes the No. 200 sieve (.075) mm). The typical moisture content and dry density for the ash are 6% and 60 lbs/cf, respectively.

Samples collected from AFP were sampled for radionuclides, VOCs, SVOCs, pesticides/PCBs, TCLP metals, and hazardous characteristics. A summary of the preliminary contaminants of concern are provided in Table 1-2.

1.4.3 Inactive Flyash Pile

The depth-of-fill in the Inactive Flyash Pile may be estimated by changes in elevation during the time that waste disposal occurred. Where borings were drilled, the fill/native soil interface can be measured more accurately. Based on a review of topographic maps from 1951 and 1988 (DOE 1988b, EPA 1988b), and boring logs from the Inactive Flyash Pile the maximum depth of fill is 34 feet. Using north-south cross-sections at 125-foot intervals across the unit, the average-end-area method was used to estimate fill volume at 61,450 cubic yards.

Boring logs indicate the presence of concrete, rubble pieces of wood, and other debris throughout the Inactive Flyash Pile. In situ dry density of surface material in the Inactive Flyash Pile is approximately 50 lb/ft$^3$, with a typical moisture content of 6%.

Samples collected from the Inactive Flyash Pile were analyzed for radionuclides, VOCs, SVOCs, pesticides/PCBs, TCLP metals, and hazardous characteristics. A summary of the preliminary contaminants of concern are provided in Table 1-3. A summary of all pertinent analytical data from the OU2 Draft RI is provided in Appendix C.

TABLE 1-2

PRELIMINARY CONTAMINANTS OF CONCERN FOR ACTIVE FLYASH PILE
FERNALD, OHIO

| Primary Contaminants | Frequency of Detection | Range of Positive Direction (ppm) | Upper Confidence Level (ppm) |
|---|---|---|---|
| Aroclor-1260 | 1 of 1 | 0.038 | 0.038[a] |
| Arsenic | 10 of 10 | 4.6 - 66.5 | 66.5[a] |
| Barium | 10 of 10 | 16.7 - 508.0 | 500.473 |
| Beryllium | 10 of 10 | 0.470 - 4.60 | 4.503 |
| Cadmium | 3 of 10 | 1.3 - 5.2 | 1.148 |
| Chromium | 10 of 10 | 4.4 - 26.8 | 24.12 |
| Copper | 10 of 10 | 14.3 - 66.1 | 54.397 |
| 1,1-dichloroethane | 1 of 5 | 0.002 | 0.002[a] |
| Di-n-octyl phthalate | 1 of 12 | 3.0 | 0.395 |
| Lead | 10 of 10 | 5.8 - 46.7 | 33.968 |
| Methylene Chloride | 5 of 7 | 0.007 - 0.065 | 0.041 |
| Molybdenum | 10 of 10 | 4.3 - 18.8 | 15.847 |
| Lead-210 | 2 of 2 | 1.52 - 1.63 (pCi/g) | 1.63[a] (pCi/g) |
| Radium-226 | 2 of 2 | 3.44 - 3.74 (pCi/g) | 3.74 (pCi/g) |
| Radium-228 | 14 of 14 | 0.47 - 6.22 (pCi/g) | 3.88 (pCi/g) |
| Selenium | 7 of 10 | 0.85 - 10.2 | 10.2[a] |
| Strontium-90 | 10 of 14 | 0.7 - 3.61 (pCi/g) | 1.92 (pCi/g) |
| Thallium | 5 of 10 | 0.96 - 2.1 | 1.119 |
| Thorium-228 | 14 of 14 | 0.813 - 5.79 (pCi/g) | 3.58 (pCi/g) |
| Uranium-238 | 14 of 14 | 0.97 - 12.60 (pCi/g) | 6.88 (pCi/g) |
| Zinc | 10 of 10 | 18.9 - 117 | 92.571 |

Note: Table is comprised of data from the Draft Remedial Investigation and will be revised based on the additional sampling results.

[a] The maximum detected concentration is substituted if the upper 95% confidence limit on the mean exceeds the maximum detected concentration or if the sample size $\leq 2$.

## TABLE 1-3

## PRELIMINARY CONTAMINANTS OF CONCERN FOR INACTIVE FLYASH PILE FERNALD, OHIO

| Primary Contaminants | Frequency of Detection | Range of Positive Direction (ppm) | Upper Confidence Level (ppm) |
|---|---|---|---|
| Acetone | 8 of 13 | 0.003 - 0.19 | 0.133 |
| Antimony | 4 of 8 | 8.8 - 16.3 | 10.56 |
| Arochlor-1242 | 1 of 1 | 0.006 | 0.006[a] |
| Aroclor-1254 | 1 of 1 | 0.21 | 0.21[a] |
| Arsenic | 12 of 12 | 1.7 - 74.8 | 72.108 |
| Barium | 12 of 12 | 13.1 - 892.0 | 438.185 |
| Benzo (a) pyrene | 1 of 1 | 0.13 | 0.13[a] |
| Beryllium | 12 of 12 | 0.54 - 6.7 | 5.313 |
| Cadmium (1) | 9 of 12 | 0.65 - 4.1 | 2.078 |
| Copper | 12 of 12 | 12.1 - 44.9 | 30.582 |
| Lead | 12 of 12 | 6.4 - 67.1 | 31.485 |
| Radium-226 | 16/16 | 0.95 - 36.0 (pCi/g) | 6.81 (pCi/g) |
| Technician-99 | 1/4 | 594 (pCi/g) | 594 (pCi/g) |
| Thallium | 3 of 12 | 0.8 - 1.0 | 0.483 |
| Thorium-228 | 16/16 | 0.2 - 4.1 (pCi/g) | 2.66 (pCi/g) |
| Thorium-230 | 16/16 | 0.2 - 54.6 (pCi/g) | 18.2 (pCi/g) |
| Uranium-234 | 15 of 15 | 1.73 - 187 (pCi/g) | 92.0 (pCi/g) |
| Uranium-235/236 | 9 of 15 | 0.2 - 18.5 (pCi/g) | 6.96 (pCi/g) |
| Uranium-238 | 15 of 15 | 1.76 - 191 (pCi/g) | 92.4 (pCi/g) |

Note: Table is comprised of data from the Draft Remedial Investigation and will be revised based on the additional sampling results.

[a] The maximum detected concentration is substituted if the upper 95% confidence limit on the mean exceeds the maximum detected concentration or if the sample size $\leq 2$.

## 2.0 BASELINE SAMPLING AND ANALYSIS

This section will describe sampling and analysis of the material which will be collected for the treatability study. Baseline analysis will be performed as described in this section to develop an initial characterization of the material which will be used for the treatability study. The results of the baseline analysis will be used for comparison of the initial material characteristics to those of the mixed material following completion of the treatability study.

### 2.1 INTRODUCTION

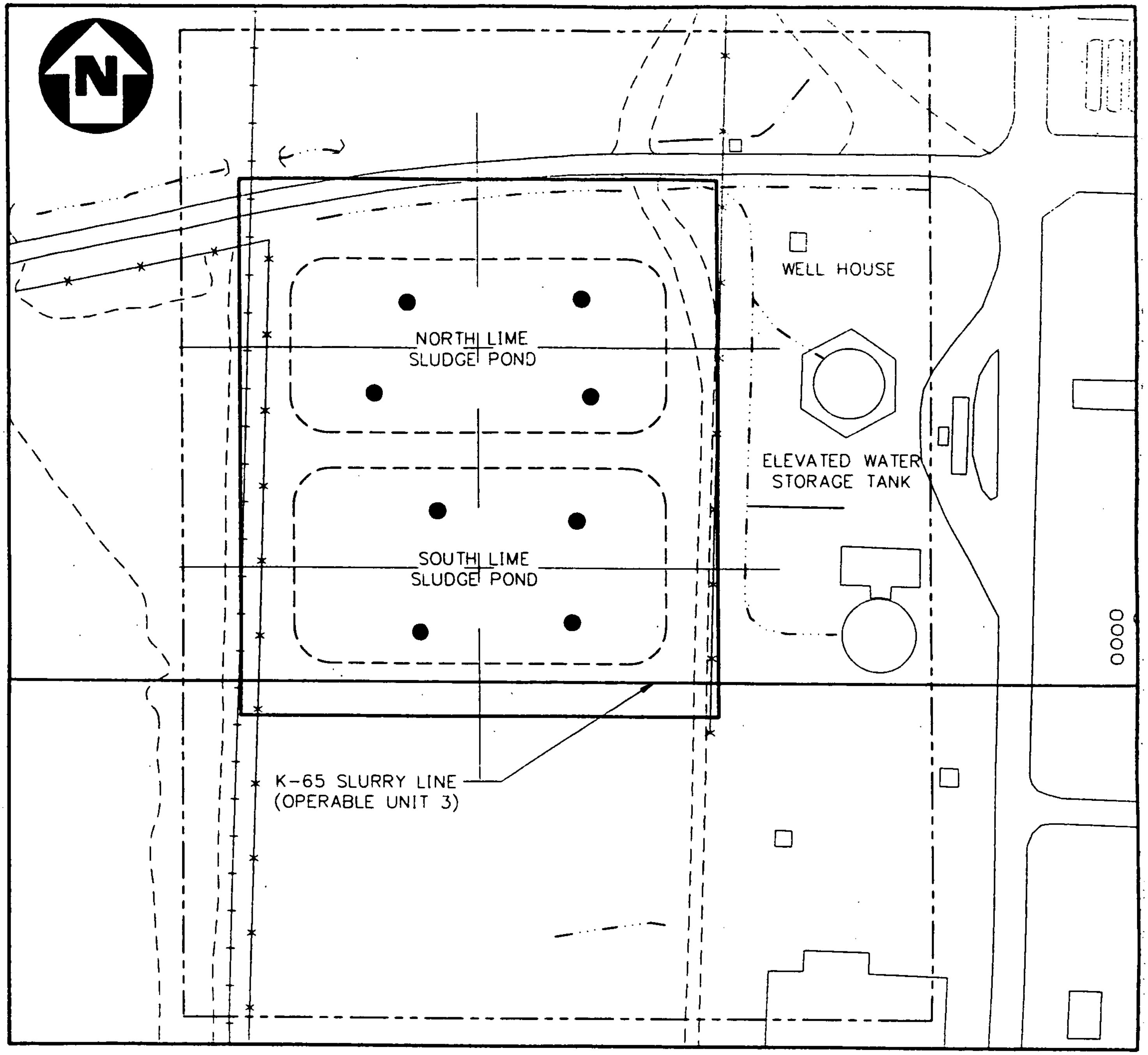
The treatability study will consist of two studies, Study A and Study B. The purpose of Study A will be to mix lime sludge from the Lime Sludge Ponds, flyash from the Active and Inactive Flyash Piles, and clay, if necessary, from the Inactive Flyash Pile to form a low permeability product. Study B will be performed to develop mixes that will be used to solidify/stabilize clay from the Inactive Flyash Pile. Study B mixes will include clay, flyash, lime, and cement. Study A will require one composite sample of lime sludge to be collected from the North and South Lime Sludge Ponds, one composite sample of flyash from the Active Flyash Pile, one composite sample of flyash from the Inactive Flyash Pile, and one composite sample of clay from the Inactive Flyash Pile. Study B will require one composite sample of flyash and one composite sample of clay from the Inactive Flyash Pile. This section will describe the procedures for sampling and the analytical methods for performing the baseline analysis of the treatability study samples.

### 2.2 SAMPLING FOR LIME SLUDGE, FLYASH, AND CLAY

The purpose of this sampling effort is to obtain representative composite samples from the Lime Sludge Ponds, the Active Flyash Pile, and the Inactive Flyash Pile for use in developing an accurate baseline analytical assessment and also to obtain an adequate amount of sample to perform the treatability study. Table 2-1 identifies sample collection requirements. As shown on Table 2-1 an additional mass factor of 1.5 was used to ensure collection of a sufficient amount of sample for performance of the treatability study.

#### 2.2.1 Sampling of the North and South Lime Sludge Ponds

The North and South Lime Sludge Ponds will be divided into quadrants as shown on Figure 2-1. As shown in Table 2-1, a 1.25-gallon sample will be collected from each quadrant of both the north and south ponds. Approximate sampling locations are shown on Figure 2-1.




