Shieldalloy Metallurgical Corporation

Cambridge, Ohio

West Pile Decommissioning Plan

ENSR Consulting and Engineering

(Formerly ERT)

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Document Number 5990-001-200

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1. INTRODUCTION

This document describes the decommissioning plan for the West Pile of the Shieldalloy Metallurgical Corporation facility at Cambridge, Ohio. Shieldalloy is submitting this document in order to obtain approval for decommissioning of licensed material in accordance with 10 CFR § 20.302.

The plan is being submitted as a supplement to the Decontamination and Decommissioning Plan dated November 1987, Document No. G277-200. A separate plan for decommissioning the East Pile will be submitted.

1.1 Site Description

In June 1987, the Shieldalloy Metallurgical Corporation (Shieldalloy) acquired the Foote Mineral facility near Cambridge, Ohio, midway between Columbus, Ohio, and Pittsburgh, Pennsylvania. Currently, ferrovanadium alloys and vanadium chemicals are manufactured at the site from materials brought in by rail or truck.

The Decontamination and Decommissioning Plan, document G277-200, contains a large amount of reference data on the facility, and, in order to limit the size of this document, all of these data are not reproduced here. Specific relevant details are quoted for the convenience of the reader, and reference should be made as appropriate to the more complete information in the document G277-200.

1.2 Background

Shieldalloy currently holds U.S. Nuclear Regulatory Commission (NRC) license SMB-1507, issued on May 29, 1987, for the facility. This license applies to the possession of slags containing uranium and thorium at the facility. The document G277-200 was prepared following the conditions of the license SMB-1507. Documentation on licenses held by predecessors to Shieldalloy is contained in Appendix I of document G277-200.

NRC responded to the document G277-200 with a letter dated July 27, 1988. Enclosed with this letter was a survey report of the Cambridge facility prepared by Oak Ridge Associated Universities (ORAU), along with a list of items prepared by NRC to be addressed by Shieldalloy. In April 1989, Shieldalloy submitted a document entitled "Radiological Characterization Plan," document no. 5990-001-225C, which responded to these items. Those items of relevance to the West Pile Decommissioning Plan are discussed in Section 2.1, and the subsequent radiological characterization is reported in Section 2.2 below.

Regulations affecting the facility, other than those administered by the NRC, are addressed in the document G277-200. Communications to date have involved the Ohio Environmental Protection Agency, the Ohio Department of Public Health, the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency. The potential involvement of agencies other than NRC is further discussed in Section 2.4.

1.3 Current Site Status

The decommissioning of the West Pile is part of a comprehensive program of work planned for the Cambridge site. The overall objective was to identify and excavate mislocated radioactive slag at the facility, placing the material on the West and East Slag Piles; delicense the remainder of the site; and subsequently to decommission the West and East Piles in place.

The characterization and decontamination program described in the documents G277-200 and 5990-001-225C has been completed. The excavated materials from the decontamination program that were destined for placement on the West Pile are now in this location. Documentation reporting on the site decontamination has been separately reported to the NRC in document no. 5990-001-230, January 1990 entitled Decontamination Report, License SMB-1507.

In conjunction with the decontamination program, a cover material is being generated for the West Pile utilizing existing baghouse dust emanating from the ferrovanadium production operations. This low permeability cover material, as previously reported in the documents mentioned, results from the chemical treatment of the dust. A geotextile biobarrier is being laid on top of the treated material, upon which a silty sand layer is being added to provide interim protection against erosion. This work will be completed by March 1990.

2. SLAG PILE CHARACTERIZATION AND SELECTED DECOMMISSIONING APPROACH

2.1 Action Items from NRC Response to Decontamination and Decommissioning Plan

Several of the items identified by NRC in the attachment to the letter of July 27, 1988 (see Section 1.2) are relevant to the decommissioning of the West Pile. These items are listed below.