LEGEND

| | |
|---|---|
| - - - - - - | EXTENT OF FILL |
| ——— | LIME SLUDGE PONDS BOUNDARY |
| — - - — | OPERABLE UNIT 2 STUDY AREA |
| ● | SAMPLE LOCATION |

0 100 200
SCALE IN FEET

0022

FIGURE 2-1

LIME SLUDGE
SAMPLING LOCATIONS
OPERABLE UNIT 2, FERNALD, OH

HALLIBURTON NUS
*Environmental Corporation*

## TABLE 2-1

### SAMPLE VOLUME REQUIREMENTS
### OPERABLE UNIT 2
### FERNALD, OHIO

| | Minimum Required Mass (Dry Weight) | Mass Required In Situ | Additional Mass Factor | Total Mass Required | Total Volume Required | Number Sample Locations | Volume/ Location |
|---|---|---|---|---|---|---|---|
| **Study A** | | | | | | | |
| Lime Sludge | 10 Kg | 20 Kg | 1.5 | 30 Kg | 10 gal | 8 | 1.25 gal |
| Active Flyash | 62 Kg | 66 Kg | 1.5 | 99 Kg | 28 gal | 4 | 7 gal |
| Inactive Flyash | 62 Kg | 66 Kg | 1.5 | 99 Kg | 32 gal | 4 | 8 gal |
| Clay | 9 Kg | 10 Kg | 1.5 | 15 Kg | 5 gal | 4 | 1.25 gal |
| **Study B** | | | | | | | |
| Inactive Flyash | 5.3 Kg | 6 Kg | 1.5 | 9 Kg | 4 gal | 4 | 1 gal |
| Clay | 4 Kg | 4.5 Kg | 1.5 | 7 Kg | 4 gal | 4 | 1 gal |

**NOTE:** Required quantities are approximate for field sample collection purposes only.

2.2.1.1 Sampling Procedures (Lime Sludge Ponds)

Eight sample locations will be used for collection of eight sample volumes. Hand augers and trowels will be used to collect samples from the Lime Sludge Ponds. Sample volumes will be collected from the available surface material and continuously throughout the total depth of the Lime Sludge Pond at the sample location. The North Lime Sludge Pond has an average depth of 5.3 feet and the South Lime Sludge Pond has an average depth of 11.2 feet. If field conditions are not conducive for sample collection at depth, samples will be collected as available. Sample volumes collected from each location will be homogenized individually and will then be composited and homogenized for use in the baseline assessment and treatability study. One composited sample will be submitted for the baseline analysis.

2.2.2 Sampling of the Active Flyash Pile

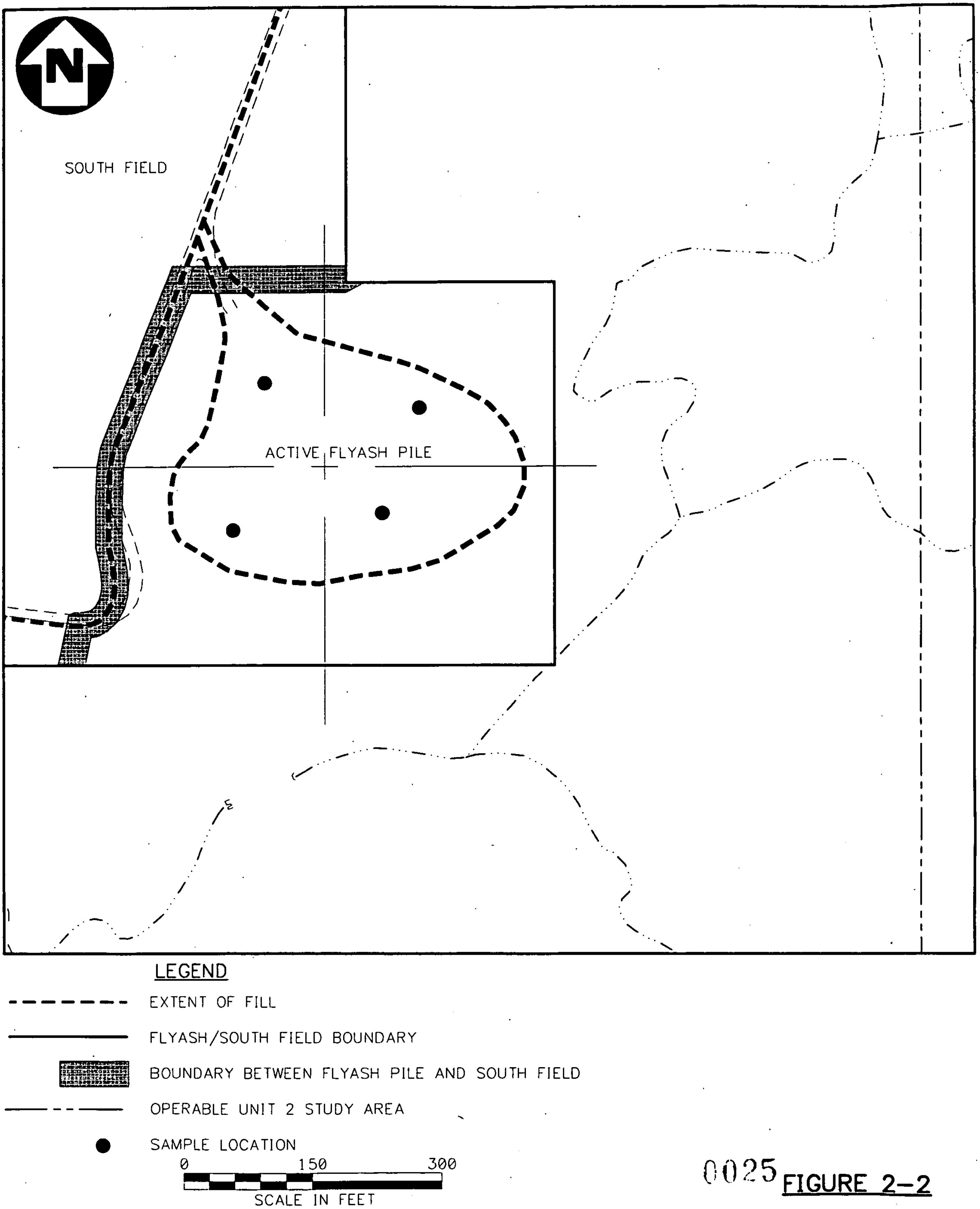
The Active Flyash Pile will be divided into quadrants as shown on Figure 2-2. As shown in Table 2-1, a 7-gallon sample will be collected from each quadrant. Sample locations are shown on Figure 2-2.

2.2.2.1 Sampling Procedures (Active Flyash Pile)

Four sample locations will be used for collection of four sample volumes. Hand augers and trowels will be used to collect samples from the Active Flyash Pile. Sample volumes will be collected from the available surface material and continuously throughout a ten foot interval in depth, where available. The Active Flyash Pile varies in depth from 3 to 40 feet. If field conditions are not conducive for sample collection at depth, samples will be collected as available. All samples will be composited and homogenized for use in the baseline assessment and treatability study. One composited sample will be submitted for the baseline analysis.

2.2.3 Sampling of Inactive Flyash Pile

The Inactive Flyash Pile will be sampled at locations shown on Figure 2-3 and 2-4. As shown in Table 2-1, an 8-gallon sample of flyash will be collected for study A from the locations shown on Figure 2-3. A 1-gallon sample of flyash will be collected for study B from the locations shown on Figure 2-4.