2.1.1 Item 1: Radiological Characterization of East and West Piles

Shieldalloy, as indicated in the Radiological Characterization Plan of April 1989, responded to this item by performing a statistically valid sampling and analysis program to determine the predominant isotopic activity levels present in the East, West and Grainal Piles. This program has been implemented and was reported to NRC in the letter from ENSR Consulting and Engineering dated July 10, 1989 (see Appendix A). The results of this program are discussed in Section 2.2 below.

2.1.2 Item 3: Disposal Option for Contaminated Slag

The action indicated in response to this item is the characterization program indicated in Section 2.1.1.

2.1.3 Item 4: Onsite Disposal in Floodplain Area

Floodplain data was included in the Radiological Characterization Plan. A more complete analysis of the floodplain issue, including the engineering features of the decommissioning design that address that issue, is described in Section 3.

2.1.4 Item 6: Analytical Techniques

A split sampling program was included in the characterization plan, whereby the duplicate samples were submitted to Oak Ridge Associated Universities (ORAU) for independent analysis. ORAU has reported to NRC by a letter dated August 15, 1989 on the results of their analysis (see Appendix B). The results of this analysis are discussed in Section 2.2.

2.2 Radiological Characterization of the West Pile

The West Pile as it now exists consists of the original pile, i.e., the pile as it existed before commencement of the decontamination activities, the excavated materials from the decontamination program, and cover material. Characterization of these three elements of the pile is addressed below.

Background activities in the area were measured (see Appendix A) as follows :

- Th-232 1.5 pCi/gm
- U-238 1.7 pCi/gm
- Ra-226 1.5 pCi/gm

2.2.1 Original Pile

In accordance with the action items arising out of the NRC response discussed in Section 2.1, a comprehensive radiological characterization of the West, East and Grainal Piles was conducted. The work was performed following the Radiological Characterization Plan, and was reported to NRC by the ENSR Consulting and Engineering letter of July 10, 1989 (see Appendix A). For the West Pile, 30 samples were collected for analysis. Duplicate samples were collected at every fifth sampling location, and sent to the ORAU. The analytical methodology followed for the 30 samples is described in the

July 10 letter. This work was performed before excavated material from decontamination activities was placed on the West Pile.

The results of the West Pile characterization are shown in Table 2-1.

As noted in the July 10 letter, the relatively large standard deviation observed in the results is not considered to arise from any deficiency in the sampling method, or from collection of an insufficient number of samples, but rather from the inhomogeneity of the pile.

The results of the analysis performed by ORAU were reported to NRC in a letter dated August 15, 1989 (see Appendix B). Those duplicate samples that pertain to the West Pile have been indicated in Appendix B. ORAU compared the results of the ENSR and ORAU analyses. As noted by ORAU, there is general agreement between the ORAU and ENSR data.

2.2.2 Excavated Material

Representative samples of material excavated from each of the areas subject to decontamination were composited and analyzed using the procedures followed for the West Pile characterization. The results of the analysis are shown in Table 2-2. The laboratory analytical results are contained in Appendix C. The amount of material excavated from each of the areas is also shown in the table. These amounts have been used to "weight" the respective activities and calculate mean activity values.

2.2.3 Cover Materials

The total amount of cover materials added or planned to be added to the West Pile is shown in Table 2-3. The activity of the ferrovanadium dust to be used, after treatment, as a cover material was found to be below background (see Appendix D). The remaining materials to be used are basically of natural,

TABLE 2-1

WEST PILE CHARACTERIZATION RESULTS

(PRIOR TO ADDITION OF EXCAVATED MATERIAL)

	Th-232	U-238	Ra-226
Highest Value pCi/gm	3.1 ± 0.2	13 ± 1	8.5 ± 0.2
Lowest Value pCi/gm	0.4 ± 0.1	0.9 ± 0.2	0.5 ± 0.1
Mean Value and Standard Deviation pCi/gm	1.4 ± 1.52	3.00 ± 2.00	2.38 ± 2.15