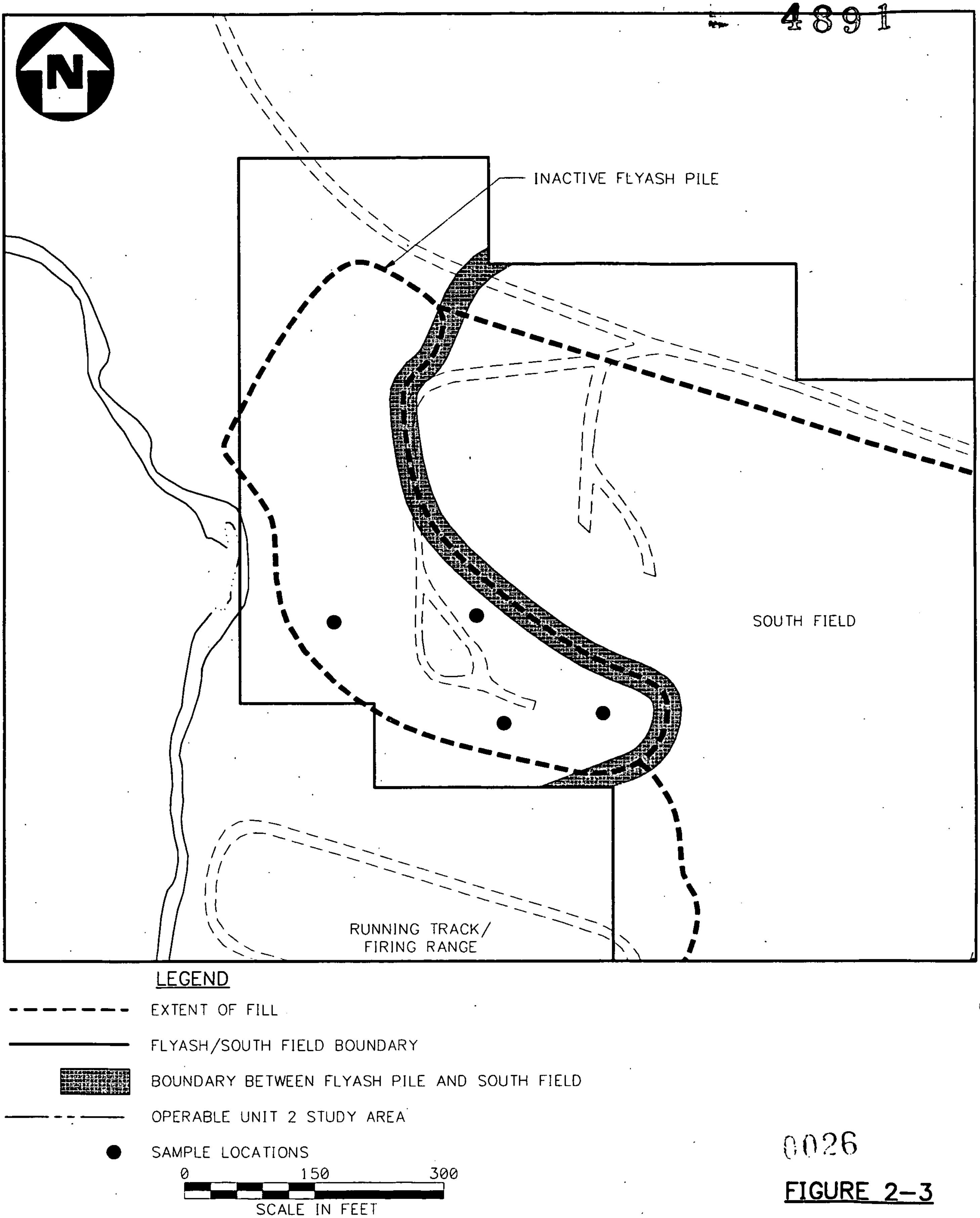

0025 FIGURE 2-2

**ACTIVE FLYASH**
**SAMPLING LOCATIONS**
**OPERABLE UNIT 2, FERNALD, OH**

HALLIBURTON NUS
*Environmental Corporation*

ACAD: C:\4P94\OU2\SITEOU2.DWG MB 8/12/93 AVERTI PLOT150RA DWG150RA

4891




ACAD: C:\4P94\OU2\SITEOU2.DWG MB 8/11/93 AVERT1 PLOT150LA DWG150LA

0026

FIGURE 2-3

INACTIVE FLYASH
SAMPLE LOCATIONS
OPERABLE UNIT 2, FERNALD, OH

HALLIBURTON NUS
*Environmental Corporation*

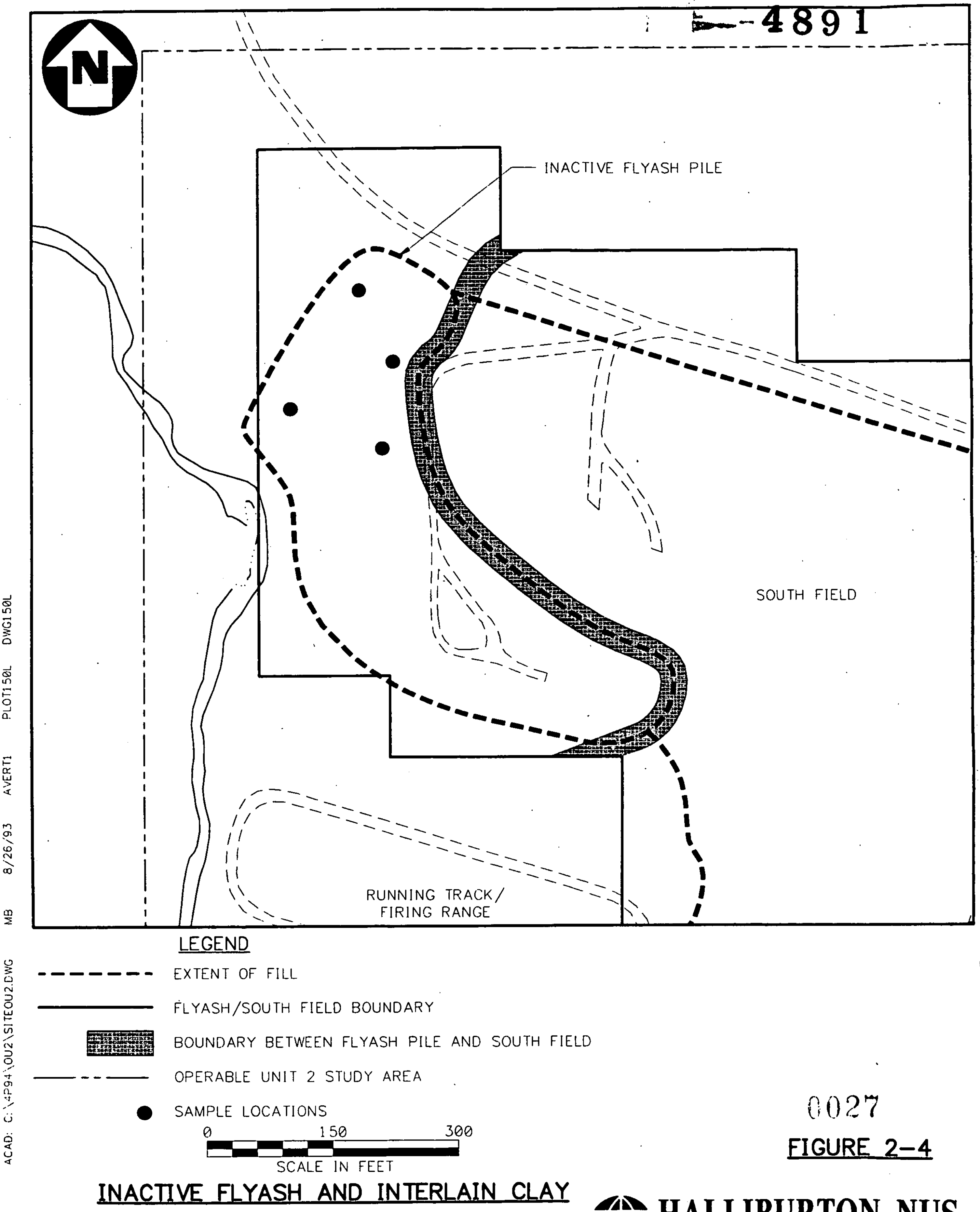



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FIGURE 2-4

INACTIVE FLYASH AND INTERLAIN CLAY SAMPLE LOCATIONS OPERABLE UNIT 2, FERNALD, OH

HALLIBURTON NUS
*Environmental Corporation*

2.2.3.1 Sampling Procedures (Inactive Flyash Pile)

Samples will be collected from eight different locations at the Inactive Flyash Pile. Samples from four of these locations will be used in Study A (see Figure 2-3). The remaining samples will be used in Study B (see Figure 2-4). Hand augers and trowels will be used to collect samples from the Inactive Flyash Pile. Sample volumes of flyash will be collected from the available surface material and continuously throughout a ten foot interval in depth, where available. If field conditions are not conducive for sample collection at depth, samples will be collected as available. Also, sample collection will be performed to avoid collection of the interlain clay layers. Samples collected from the four locations for study A and the four locations for study B will be homogenized and composited individually for use in the baseline assessment and treatability study. One composited sample for Study A and one for Study B will be submitted for baseline analysis.

2.2.4 Sampling of the Clay in the Inactive Flyash Pile

The Inactive Flyash Pile contains clay-like soil which is interlain with the flyash. Based on previous soil borings, the north end of the Inactive Flyash Pile is more predominantly interlain with clay layers. Existing soil borings were used to identify the four sampling locations shown on Figure 2-4. The boring logs used for sample location selection are presented in Appendix D. As shown in Table 2-1, a 2.25-gallon sample will be collected from each location.

2.2.4.1 Sampling Procedures (Inactive Flyash Pile [Clay])

Four sample locations will be used for collection of four sample volumes. Sampling locations were selected based on previous boring logs. Hand augers and trowels will be used to collect clay samples from the Inactive Flyash Pile. Sample volumes will be collected from the available clay layer used for surface capping, where available. If field conditions are not conducive for sample collection at depth, samples will be collected as available. All samples will be composited and homogenized for use in the treatability study. One composited sample will be submitted for baseline analysis.

2.3 BASELINE SAMPLE ANALYSIS

The baseline analysis will be used to develop an initial waste characterization for the lime sludge, flyash, and clay to be used for the treatability study. Samples collected from the Lime Sludge Ponds, the Active Flyash Pile, and the Inactive Flyash Pile will be analyzed for a full range of parameters that will provide input for system design and correlation to results of the treatability study. The parameters and their corresponding methods for analysis are summarized in Table 2-2. Appendix E

TABLE 2-2

SUMMARY OF ANALYSES AND METHODOLOGIES FOR THE BASELINE ANALYSIS OF THE TREATABILITY STUDY SAMPLES
OPERABLE UNIT 2
FERNALD, OHIO

| Analyte | Method |
|---|---|
| **ORGANICS** | |
| Volatile Organics[1] | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| Semi-Volatile Organics[2] | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| Pesticides/Polychlorinated Biphenyls[2] | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| **INORGANICS** | |
| Metals[3] and Inorganics[4] | U.S. EPA CLP SOW for Inorganic Analyses, IOLMO2.1, September 1991 |
| **RADIONUCLIDES** | |
| Radiological Parameters[5] | Analyzed by following in-house methodologies and QA/AC procedures. |
| **GENERAL CHEMISTRY** | |
| Total Organic Carbon | Walkley-Black |
| Sulfate | Agronomy 13-10.2, EPA 375.4 |
| **GEOTECHNICAL** | |
| Specific Gravity | ASTM D854-83 |
| Moisture Content | ASTM D2216-90 |
| Atterberg Limits | ASTM D4318-84 |
| Particle Size Distribution (Sieve and hydrometer) | ASTM D422-63 |
| Available Lime (CaO) | ASTM C25 |
| Loss on Ignition | ASTM C831 |
| **EXTRACTION** | |
| TCLP Procedure: (Extraction for Metals and Inorganics) | U.S. EPA, SW-846, Method 1311, Rev. 0, 1986. |

**TABLE 2-2**
**(Continued)**

(1) Complete analyte listing provided as Appendix E.1.

(2) Complete analyte listing provided as Appendix E.2.

(3) The following metals will be analyzed in the TCLP leachate: Al, As, Ba, Ca, Cd, Cr, Cu, Pb, Hg, Se, Ag, Fe, Mn, Zn, U-234, U-235, U-238, and pH.

(4) Complete analyte listing provided as Appendix E.3.

(5) **THE FEMP FULL LIST OF RADIOLOGICAL PARAMETERS**

| | |
|---|---|
| Cesium-137 | Thorium-228 |
| Lead-210 | Thorium-230 |
| Neptunium-237 | Thorium-232 |
| Plutonium-238 | Total Thorium |
| Plutonium-239/240 | Uranium-234 |
| Radium-224 | Uranium-235 |
| Radium-226 | Uranium-235/236 |
| Radium-228 | Uranium-238 |
| Ruthenium-106 | Total Uranium |
| Strontium-90 | Gross Alpha |
| Technetium-99 | Gross Beta |

identifies the parameters included on the Hazardous Substance List (HSL), the list of RCRA toxicity parameters and pH, the list of required geotechnical parameters, and the additional parameters required for waste classification or data validation.

### 2.3.1 Data Validation

Validity of data (i.e., 95-percent confidence limit) with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols outlined in EPA's "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analysis 2/88" and "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses 7/88". These functional guidelines will be used as set forth by EPA Region V. The data validation process for the radiological analyses will be done in accordance with the approved FEMP internal guidelines.

The Analytical Support Level (ASL) to be used for all chemical analysis in the baseline assessment is Level D, the ASL for all geotechnical analysis is Level C. Level D requires data validation of sample analysis in accordance with the "FEMP Data Validation Procedure," SSOP-1004, REV. 0. In general, results that are rejected by the validation process will be disqualified from application for the intended use. The ASL for specific parameters can be found in Section 3.5.

# 3.0 TREATABILITY STUDY

This section will describe the necessary requirements including the objectives, design, methods, and procedures for the treatability study. The treatability study will be conducted in two separate studies, Study A and Study B. Study A will entail mixing the available lime sludge and flyash to create a low permeability modified soil for use as backfill on site. Study B will evaluate formulas to solidify/stabilize the interlain clay within the Inactive Flyash Pile. Study A and Study B will be discussed separately.

## 3.1 TREATABILITY STUDY OBJECTIVES

The objective of this treatability study is to develop process design parameters for utilization of available lime sludge and flyash as well as to develop a solidification/stabilization formula for the clay from the Inactive Flyash Pile. Formulations will be developed to achieve the following:

- Create a final product which has low permeability characteristics.
- Create a final product that has favorable leaching characteristics which will achieve all regulatory criteria including RCRA toxicity criteria, exempt waste requirements for TCLP concentrations, and groundwater protection standards.

Prior to conducting the treatability study, a baseline analysis of the lime sludge, flyash, and clay will be conducted. The results of the baseline analysis will be used for waste characterization and for comparison of the individual material characteristics to the final product characteristics. The baseline analysis will determine geotechnical and engineering parameters associated with mix design and equipment selection. These parameters include:

- "As received" moisture content
- Particle size and distribution
- Specific Gravity
- Atterberg Limits

In addition to these parameters, chemical analysis will be performed on "as received" samples. Chemical analysis parameters include the Hazardous Substance List (HSL) and RCRA toxicity and OEPA Policy 4.07 parameters plus pH.

3.1.1 Study A (Objectives)

Treatability Study A (Study A) will evaluate the lime sludge from the Lime Sludge Ponds, flyash from the Active Flyash Pile and the Inactive Flyash Pile, and clay from the Inactive Flyash Pile. This study will focus on developing a mix ratio that will achieve regulatory and geotechnical goals.

The goals and objectives of this treatability study are to produce a mixed material consisting of lime sludge and flyash with potential additives of hydrated lime or clay that will yield a low permeability ($1 \times 10^{-6}$ cm/s) and minimizes the bulking factor for use as backfill on site. Additionally, the formula will be based on utilization of all available lime sludge and flyash. Also, the resultant material must pass all regulatory requirements for RCRA toxicity, OEPA 4.07, and radiological parameters and ensure groundwater protection.

3.1.2 Study B (Objectives)

Treatability Study B (Study B) will evaluate formulas for solidification/stabilization of the interlain clay located at the north end of the Inactive Flyash Pile.

The goals and objectives of this treatability study are to produce a mixed material consisting of clay and flyash with potential cement additives that will yield a moderate strength (75 psi), achieve regulatory requirements (RCRA toxicity and OEPA Policy 4.07 standards) for disposal in an approved landfill cell, and minimizes the bulking factor of the treated material.

## 3.2 STUDY A (EXPERIMENTAL DESIGN)

The mixing ratio (lime sludge to flyash) for Study A will be based on the dry weight of lime sludge and flyash. These dry weights were obtained from previous analytical data. Based on previous data, approximately 19,700 cubic yards (cy) of lime sludge, 69,000 cy flyash from the Active Flyash Pile, and 61,450 cy of flyash from the Inactive Flyash Pile are available for mixing. Based on existing dry density and estimated volumes of waste material, the optimum ratio (starting point) will be 13 percent lime sludge to flyash (by dry weights).

Study A will address mixes containing lime sludge and flyash, lime sludge and flyash with an additive, and lime sludge, flyash, and clay with an additive. The additive to be used is hydrated lime, to obtain a pH of 12.0. All mixes in Study A will be made in accordance with Section 3.4 and analyzed in accordance with Section 3.5 and 3.6.

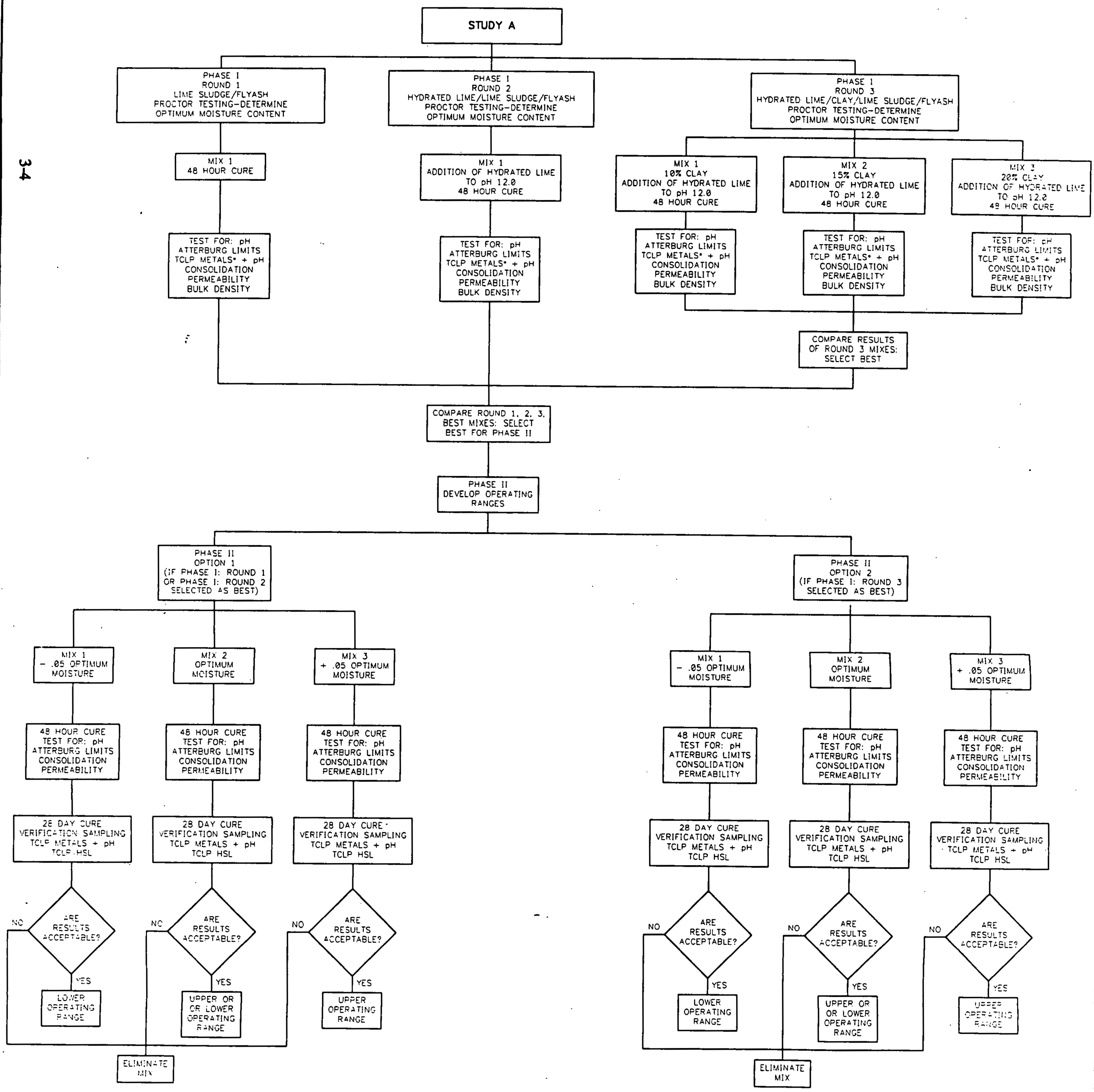
Study A testing will be performed in two phases, Phase I and Phase II. As shown on Figure 3-1, Phase I will be broken into three rounds (Round 1, Round 2, and Round 3). Each Round will consist of a mix with differing constituents but at a constant lime sludge to flyash ratio. This ratio will be based on utilization of the material available on site. Round 1 of Phase I's mix will contain lime sludge and flyash; Round 2 of Phases I's mix will contain hydrated lime, lime sludge, and flyash; and the Round 3 of Phase I's mixes will contain hydrated lime, clay, lime sludge, and flyash. The clay to be used in Round 3 will be obtained from the Inactive Flyash Pile.

During mixing of the Phase I mixes, one test will be performed to determine the optimum moisture content for each of the three rounds. The mix to be tested is identified on Figure 3-1. These moisture contents will be used for all mixes throughout Study A.

All testing in Phase I will be performed on samples with a 48-hour accelerated cure as described in Section 3.4. The mix yielding the lowest permeability and meeting regulatory requirements from Phase I will be selected for further testing in Phase II. If necessary, additional additives will be evaluated to reduce leachability of the treated material. Tables 3-1 and 3-2 summarize the required number of samples, including Quality Assurance/Quality Control (QA/QC) samples and required sample volumes for lime sludge/flyash mixes and clay/lime sludge/flyash mixes, respectively, for Study A.

Phase II testing will develop operating ranges and conduct confirmation/verification analysis to assure that the final waste form is protective of groundwater, is in regulatory compliance with RCRA toxicity, OEPA Policy 4.07, and radiological requirements. In addition, formulas will be developed to achieve all applicable geotechnical and engineering requirements for treatment and disposal of materials.

Based on the results of Phase I, one of two options (Option 1 and Option 2) will be selected for Phase II. This option will be the mix ratio from Phase I that achieved the most favorable results. Option 1 will address the operating range for mixes containing lime sludge and flyash. Option 2 will address the operating range for mixes containing lime sludge, flyash, and clay. Each Option will contain three mixes. Option 1 and Option 2 may also include the addition of hydrated lime. As shown on Figure 3-1, the optimum moisture content will be varied to determine an operating range for field implementation. Confirmation/verification analysis will be performed on Option 1 or Option 2 mixes.




* TEST ADDITIVES IF TCLP METALS EXTRACT YIELDS UNACCEPTABLE RESULTS. THIS WILL BE DONE DURING TIME OF PERMEABILITY AND CONSOLIDATION TESTING.

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STUDY A
TREATABILITY STUDY
FLOWCHART
FERNALD, OH

FIGURE 3–1

HALLIBURTON NUS
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# TABLE 3-1

## STUDY A
## LIME SLUDGE/FLYASH TREATABILITY STUDY SAMPLE REQUIREMENTS (Dry Weight)
## FERNALD, OHIO

| Sample Parameter | Number of Samples | | | Number of QA/QC Samples | | | Total Samples | | | Weight/ Sample | Lime Sludge / Flyash[1] | | | Total Lime Sludge / Flyash |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mix 1 | Mix 2 | Mix 3 | Mix 1 | Mix 2 | Mix 3 | Mix 1 | Mix 2 | Mix 3 | | Mix 1 | Mix 2 | Mix 3 | |
| **Phase I** | | | | | | | | | | | | | | |
| Standard Proctor | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 15 kg | 2.3kg / 27.7kg | -- | -- | 2.3kg / 27.7kg |
| pH | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | -- | -- | -- | -- | -- |
| TCLP Metals + pH | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 100g | 15g / 185g | -- | -- | 15g / 185g |
| Atterburg Limits | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 500g | 75g / 925g | -- | -- | 75g / 925g |
| Consolidation Test | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 1.5kg | 225g / 2.8kg | -- | -- | 225g / 2.8kg |
| Permeability Test | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 5kg | 750g / 9.3kg | -- | -- | 750g / 9.3kg |
| Bulk Density | 2 | -- | -- | 0 | 0 | 0 | 2 | -- | -- | 100g | 15g / 185g | -- | -- | 15g / 185g |
| **Phase II: Option 1** | | | | | | | | | | | | | | |
| ZHE HSL VOAs | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 100g | 15g / 185g | 7.5g / 92.5g | 7.5g / 92.5g | 30g / 370g |
| TCLP: HSL Semi-volatiles, HSL Pesticides/PCBs, HSL Metals + pH, Rad. Parameters | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 450g | 34g / 416g | 34g / 416g | 68g / 832g | 136g / 1.7kg |
| Atterburg Limits | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 500g | 75g / 925g | 37g / 463g | 37g / 463g | 150g / 1.9kg |
| Consolidation Test | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 2 | 1 | 1.5kg | 113g / 1.4kg | 225g / 2.8kg | 113g / 1.4kg | 450g / 5.6kg |
| Permeability Test | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 5kg | 375g / 4.6kg | 375g / 4.6kg | 750g / 9.3kg | 1.5kg / 18.5kg |
| pH | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | -- | -- | -- | -- | -- |
| | | | | | | | | | | | | | | 5.6kg / 69 kg |

[1] Ratios of lime sludge to flyash are only for sample collection estimates and should not be used to develop mixes.

FER\CRU2\JLG\TS\TAB3-1.WP\October 21, 1993 9:37am



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# TABLE 3-2

## STUDY A
## CLAY/LIME SLUDGE/FLYASH
## TREATABILITY STUDY SAMPLE REQUIREMENTS (Dry Weight)
## FERNALD, OHIO

| Sample Parameter | Number of Samples | | | Number of QA/QC Samples | | | Total Samples | | | Weight/ Sample | Clay / Lime Sludge / Flyash[1] | | | Total Clay / Lime Sludge / Flyash |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mix 1 | Mix 2 | Mix 3 | Mix 1 | Mix 2 | Mix 3 | Mix 1 | Mix 2 | Mix 3 | | Mix 1 | Mix 2 | Mix 3 | |
| **Phase I** | | | | | | | | | | | | | | |
| Standard Proctor | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 15 kg | -- | 1.95kg / 975g / 12.1kg | -- | 1.95kg / 975g / 12.1kg |
| pH | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | -- | -- | -- | -- | -- |
| TCLP Metals + pH | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 100g | 9g / 7g / 84g | 13g / 6.5g / 80.5g | 17g / 6g / 77g | 39g / 20g / 242g |
| Atterburg Limits | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 500g | 45g / 35g / 420g | 65g / 33g / 402g | 85g / 30g / 385g | 195g / 98g / 1.2kg |
| Consolidation Test | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1.5kg | 135g / 105g / 1.3kg | 195g / 98g / 1.2kg | 255g / 90g / 1.2kg | 585g / 293g / 3.7kg |
| Permeability Test | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 5kg | 450g / 350g / 4.2kg | 650g / 325g / 4kg | 850g / 300g / 3.9kg | 2kg / 975g / 12.1kg |
| Bulk Density | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 100g | 9g / 7g / 84g | 13g / 6.5g / 80.5g | 17g / 6g / 77g | 39g / 20g / 242g |
| **Phase II: Option 2** | | | | | | | | | | | | | | |
| ZHE HSL VOAs | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 100g | 18g / 14g / 168g | 13g / 6.5g / 80.5g | 17g / 6g / 77g | 48g / 27g / 326g |
| TCLP: HSL Semi-volatiles, HSL Pesticides/PCBs, HSL Metals + pH, Rad. Parameters | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 450g | 40g / 32g / 378g | 59g / 29g / 362g | 153g / 54g / 693g | 252g / 115g / 1.4kg |
| Atterburg Limits | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 500g | 90g / 70g / 840g | 65g / 33g / 402g | 85g / 30g / 385g | 240g / 133g / 1.6kg |
| Consolidation Test | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 2 | 1 | 1.5kg | 135g / 105g / 1.3kg | 390g / 195g / 2.4kg | 255g / 90g / 1.2kg | 780g / 390g / 4.9kg |
| Permeability Test | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 2 | 5kg | 450g / 350g / 4.2kg | 650g / 325g / 4kg | 1.7kg / 600g / 7.7kg | 2.8kg / 1.3kg / 16kg |
| pH | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | -- | -- | -- | -- | -- |
| | | | | | | | | | | | | | | 8.9kg / 4.3kg / 53.8kg |

[1] Clay/lime sludge/Flyash ratios are only for sample collection estimates and should not be used to develop mixes.

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Testing for engineering/geotechnical parameters will be performed on samples that have undergone a 48 hour accelerated cure. Testing of samples for confirmation will be performed as footnoted on Table 3-3. Samples for confirmation will undergo a 28-day standard cure as described in Section 3.4. A complete list of HSL parameters is presented in Appendix E.

### 3.2.1 Study A/Phase I

Phase I of Study A will consist of three Rounds (Rounds 1, 2, and 3) which will be used to evaluate mixes containing lime sludge, flyash, and various additives. Phase I mixes will be performed at a constant lime sludge to flyash ratio. Round 1 will utilize this ratio, Round 2 will utilize this ratio with the addition of hydrated lime, and Round 3 will utilize this ratio with the addition of hydrated lime and clay. Based on the results of Phase I, the mix with the most favorable permeability and leachability characteristics will be selected for development of an operating range in Phase II.

#### 3.2.1.1 Study A/Phase I/Round 1

As shown on Figure 3-1, Round 1 of Phase I will be performed on one mix containing lime sludge and flyash. The moisture content for the lime sludge and the flyash will be determined on a regular basis to determine the appropriate quantity of material to be added for each mix. Round 1 testing will be performed on one mix containing a ratio of 13 percent lime sludge to flyash. Testing to determine the optimum moisture content will be performed on this mix. Table 3-3 identifies the method for determining the optimum moisture content.

Following determination of the optimum moisture content at the calculated lime sludge to flyash ratio, the formula will be re-mixed and cured using a 48-hour accelerated cure. Mixing and curing procedures are included in Section 3.4. Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-1 and Section 3.6. Each of the mixes will be tested for the following parameters:

- pH
- Atterberg Limits
- Consolidation
- Permeability
- TCLP metals + pH
- Bulk Density

# TABLE 3-3

## SUMMARY OF ANALYSES AND METHODOLOGIES FOR TREATABILITY STUDY SPECIMENS OPERABLE UNIT 2 FERNALD, OHIO

| Analyte | Method |
|---|---|
| **ORGANICS** | |
| Volatile Organics Analysis(1) | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| Semi-Volatile Organics(2) | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| Pesticides/Polychlorinated Biphenyls(2) | U.S. EPA CLP SOW for Organic Analyses, OLMO1.8, August 1991 |
| **INORGANICS** | |
| Metals(3,4) | U.S. EPA CLP SOW for Inorganic Analyses, IOLMO2.1, September 1991 |
| Radiological Analysis(5) | Analyzed by gamma spectrometry following in-house methodologies and QA/AC procedures. |
| **GEOTECHNICAL** | |
| pH | U.S. EPA, SW-846, Method 9045, Rev. 0, 1986. |
| Atterberg Limits | ASTM D4318-84 |
| Unconfined Compressive Strength | ASTM D4219-83 |
| Consolidation Test | ASTM D2435-90 |
| Permeability | U.S. EPA,SW-846, Method 9100, Rev. 0, 1986 |
| Moisture Density - Standard Proctor | ASTM D698-91 |
| Moisture Content | ASTM D2216-90 |
| Bulk Density | Agronomy No. 9, CH. 30 |
| Paint Filter | U.S. EPA, SW-9095 |
| **EXTRACTION** | |
| ZHE for Volatile Organics | U.S. EPA CLP SW-846, Method 1311, Rev. 0, 1986 |
| TCLP Procedure for Semi-Volatile, Pest./PCB, Metals, Radionuclide Parameters | U.S. EPA, SW-846, Method 1311, Rev. 0, 1986. |

**TABLE 3-3**
**(Continued)**

(1) Analysis to be performed for confirmation/verification purposes. Complete analyte list provided as Appendix E.1. All parameters to be analyzed in the Zero Headspace Extraction (ZHE).