TABLE 2-2

EXCAVATED MATERIAL CHARACTERIZATION RESULTS

pCi/gm

	Th-232	U-238	Ra-226	Amount Excavated (tons)
Area E	1.6 ± 0.4	14 ± 1	30 ± 3	6,700
Area F	180 ± 10	3.8 ± 0.5	20 ± 2	2,200
Area G	0.3 ± 0.3	2.1 ± 0.2	6.3 ± 0.3	5,890
Area H	100 ± 10	180 ± 10	18 ± 2	25,290
Area I	30 ± 3	31 ± 1	62 ± 6	69,750
Area J	130 ± 10	18 ± 1	66 ± 7	5,210
Area K	1 ± 0.2	2.1 ± 0.2	3.1 ± 0.2	6,580
Area L	28 ± 3	35 ± 3	23 ± 2	3,540
Area M	1.0 ± 0.5	68 ± 3	68 ± 7	890
Area O	2.0 ± 1	35 ± 1	27 ± 2	13,500
Total Amount Excavated				139,550
Weighted Mean Value	42	54	42	

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TABLE 2-3

QUANTITY OF COVER MATERIALS

Treated Ferrovanadium Dust/Clay	75,100 tons
Silty Sand	18,900 tons
Riprap	4,000 tons
Topsoil	12,600 tons
<u>Total</u>	<u>110,600 tons</u>

mainly local, origin. Therefore, the conservative assumption is made that the average activity of the cover material is equal to background.

2.2.4 Combined West Pile

The mean activity of the three radionuclides for the present pile, i.e. the "original" pile plus the excavated and cover materials, can be calculated. The material quantity estimates are as follows:

The quantity of material contained in the original pile (as reported by ENSR in the July 10, 1989 letter, Appendix A):

- 282,000 tons

The quantity of excavated material placed on the West Pile from the decontamination activities:

- 139,550 tons

The amount of cover materials (see Table 2-3):

- 110,600 tons

The quantity of material in the total combined pile is therefore:

- 532,150 tons

Weighting the results under Sections 2.2.1, 2.2.2 and 2.2.3 according to these respective quantities, as shown in Table 2-4, gives final adjusted mean activity values for the combined pile as follows:

TABLE 2-4

WEIGHTED ACTIVITY VALUES

	Material Quantity (tons)	% of Total	Th-232 pCi/gm	U-238 pCi/gm	Ra-226 pCi/gm
Original Pile	282,000	0.53	1.4	3.0	2.38
Excavated Material	139,550	0.26	42	54	42
Cover Materials	110,600	0.21	1.5	1.7	1.5
Total	532,150				
Mean Activities (incl. background)			12	16	12.5
Mean Activities (above background)			10.5	14.3	11

- Th-232 12 pCi/gm
- U-238 16 pCi/gm
- Ra-226 12.5 pCi/gm

These values represent total activity including background.

Activity levels of the identified radionuclides in the West Pile, above background, are:

- Th-232 10.5 pCi/gm
- U-238 14.3 pCi/gm
- Ra-226 11 pCi/gm.

These results are used to develop the total activities for natural thorium and uranium as follows:

Total activity (above background) of Th-232

= 10.5 pCi/gm

Total activity (above background) of natural thorium (Th-232 + Th-228)

= 21 pCi/gm

assuming that Th-232 is in secular equilibrium with its daughters.

Total activity (above background) of U-238

= 14.3 pCi/gm

Total activity (above background) of natural uranium (U-238 + U-234)

= 28.6 Ci/gm

assuming that U-238 is in secular equilibrium with its daughters.

The adjusted mean activity value above background for Ra-226 is 11 pCi/gm which is 77% of the U-238 value.

2.3 Selected Decommissioning Approach

In the Decontamination and Decommissioning Plan, document G277-200, the advantages and disadvantages of various decommissioning options were reviewed. The West Pile option selected was in-situ decommissioning. In the light of the characterization results presented in Section 2.2, the approach can be more precisely stated as in-situ decommissioning in a manner which will allow for future unrestricted use of the property.