(2) Analysis to be performed for confirmation/verification purposes. Complete analyte list provided as Appendix E.2. All parameters to be analyzed in the Toxicity Characteristic Leaching Procedure (TCLP) leachate. The pH of the leachate will also be analyzed.

(3) TCLP metals + pH testing will be performed on Study A, Phase I and Study B, Phase II samples. The following will be analyzed in the TCLP leachate: Al, As, Ba, Ca, Cd, Cr, Cu, Pb, Hg, Se, Ag, Fe, Mn, Zn, U-234, U-235, U-238, and pH.

(4) Analysis to be performed for confirmation/verification purposes. Complete analyte list provided as Appendix E.3. All parameters to be analyzed in the Toxicity Characteristic Leaching Procedure (TCLP) leachate. The pH of the leachate will also be analyzed.

(5) **THE FEMP FULL LIST OF RADIOLOGICAL PARAMETERS** (To be analyzed in the TCLP Leachate during confirmation/verification.)

| | |
|---|---|
| Cesium-137 | Thorium-228 |
| Lead-210 | Thorium-230 |
| Neptunium-237 | Thorium-232 |
| Plutonium-238 | Total Thorium |
| Plutonium-239/240 | Uranium-234 |
| Radium-224 | Uranium-235 |
| Radium-226 | Uranium-235/236 |
| Radium-228 | Uranium-238 |
| Ruthenium-106 | Total Uranium |
| Strontium-90 | Gross Alpha |
| Technetium-99 | Gross Beta |

Table 3-3 identifies the methods to be used to perform testing for these parameters. The pH will be taken during mixing to ensure addition of hydrated lime to a pH of 12.0, refer to Section 3.4. Atterberg Limits will be determined immediately following the conclusion of mixing. Bulk Density and TCLP metals analysis will be performed at the conclusion of the accelerated cure. Consolidation and Permeability testing will take approximately 2 weeks to perform. In the interim, TCLP metal analysis results will be reviewed to determine if regulatory requirements are achieved. If these results do not meet regulatory criteria, additional mixes containing additives for decreasing leachability will be created, cured, and tested prior to continuation of the Phase I.

At the conclusion of Phase I testing, results from the three Rounds will be compared and the mix with the most favorable geotechnical parameters, lowest permeability, and best leachability results will be selected for Phase II testing and operating range development. All other mixes will be eliminated.

3.2.1.2 Study A/Phase I/Round 2

As shown on Figure 3-1, Round 2 of Phase I will be performed on one mix containing hydrated lime (to a pH of 12.0), lime sludge, and flyash. The moisture contents for the lime sludge and flyash will be determined on a regular basis to determine the appropriate quantity of material to be added to each mix. Round 2 testing will be performed on one mix containing a ratio of 13 percent lime sludge to flyash with the addition of hydrated lime. This mix will be tested to determine optimum moisure content. Table 3-3 identifies the method for determining the optimum moisture content.

Following determination of the optimum moisture content at the calculated lime sludge to flyash ratio, the formula will be re-mixed and cured using a 48-hour accelerated cure. Mixing and curing procedures are included in Section 3.4. Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-1 and Section 3.6. Each of the mixes will be tested for the following parameters:

- pH
- Atterberg Limits
- Consolidation
- Permeability
- TCLP metals + pH
- Bulk Density

Table 3-3 identifies the methods to be used to perform testing for these parameters. The pH will be taken during mixing to ensure addition of hydrated lime to a pH of 12.0, refer to Section 3.4. Atterberg Limits will be determined immediately following the conclusion of mixing. Bulk Density and TCLP metals analysis will be performed at the conclusion of the accelerated cure. Consolidation and Permeability testing will take approximately 2 weeks to perform. In the interim, TCLP metal analysis results will be reviewed to determine if regulatory requirements are achieved. If these results do not meet regulatory criteria, additional mixes containing additives for decreasing leachability will be created, cured, and tested prior to continuation of the Phase I.

At the conclusion of Phase I testing, results from the three Rounds will be compared and the mix with the most favorable geotechnical parameters, lowest permeability, and best leachability results will be selected for Phase II testing and operating range development. All other mixes will be eliminated.

3.2.1.3 Study A/Phase I/Round 3

As shown on Figure 3-1, Round 3 of Phase I will be performed using three mixes containing hydrated lime (to a pH of 12.0), clay, lime sludge, and flyash. The moisture contents for the lime sludge, flyash, and clay will be determined on a regular basis to determine the appropriate quantity of material to be added to each mix. Round 3 testing will be performed on three mixes, all at the same lime sludge to flyash ratio (13 percent dry weight of lime sludge to flyash). Each mix will have varying percentages of clay (10, 15, and 20 percent clay by dry weight of the total lime sludge and flyash dry weight). Testing will be performed to determine the optimum moisture content of the mix containing the "center point" percentage of clay (i.e. 15 percent clay by dry weight). Table 3-3 identifies the method for determining the optimum moisture content. This moisture content will also be used for mixing of the two other mixes in Round 3. Mix 1 will contain 10 percent clay by dry weight, Mix 2 will contain 15 percent clay by dry weight, and Mix 3 will contain 20 percent clay by dry weight.

Using the optimum moisture content Mix 1, Mix 2, and Mix 3 will be made and cured using a 48-hour accelerated cure. Mixing and curing procedures are included in Section 3.4. Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-2 and Section 3.6. Each of the mixes will be tested for the following parameters:

- pH
- Atterberg Limits
- Consolidation
- Permeability

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- TCLP metals + pH
- Bulk Density

Table 3-3 identifies the methods to be used to perform testing for these parameters. The pH will be taken during mixing to ensure addition of hydrated lime to a pH of 12.0, refer to Section 3.4. Atterberg Limits will be determined immediately following the conclusion of mixing. Bulk Density and TCLP metals analysis will be performed at the conclusion of the accelerated cure. Consolidation and Permeability testing will take approximately 2 weeks to perform. In the interim, TCLP metal analysis results will be reviewed to determine if regulatory requirements are achieved. If these results do not meet regulatory criteria, additional mixes containing additives for decreasing leachability will be created, cured, and tested prior to continuation of the Phase I.

At the conclusion of Round 3 testing the three mixes will be compared and the mix with the best geotechnical parameters and best leachability results will be selected for further comparison to Round 1 and Round 2 mixes. The mix with the most favorable geotechnical parameters, lowest permeability, and best leachability results will be selected for Phase II testing and development of an operating range. All other mixes will be eliminated. Also, if the best mix from Phase I is selected from Round 3, results from Round 3 analysis for permeability and leachability will be compared and the two best mixes will be selected. The clay percentages associated with these two mixes will be used as the operating range for field implementation.

### 3.2.2 Study A/Phase II

Phase II will be conducted to develop an operating range for the selected formulation from Phase I. Based on the results of Phase I, one of two options (Option 1 and Option 2) will be selected for Phase II. This option will be the mix ratio from Phase I that achieved the most favorable results. Option 1 will address the operating range for mixes containing lime sludge and flyash. Option 2 will address the operating range for mixes containing lime sludge, flyash, and clay. The best formula and associated operating range will be utilized for design of a treatment system.

#### 3.2.2.1 Study A/Phase II/Option 1

Option 1 will be performed if the best mix is selected from Round 1 of Phase I or Round 2 of Phase I which includes lime sludge and flyash with or without hydrated lime as an additive. As shown on Figure 3-1, Option 1 will include three mixes which utilize the optimum lime sludge to flyash ratio and will vary the optimum moisture content to develop both a lower and upper operating range. Confirmation/verification sampling will be performed on all three of the Option 1 mixes. QA/QC samples will be included as part of each mix as per the requirements listed in Section 3.6.

As part of the confirmation/verification, sampling and analysis will be performed on all of the mixes. Engineering/geotechnical parameter testing will be performed on samples that have undergone a 48-hour accelerated cure. Sample testing for confirmation of chemical parameters will be performed as footnoted on Table 3-3. Samples for confirmation will undergo a 28-day standard cure as described in Section 3.4. Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-1 and Section 3.6. A complete list of HSL parameters is presented in Appendix E.

Each of the mixes will be evaluated for the following parameters:

- pH
- Atterberg Limits
- Consolidation
- Permeability
- Bulk Density

Table 3-3 identifies the methods to be used to perform testing for these parameters. The pH will be taken during mixing to ensure addition of hydrated lime to a pH of 12.0, refer to Section 3.4. Atterberg Limits will be determined immediately following the conclusion of mixing. Bulk Density will be performed at the conclusion of the accelerated cure. Consolidation and Permeability testing will take approximately 2 weeks to perform. Additional samples from Option 1 will be cured for 28 days for performance of confirmatory chemical analysis in accordance with Table 3-3.

3.2.2.2 Study A/Phase II/Option 2

Option 2 will be performed if the best mix is selected from Round 3 of Phase I which includes the addition of hydrated lime and clay. As shown on Figure 3-1, Option 2 will include three mixes which utilize the optimum lime sludge to flyash ratio and will vary the optimum moisture content to develop both a lower and upper operating range. Confirmation/verification sampling will be performed on all three of the Option 2 mixes. QA/QC samples will be included as part of each mix as per the requirements listed in Section 3.6.

As part of the confirmation/verification, sampling and analysis will be performed on all of the mixes. Engineering/geotechnical parameter testing will be performed on samples that have undergone a 48 hour accelerated cure. Sample testing for confirmation of chemical parameters will be performed as footnoted on Table 3-3. Samples for confirmation will undergo a 28-day standard cure as described in Section 3.4. Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-2 and Section 3.6. A complete list of HSL parameters is presented in Appendix E.

Each of the mixes will be evaluated for the following parameters:

- pH
- Atterberg Limits
- Consolidation
- Permeability
- Bulk Density

Table 3-3 identifies the methods to be used to perform testing for these parameters. The pH will be taken during mixing to ensure addition of hydrated lime to a pH of 12.0, refer to Section 3.4. Atterberg Limits will be determined immediately following the conclusion of mixing. Bulk Density will be performed at the conclusion of the accelerated cure. Consolidation and Permeability testing will take approximately 2 weeks to perform. Additional samples from Option 1 will be cured for 28 days for performance of confirmatory chemical analysis in accordance with Table 3-3.

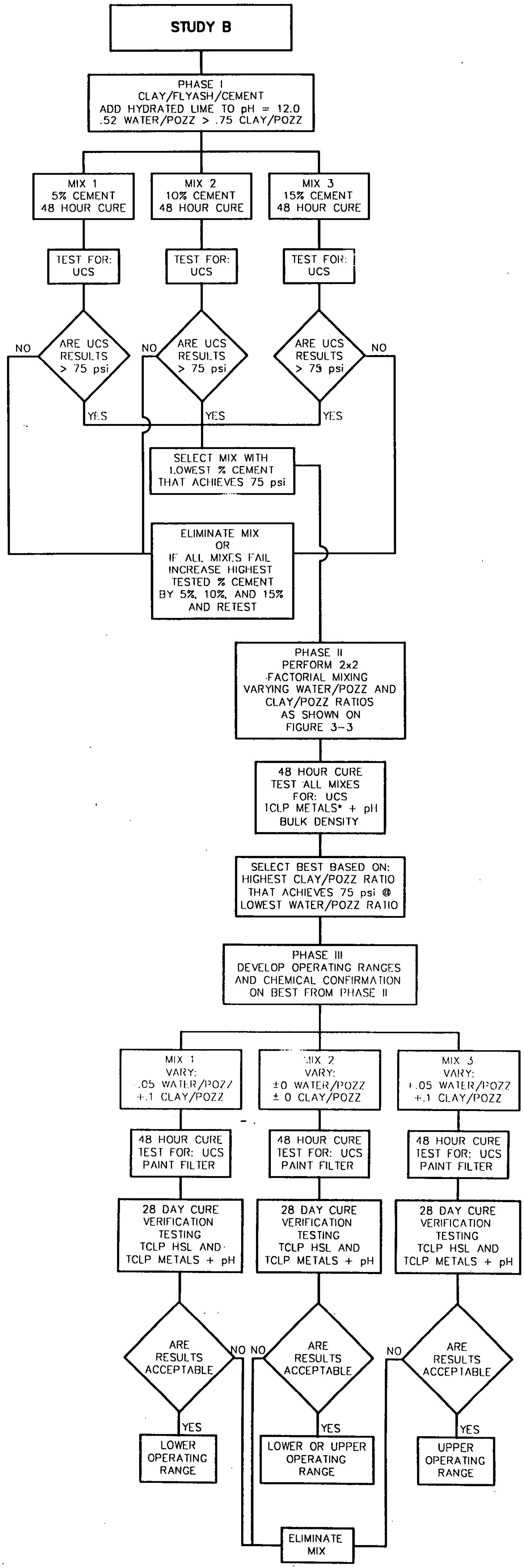
## 3.3 STUDY B (EXPERIMENTAL DESIGN)

Study B will be performed to evaluate solidification/stabilization of the interlain clay and clay cover from the Inactive Flyash Pile. All mixing ratios will be determined based on the dry weight of the "as received" material; this can be obtained from the baseline assessment. Study B will evaluate formulas containing clay and flyash with additives. The additives to be used are hydrated lime, to obtain a pH of 12.0, and varying percentages of Type I Portland cement. Study B will assume all mixes will require the addition of cement and hydrated lime. All mixes in Study B will be made in accordance with Section 3.4 and analyzed in accordance with Section 3.5 and Section 3.6.

Study B will be performed in three phases (Phase I, Phase II, and Phase III). Ratios of 0.52 water to pozzolan and 0.75 clay to pozzolan have been selected as starting points for Phase I. Pozzolan will be defined as the dry weight of flyash plus cement. Phase II will use the ratios from Phase I as a "center point" and will vary them accordingly for a two by two factorial experiment, as described below. Phase III will be performed to develop operating ranges and chemical confirmation/ verification. Study B testing criteria includes Unconfined Compressive Strength (UCS), Bulk Density, Paint Filter, and TCLP leachate testing. The goal of the formulas will be to achieve a UCS result of 75 psi. Bulk Density will be used to determine the bulking potential of the treated material. Mixes must also meet all regulatory requirements. Additional testing of additives may be required to obtain acceptable results.

As shown on Figure 3-2, Phase I will be a preliminary phase containing three mixes. This phase will be performed to determine the best ratio of cement to dry weight of flyash to be utilized in mixes throughout Study B. Phase I mixes will contain clay, flyash, cement, and hydrated lime. Phase I mixes will be performed at predetermined water to pozzolan and clay to pozzolan ratios. Table 3-4 summarizes the required number of samples, including QA/QC samples, and required sample volumes for Phase I, II, and III of Study B. All testing in Phase I will be performed on samples with a 48-hour accelerated cure as described in Section 3.4. Testing in Phase I will be for UCS only and will determine which percentage of cement will provide sufficient UCS results. The lowest quantity of cement that achieves 75 psi for a UCS result will be selected for future studies.

Phase II of Study B will be performed to develop the best water to pozzolan and clay to pozzolan ratios. Phase II will utilize a two by two factorial experiment to determine the best mix design. Factorial experiments are characterized in that the effect of changes on one variable can be assessed independently of the other variables. The factorial experiment is accomplished by using, as the design, each of the possible combinations of the levels (concentrations) of each factor (parameter or variable). In a factorial experiment, all factors may be varied simultaneously. The factorial approach allows the assessment of the interaction of two or more variables. A two by two factorial experiment utilizes two variables (water/pozzolan and clay/pozzolan ratios) and a center point. The center point will be 0.52 water/pozzolan and 0.75 clay/pozzolan. For the factorial experiment the water to pozzolan ratio will be varied by $\pm 0.10$ and the clay to pozzolan ratio will be varied by $\pm 0.25$. Figure 3-3 shows how the two variables will be evaluated. As shown on this figure, five mixes will be evaluated. The percentage of cement determined in Phase I will be used for each mix and the water/pozzolan and clay/pozzolan ratios will be varied. All testing in Phase II will be performed on samples with a 48 hour accelerated cure as described in Section 3.3. Testing in Phase II will be for UCS, TCLP metals plus pH, and Bulk Density. Results of the TCLP sampling will be used to determine if additional additives are required to decrease leachability.




* TEST ADDITIVES IF TCLP EXTRACT YIELDS UNACCEPTABLE RESULTS

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STUDY B
TREATABILITY STUDY
FLOWCHART
FERNALD, OH

FIGURE 3-2

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# TABLE 3-4

## STUDY B
## CLAY/FLYASH TREATABILITY STUDY
## SAMPLE REQUIREMENTS (Dry Weight)
## FERNALD, OHIO

| Sample Parameter | Number of Samples | | | | | Number of QA/QC Samples | | | | | Total Samples | | | | | Weight/ Sample | Clay / Flyash[1] | | | | | Total Clay / Flyash |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mix 1 | Mix 2 | Mix 3 | Mix 4 | Mix 5 | Mix 1 | Mix 2 | Mix 3 | Mix 4 | Mix 5 | Mix 1 | Mix 2 | Mix 3 | Mix 4 | Mix 5 | | Mix 1 | Mix 2 | Mix 3 | Mix 4 | Mix 5 | |
| **Phase I** | | | | | | | | | | | | | | | | | | | | | | |
| UCS | 1 | 1 | 1 | -- | -- | 0 | 0 | 0 | -- | -- | 1 | 1 | 1 | -- | -- | 450 g | 193g / 257g | 193g / 257g | 193g / 257g | -- | -- | 579g / 771g |
| **Phase II** (2 x 2 Factorial) | | | | | | | | | | | | | | | | | | | | | | |
| UCS | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 450g | 193g / 257g | 193g / 257g | 193g / 257g | 193g / 257g | 193g / 257g | 965g / 1.3kg |
| TCLP Metal + pH | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 100g | 43g / 57g | 43g / 57g | 43g / 57g | 43g / 57g | 43g / 57g | 215g / 285g |
| Bulk Density | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 100g | 43g / 57g | 43g / 57g | 43g / 57g | 43g / 57g | 43g / 57g | 215g / 285g |
| **Phase III** | | | | | | | | | | | | | | | | | | | | | | |
| UCS | 1 | 1 | 1 | -- | -- | 0 | 1 | 0 | -- | -- | 1 | 2 | 1 | -- | -- | 450g | 193g / 257g | 386g / 514g | 193g / 257g | -- | -- | 772g / 1kg |
| ZHE HSL VOAs | 1 | 1 | 1 | -- | -- | 1 | 0 | 0 | -- | -- | 2 | 1 | 1 | -- | -- | 100g | 86g / 114g | 43g / 57g | 43g / 57g | -- | -- | 172g / 228g |
| TCLP: HSL Semi-volatiles, HSL Pesticides/PCBs, HSL Metals + pH, Rad. Parameters | 1 | 1 | 1 | -- | -- | 0 | 0 | 1 | -- | -- | 1 | 1 | 2 | -- | -- | 450g | 193g / 257g | 193g / 257g | 386g / 514g | -- | -- | 772g / 1kg |
| Paint Filter | 1 | 1 | 1 | -- | -- | 0 | 0 | 0 | -- | -- | 1 | 1 | 1 | -- | -- | 200g | 96g / 114g | 96g / 114g | 96g / 114g | -- | -- | 288g / 342g |
| | | | | | | | | | | | | | | | | | | | | | | 4kg / 5.3kg |

[1] Ratios of clay to Flyash are only for sample collection estimates and should not be used to develop mixes.

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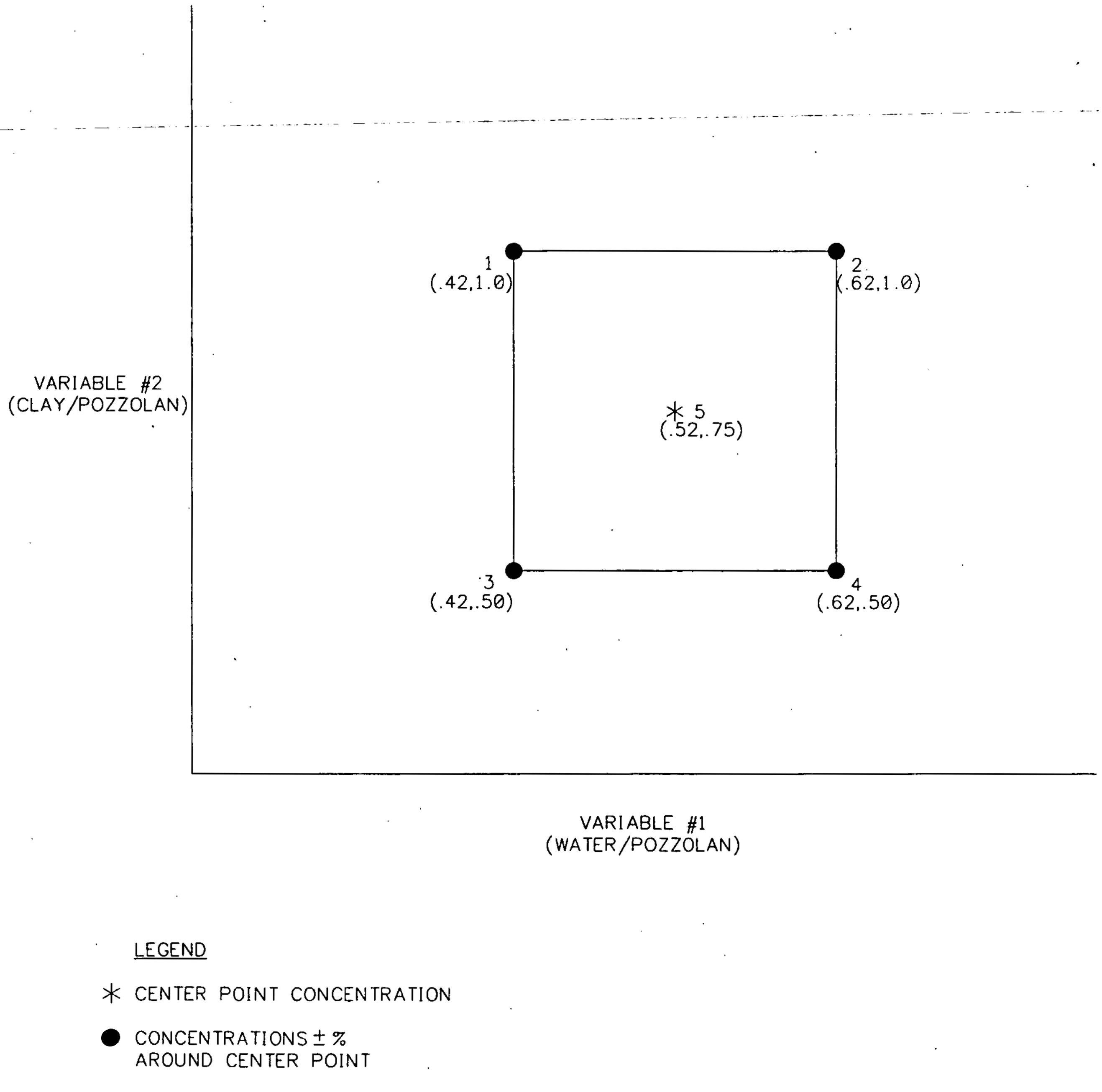


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FIGURE 3–3

**EXAMPLE OF TWO BY TWO MATRIX**
**FERNALD, OHIO**
NOT TO SCALE

HALLIBURTON NUS
*Environmental Corporation*

geotechnical and engineering parameters will be performed on samples that have undergone the 48-hour accelerated cure as described in Section 3.4. Testing for chemical confirmation/verification will be performed on samples that have undergone the 28-day standard cure as described in Section 3.4. Mixes 1, 2, and 3 will be tested for UCS, Paint Filter, TCLP metals + pH, and a full HSL analysis on TCLP extract (including ZHE HSL VOAs). Also, QA/QC samples will be included as part of each mix as per the requirements listed in Table 3-4 and Section 3.6. The methods to be used for testing are presented in Table 3-3.

## 3.4 PROCEDURES

This section presents the procedures for conducting the treatability study. Procedures required for sample preparation, mixing, and curing are included in the following paragraphs. Analytical procedures are promulgated in each specific method. Specific analytical methods are shown in Table 3-3.

### 3.4.1 Curing Procedures

Two procedures for curing samples will be employed during the treatability study. A 48-hour accelerated cure will be used on all geotechnical samples and also samples that will be performed to determine the need for additional additives. The 28-day standard cure will be used on all samples that will undergo confirmatory analysis.

#### 3.4.1.1 48-Hour Accelerated Curing Procedure

This procedure will be performed as per ASTM C684-89, Procedure A, "Making, Accelerated Curing, and Testing of Concrete Compression Test Specimens" with the following modifications:

Molds

The molds specified in the curing method will not be used. Jatco polyethelene (2" x 4") cylinders, or equal, will be used for all testing with the exception of Consolidation and Permeability. Molds amenable to Consolidation and Permeability will be used as required. The top of the specimen is to be leveled and covered to prevent specimen loss during curing.

Curing Time

48 hrs. ± 30 min. shall be the duration of the curing time using Procedure A - Warm Water Method.

Slump and air content measurements will not be required.

3.4.1.2 28-Day Standard Curing Procedure

This procedure will be performed as per ASTM C192-90a "Standard Method of Making and Curing Concrete Test Specimens in the Laboratory" with the following modifications:

Molds

The molds specified in the curing method will not be used. Jatco polyethelene (2" x 4") cylinders, or equal, will be used for all testing. The top of the specimen is to be leveled and covered to prevent specimen loss during curing.

Curing Time

28 days ± 30 min. shall be the duration of the curing time.

Slump and air content measurements will not be required.

Curing Temperature

Specimens must remain at a constant temperature throughout the 28 day curing time. A recommended temperature is 70 F +/- 5 F.

Curing Conditions

Specimens must be cured in a humid chamber. If a standard curing chamber is not available, specimens can be cured in coolers containing a small amount of water. The coolers will provide a moist atmosphere while insulating the specimens from temperature fluctuations.

3.4.2 Sample Preparation

Representative aliquots of the waste media to be tested will be taken from the sample storage containers. Sample moisture content will be tested daily and recorded. No further preparation will be required.

3.4.3 Sample Weighing

The materials for a particular batch will be weighed on an analytical balance to the nearest 0.01g and the weight recorded.

### 3.4.4 Sample Mixing

When preparing samples with additives (i.e. hydrated lime, cement, and clay) the order of addition will be as follows:

- Flyash
- Water to obtain proper moisture content
- Hydrated lime to obtain a pH of 12.0, as required
- Cement, as required
- Lime Sludge, as required
- Clay, as required

The materials for a particular batch are to be mixed using a Hobart mixer (or equivalent) for 5 minutes, or until completely homogenized. The speed and time of the mixing will be initially determined by the technician and will be held constant for all batches. All cylinders should be filled to ensure no void spaces. Cylinders shall be filled in three equal lifts with each successive lift being tamped with a one quarter-inch rounded rod 25 times for each lift. All cylinders should be leveled off and capped to ensure a seal.

### 3.4.5 Cleanup

Equipment must be decontaminated (cleaned) before the next batch is mixed. A thorough rinsing of the equipment with deionized (DI) water will be used for all equipment which contacts the sample material to avoid cross contamination.

### 3.4.6 Disposal of Laboratory Wastes

All treatability study residuals will be returned to the FEMP facility. This includes all unused sample and wastes generated during the treatability studies. The laboratory will be responsible for the packaging and transportation the waste following all applicable state, federal, and FEMP regulations.

The laboratory will be responsible for the disposal of all Dry Active Waste (DAW) generated during the treatability studies. The plan for DAW disposal must be approved by FEMP. If a disposal facility is not available the DAW will be returned to the FEMP facility.

## 3.5 ANALYTICAL METHODS

The analytical methods to be used are summarized in Table 3-3.

### 3.5.1 Analytical Support Level (ASL)

Analytical Support Levels (ASLs) and Data Quality Objectives (DQOs) are qualitative and/or quantitative statements regarding the quality of data needed to support the treatability study activities. In order to develop project-specific ASLs, the intended use of the data must be defined. This use must be balanced between data quality needs and time as well as cost constraints.

Specific analytical protocols are selected to meet the ASLs in the following ways:

- Compare data needs to the detection limits for available analytical methods.
- Select analytical methods to allow quantification of the analytes at levels sufficiently below the data needs to minimize the number of critical data points.
- Evaluate the maximum allowable variability in the data based on the data needs comparison.
- Develop project-specific acceptable variability based on the intended data use and method-specific precision and accuracy information.

The analyses of the treatability study specimens shall adhere to appropriate FEMP ASL Level (EPA DQO Level IV) of quality control criteria as specified in the Sitewide CERCLA Quality Assurance Project Plan (SCQ). This is shown in Tables 3-5 and 3-6 for Study A and Study B, respectively. All analyses will require a CLP data package included as a deliverable. In the case of the physical parameters and radiological parameters, the data should be presented in a "CLP-equivalent" data package format. FEMP ASL Level D (EPA DQO Level IV) is considered legally defensible data and is sufficient to document compliance with regulatory requirements.

### 3.5.2 Data Validation

Validity of data (i.e., 95-percent confidence limit) with respect to its intended use will be assessed based on laboratory-supplied QA/QC data and protocols outlined in EPA's "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analysis 2/88" and "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses 7/88". The functional guidelines will be used in conjunction set forth by EPA Region V. The data validation process for the radiological analyses will be done in accordance with the appropriate FEMP internal guidelines.

Data validation will be performed on all of the ASL Level D analyses, as shown in Tables 3-5 and 3-6, within the treatability studies in accordance with the "FEMP Data Validation Procedure",

## TABLE 3-5

## TREATABILITY STUDY A
## ANALYTICAL SUPPORT LEVEL REQUIRED FOR ANALYSIS

| | ASL Level[1] |
|---|---|
| **Phase I** | |
| TCLP Metals + pH | C |
| Atterberg Limits | C |
| Consolidation | C |
| Permeability | C |
| **Phase II** | |
| ZHE + HSL Organics | D |
| TCLP + HSL Metals + Radionuclides + pH | D |
| Atterberg Limits | C |
| Consolidation | C |
| Permeability | C |

(1) As defined in the Sitewide CERCLA Quality Assurance Project Plan (SCQ).

**NOTE:** Complete listing of analytical parameters and methods are shown in Table 3-1.

## TABLE 3-6

## TREATABILITY STUDY B
## ANALYTICAL SUPPORT LEVEL REQUIRED FOR ANALYSIS

| | ASL Level[1] |
|---|---|
| **Phase I** | |
| UCS | C |
| **Phase II** | |
| TCLP Metals + pH | C |
| UCS | C |
| Density | C |
| **Phase III** | |
| ZHE + HSL Organics | D |
| TCLP + HSL Metals + Radionuclides + pH | D |
| UCS | C |

[1] As defined in the Sitewide CERCLA Quality Assurance Project Plan (SCQ).

**NOTE:** Complete listing of analytical parameters and methods are shown in Table 3-4.

SSOP-1004, REV.0. In general, results that are rejected by the validation process will be disqualified from application for the intended use.

## 3.6 INTERNAL QUALITY CONTROL CHECKS

Quality Control checks to be implemented in the laboratory are described in this section. Laboratory analyses will be conducted in accordance with the appropriate analytical methods (See Table 3-3). Internal laboratory quality control checks may include surrogate and matrix spike addition and analysis and reagent blank generation and analysis as specified in the method. Internal laboratory quality control checks for other methods are described below.

### 3.6.1 QA/QC Samples

One in 20 samples analyzed for a specific parameter is run in duplicate or one per batch, whichever is more frequent. A duplicate sample will be taken from the same batch as the original sample.

### 3.6.2 Radiological Analyses and Physical Parameters

The quality control procedures are to be detailed in the Laboratory's General Quality Assurance Plan.

# 4.0 PROJECT ORGANIZATION AND SCHEDULE

The Fernald Environment Restoration Management Company (FERMCO) will be responsible for all activities conducted during the treatability study. The FERMCO Project Manager will be responsible for the overall quality of the study including cost and schedule. The FERMCO Project Engineer will be responsible for providing direction of day-to-day activities and project continuity.

FERMCO personnel will collect samples for the Treatability Study. Samples for the baseline geotechnical analysis will be provided by FERMCO, to a Parsons' designated laboratory. FERMCO will provide samples to a FERMCO approved laboratory (CLP approved) for the baseline chemical and radiological analysis. FERMCO will also provide the required samples to Parsons' designated laboratory to conduct the Treatability Study.

All laboratory work conducted for the formulation development and geotechnical analysis will be the responsibility of Parsons and their designated laboratory. All other analytical work will be conducted by the FERMCO approved laboratory on the samples shipped from Parsons' designated laboratory. FERMCO will be responsible for coordinating all activities between Parsons and the FERMCO approved analytical laboratory. Parsons will be responsible for providing a contact who will be responsible for all work conducted by the laboratory. The required laboratory technicians will conduct all hands-on work for the study as described in this Work Plan or with any modifications which are approved by the FERMCO project manager.

## 4.1 RESPONSIBILITY OF KEY PERSONNEL

The FERMCO Project Manager will be responsible for the overall performance of the treatability study. The FERMCO Project Manager will be assisted by a Project Engineer who will be assisting with various engineering tasks and day-to-day coordination of the treatability study.

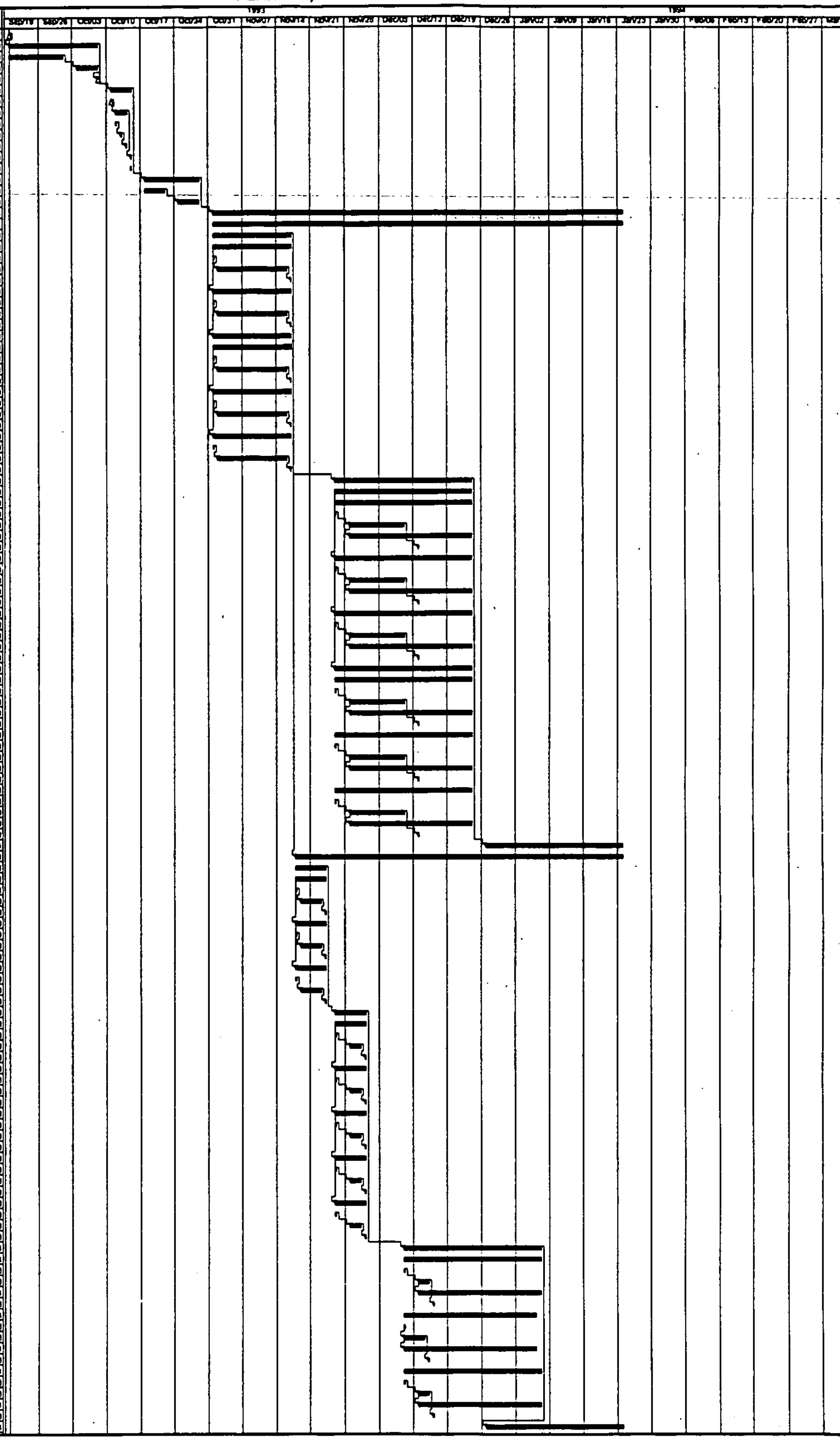
Parsons will be responsible for providing all necessary internal project management. In addition, Parsons will provide a contact to be responsible for all work performed by the laboratory. Technical personnel will be provided by the laboratory to conduct all activities necessary to complete the treatability study.

## 4.2 SCHEDULE

Figure 4-1 identifies the schedule for the Treatability Study. As shown in this schedule the study will be conducted during the period of September 20, 1993 to January 24, 1994. Delays may be encountered for the start date, however, all durations will remain as shown for each task.

# FIGURE 4-1
## TREATABILITY STUDY SCHEDULE
## FERNALD, OHIO

| ROW # | Task Name | Duration | Start | End |
|---|---|---|---|---|
| 1 | REGULATORY APPROVAL | 0.00 d | Sep/20/93 | Sep/20/93 |
| 2 | SUBCONTRACTOR PROCU | 15.00 d | Sep/20/93 | Oct/08/93 |
| 3 | Request for Proposal | 10.00 d | Sep/20/93 | Oct/01/93 |
| 4 | Proposal Review | 5.00 d | Oct/04/93 | Oct/08/93 |
| 5 | Project Award | 0.00 d | Oct/08/93 | Oct/08/93 |
| 6 | FIELD SAMPLE COLLECTIO | 4.00 d | Oct/11/93 | Oct/14/93 |
| 7 | Mobilize | 0.00 d | Oct/11/93 | Oct/11/93 |
| 8 | Study A | 3.00 d | Oct/12/93 | Oct/14/93 |
| 9 | Collect lime sludge | 1.00 d | Oct/12/93 | Oct/12/93 |
| 10 | Collect active flyash | 1.00 d | Oct/13/93 | Oct/13/93 |
| 11 | Collect inactive flyash | 1.00 d | Oct/14/93 | Oct/14/93 |
| 12 | Study B | 1.00 d | Oct/15/93 | Oct/15/93 |
| 13 | Collect interim clay | 1.00 d | Oct/15/93 | Oct/15/93 |
| 14 | BASELINE ANAYSIS | 10.00 d | Oct/18/93 | Oct/29/93 |
| 15 | Analysis | 5.00 d | Oct/18/93 | Oct/22/93 |
| 16 | Report | 5.00 d | Oct/25/93 | Oct/29/93 |
| 17 | TREATABILITY STUDY | 60.00 d | Nov/01/93 | Jan/24/94 |
| 18 | Study A | 60.00 d | Nov/01/93 | Jan/24/94 |
| 19 | Phase I (48 Hour Cure) | 12.00 d | Nov/01/93 | Nov/17/93 |
| 20 | Round 1 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 21 | Mix | 1.00 d | Nov/01/93 | Nov/01/93 |
| 22 | Analyze | 10.00 d | Nov/02/93 | Nov/16/93 |
| 23 | Report | 1.00 d | Nov/17/93 | Nov/17/93 |
| 24 | Round 2 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 25 | Mix | 1.00 d | Nov/01/93 | Nov/01/93 |
| 26 | Analyze | 10.00 d | Nov/02/93 | Nov/16/93 |
| 27 | Report | 1.00 d | Nov/17/93 | Nov/17/93 |
| 28 | Round 3 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 29 | Mix 1 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 30 | mix | 1.00 d | Nov/01/93 | Nov/01/93 |
| 31 | analyze | 10.00 d | Nov/02/93 | Nov/16/93 |
| 32 | report | 1.00 d | Nov/17/93 | Nov/17/93 |
| 33 | Mix 2 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 34 | mix | 1.00 d | Nov/01/93 | Nov/01/93 |
| 35 | analyze | 10.00 d | Nov/02/93 | Nov/16/93 |
| 36 | report | 1.00 d | Nov/17/93 | Nov/17/93 |
| 37 | Mix 3 | 12.00 d | Nov/01/93 | Nov/17/93 |
| 38 | mix | 1.00 d | Nov/01/93 | Nov/01/93 |
| 39 | analyze | 10.00 d | Nov/02/93 | Nov/16/93 |
| 40 | report | 1.00 d | Nov/17/93 | Nov/17/93 |
| 41 | Phase II | 21.00 d | Nov/26/93 | Dec/24/93 |
| 42 | Option 1 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 43 | Mix 1 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 44 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 45 | Analyze | 10.00 d | Nov/29/93 | Dec/10/93 |
| 46 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 47 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 48 | Mix 2 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 49 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 50 | Analyze | 10.00 d | Nov/29/93 | Dec/10/93 |
| 51 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 52 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 53 | Mix 3 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 54 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 55 | Analyze geotechnic | 10.00 d | Nov/29/93 | Dec/10/93 |
| 56 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 57 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 58 | Option 2 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 59 | mix 1 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 60 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 61 | Analyze geotechnic | 10.00 d | Nov/29/93 | Dec/10/93 |
| 62 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 63 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 64 | mix 2 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 65 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 66 | Analyze geotechnic | 10.00 d | Nov/29/93 | Dec/10/93 |
| 67 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 68 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 69 | mix 3 | 21.00 d | Nov/26/93 | Dec/24/93 |
| 70 | mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 71 | Analyze | 10.00 d | Nov/29/93 | Dec/10/93 |
| 72 | Analyze / confirmati | 20.00 d | Nov/29/93 | Dec/24/93 |
| 73 | report | 1.00 d | Dec/13/93 | Dec/13/93 |
| 74 | Study A Final Report | 20.00 d | Dec/27/93 | Jan/24/94 |
| 75 | Study B | 46.00 d | Nov/18/93 | Jan/24/94 |
| 76 | Phase I | 5.00 d | Nov/18/93 | Nov/24/93 |
| 77 | Mix 1 | 5.00 d | Nov/18/93 | Nov/24/93 |
| 78 | Mix | 1.00 d | Nov/18/93 | Nov/18/93 |
| 79 | Analyze | 3.00 d | Nov/19/93 | Nov/23/93 |
| 80 | Report | 1.00 d | Nov/24/93 | Nov/24/93 |
| 81 | Mix 2 | 5.00 d | Nov/18/93 | Nov/24/93 |
| 82 | Mix | 1.00 d | Nov/18/93 | Nov/18/93 |
| 83 | Analyze | 3.00 d | Nov/19/93 | Nov/23/93 |
| 84 | Report | 1.00 d | Nov/24/93 | Nov/24/93 |
| 85 | Mix 3 | 5.00 d | Nov/18/93 | Nov/24/93 |
| 86 | Mix | 1.00 d | Nov/18/93 | Nov/18/93 |
| 87 | Analyze | 3.00 d | Nov/19/93 | Nov/23/93 |
| 88 | Report | 1.00 d | Nov/24/93 | Nov/24/93 |
| 89 | Phase II | 5.00 d | Nov/26/93 | Dec/02/93 |
| 90 | Mix 1 | 5.00 d | Nov/26/93 | Dec/02/93 |
| 91 | Mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 92 | Analize | 3.00 d | Nov/29/93 | Dec/01/93 |
| 93 | Report | 1.00 d | Dec/02/93 | Dec/02/93 |
| 94 | Mix 2 | 5.00 d | Nov/26/93 | Dec/02/93 |
| 95 | Mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 96 | Analyze | 3.00 d | Nov/29/93 | Dec/01/93 |
| 97 | Report | 1.00 d | Dec/02/93 | Dec/02/93 |
| 98 | Mix 3 | 5.00 d | Nov/26/93 | Dec/02/93 |
| 99 | Mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 100 | Analize | 3.00 d | Nov/29/93 | Dec/01/93 |
| 101 | Report | 1.00 d | Dec/02/93 | Dec/02/93 |
| 102 | Mix 4 | 5.00 d | Nov/26/93 | Dec/02/93 |
| 103 | Mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 104 | Analyze | 3.00 d | Nov/29/93 | Dec/01/93 |
| 105 | Report | 1.00 d | Dec/02/93 | Dec/02/93 |
| 106 | Mix 5 | 5.00 d | Nov/26/93 | Dec/02/93 |
| 107 | Mix | 1.00 d | Nov/26/93 | Nov/26/93 |
| 108 | Analize | 3.00 d | Nov/29/93 | Dec/01/93 |
| 109 | Report | 1.00 d | Dec/02/93 | Dec/02/93 |
| 110 | Phase II | 21.00 d | Dec/10/93 | Jan/07/94 |
| 111 | Mix 1 | 21.00 d | Dec/10/93 | Jan/07/94 |
| 112 | Mix | 1.00 d | Dec/10/93 | Dec/10/93 |
| 113 | Analize geotechnical | 3.00 d | Dec/13/93 | Dec/15/93 |
| 114 | Analyze / confirmatio | 20.00 d | Dec/13/93 | Jan/07/94 |
| 115 | Report | 1.00 d | Dec/16/93 | Dec/16/93 |
| 116 | Mix 2 | 20.00 d | Dec/10/93 | Jan/06/94 |
| 117 | Mix | 1.00 d | Dec/10/93 | Dec/10/93 |
| 118 | Analyze geotechnical | 3.00 d | Dec/10/93 | Dec/14/93 |
| 119 | Analyze / confirmatio | 20.00 d | Dec/10/93 | Jan/06/94 |
| 120 | Report | 1.00 d | Dec/15/93 | Dec/15/93 |
| 121 | Mix 3 | 21.00 d | Dec/10/93 | Jan/07/94 |
| 122 | Mix | 1.00 d | Dec/10/93 | Dec/10/93 |
| 123 | Analize geotechnical | 3.00 d | Dec/13/93 | Dec/15/93 |
| 124 | Analyze / confirmatio | 20.00 d | Dec/13/93 | Jan/07/94 |
| 125 | Report | 1.00 d | Dec/16/93 | Dec/16/93 |
| 126 | Study B Final Report | 20.00 d | Dec/27/93 | Jan/24/94 |

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# 5.0 PROJECT REPORTING AND DOCUMENTATION

Project reporting and documentation will be required throughout the Treatability Study process. Project reporting will be the responsibility of the laboratory performing the study. This section will identify the minimal requirements for project reporting and documentation.

## 5.1 STUDY A (REPORTING)

Study A consists of two Phases (I and II). Reporting for Study A consists of both 24 hour verbal and telefax result documentation. Reporting of results will be required throughout the treatability study process. It will be necessary for the contract laboratory to provide results of analysis at all junctures in the treatability study (i.e. completion of all mixes, rounds, and phases).

### 5.1.1 Study A/Phase I

Phase I consists of three rounds. Each round will be performed on a mix with a constant line sludge to flyash ratio. Each round will analyze this ratio with different additives. Phase I mixes will be tested for: optimum moisture content, pH, Atterberg Limits, TCLP Metals + pH, Consolidation, and Permeability. At the conclusion of the Proctor Testing, the results will be relayed verbally and through telefax to the FERMCO Project Engineer within 24 hours of testing completion. Within 24 hours of the completion of the laboratory analysis for each mix, the results of the analysis will be relayed verbally and through telefax to the FERMCO Project Engineer.

### 5.1.2 Study B/Phase II

Phase II consists of two options each containing three mixes. One of these two options will be selected for Phase II development of operating ranges for field implementation. Phase II mixes will be tested for: pH, Atterberg Limits, Consolidation, and Permeability. In addition, Phase II mixes will be tested for chemical confirmation/verification. Confirmation testing will include analysis of samples for TCLP metals + pH and TCLP HSL parameters. Within 24 hours of the completion of analysis for each mix, results will be relayed verbally and through telefax to the FERMCO Project Manager. Within two weeks of the completion of Phase II, formal documentation of the results will be submitted to the FERMCO Project Manager.

## 5.2 STUDY B (REPORTING)

Study B consists of three Phases (I, II, and III). Phase I contains three mixes (1, 2, and 3), Phase II contains five mixes (1 through 5), and Phase III contains three mixes (1, 2, and 3). Reporting for Study B will consist of both 24 hour verbal results and telefax documentation. Reporting of results will be required throughout the treatability study process. It will be necessary for the contract laboratory to provide results of analysis at all junctures in the treatability study (i.e. completion of all mixes, rounds, and phases).

### 5.2.1 Study B/Phase I

Phase I of Study B contains three mixes with varying percentages of cement additive. Phase I mixes will be tested for Unconfined Compressive Strength (UCS). Within 24 hours of the completion of analysis for each mix, results will be relayed verbally and through telefax to the FERMCO Project Engineer.

### 5.2.2 Study B/Phase II

Phase II contains five mixes. Phase II will utilize center point ratios for water to pozzolan and waste to pozzolan determined in previous studies, and will vary each of these ratios. These mixes will be tested for: UCS, TCLP metals + pH, and Bulk Density. Within 24 hours of the completion of analysis for each mix, results will be relayed verbally and through telefax to the FERMCO Project Engineer.

### 5.2.3 Study B/Phase III

Phase III contains three mixes. Phase III mixes will utilize the best mix from Phase II and will vary the water to pozzolan ratio at an increased waste to pozzolan ratio in order to develop operating ranges for field implementation. Phase III mixes will be tested for: UCS and chemical confirmation/verification. Chemical confirmation testing includes TCLP metals + pH and TCLP HSL parameters. Within 24 hours of the completion of analysis for each mix, results will be relayed verbally and through telefax to the FERMCO Project Engineer.

## 5.3 STATUS REPORTS

In addition to the above reporting requirements, weekly status reports will be submitted to the FERMCO Project Manager and Project Engineer. These reports shall include the following information:

1. Status of ongoing work including any schedule concerns.

2. Results of completed work and suggestions for upcoming work.

3. Modifications and variations to methods.

4. Key personnel changes.

5. Schedule of work to be completed in the upcoming week.

6. Observations of testing as required by FERMCO (e.g., observation of how material behaves during Atterberg Limit Test.)

These reports are to be submitted by 12:00 PM on Fridays to allow for review by the FERMCO Project Manager.

## 5.4 FINAL REPORTING

At the conclusion of Study A and Study B, final reporting and documentation will be required. Within one month of the conclusion of each study the contract laboratory will be responsible for providing a complete package of results to the FERMCO Project Manager. This package must include the following information:

1. Original, signed copies of analytical data suitable for data validation requirements.

2. A report summarizing the results of the treatability study, which must also include all modifications and variations of methods described within this document.

3. Conclusions and recommendations for field implementation of the treatment process.