An evaluation is made in Section 3.5 of the extent of radiological risk to persons exposed at the surface or in the vicinity of the in-situ decommissioning site. Consideration is given to gamma radiation dose, to lung exposure to radon and to the risk of radioactive particulates and radionuclides in solution in ground and surface water. It is concluded that the engineered facility for in-situ decommissioning provides adequate protection to reduce the radiological risks defined above to negligible levels. Consideration is also given to the radiological consequences of accidental intrusion into the slag. This is concluded to be a low probability risk with small and acceptable radiological detriment.

Therefore, Shieldalloy concludes that the decommissioning plan presented in Section 3 allows for future unrestricted use of the property.

2.4 Regulatory Involvement of Other Agencies

The Decontamination and Decommissioning Plan, document G277-200, was submitted to the Ohio Environmental Protection Agency (OEPA) for informational purposes. The letter received in response, noting OEPA concurrence with the plan, is shown in Appendix E.

Contact has also been established with the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency. For correspondence relating to these agencies, refer to Appendix F.

3. DECOMMISSIONING PLAN

3.1 Site Characteristics

3.1.1 Existing Conditions

3.1.1.1 Geography

The Shieldalloy Metallurgical Corporation Cambridge Plant is located in Guernsey County, Ohio, midway between the towns of Cambridge and Byesville. The site covers 130 acres, at an average altitude of 793 ft above mean sea level. In the early 1950's the plant was developed adjacent to Route 209. To the north and east of the facility are open lands, lowlands, several residences, and an interstate interchange with resultant development. A Conrail right-of-way is located approximately 400 ft northeast of the raw material storage building. Another railroad spur runs between the East Slag Pile and the Pilot Plant. More open lands, lowlands, and an industrial park are located to the west of the property. Inactive surface mines, open lands, a country club, and two schools are located to the south of the property. A small, intermittently used, coal processing and storage plant is located east from the main plant facilities.

The communities of Cambridge and Byesville have approximate populations of 12,000 and 3,500 persons, respectively. There are an estimated 200 inhabitants living within one-mile of the facility. The facility location is shown in Figure 3-1.

3.1.1.2 Local Geology

The Cambridge Plant is located in the unglaciated region of eastern Ohio. The regional geology is characterized by generally northeast striking, gently southeast dipping Cambrian rocks. The facility lies within the Wills Creek Valley.

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FIGURE 3-1
FACILITY LOCATION
SHIELDALLOY METALLURGICAL CORP.
CAMBRIDGE, OHIO PLANT

DRAWN BY:	DATE:	PROJECT NO.
KLU	12/89	5990-001

The bedrock geology of this area has been mapped as the Pottsville and Allegheny Formations in the Wills Creek Valley and the Conemaugh Formation in the uplands. All three formations consist of coal, sandstone, shale, and limestone in varying proportions. The occurrence of coal is evidenced by the presence of surface mines on the hillsides in the area.

The geology at the Cambridge Plant Site is characterized by unconsolidated sediments overlying bedrock. Geologic logs from on-site monitoring wells indicate that the valley fill material beneath the facility ranges in thickness from less than 20 ft to over 70 ft. The alluvial fill material consists primarily of silts and clays with some sand lenses at depth.

Stratigraphic cross-section alignments are indicated on the plant facility map in Figure 3-2. These were developed to illustrate the geology under the slag piles. Cross-section A-A' (Figure 3-3) follows a northwest-southeast transect near the edges of the West and East Slag Piles. Cross-section B-B' (Figure 3-4) follows a southwest-northeast transect.

The three boring logs (MW11, MW12, and MW13) used to construct cross-section A-A' indicate a clay layer extending from the surface to a depth of 8 feet. This clay layer can be correlated laterally to each boring log. The clays were described in the boring logs as medium-stiff to very-stiff. Underlying the clay layer are alternating layers of silt, silty clay, and clayey silt. In addition, thin (one foot or less) lenses of sand to silty sand were noted in several borings. These lenses were very local in occurrence and did not exhibit lateral continuity and cannot be correlated. Boring log results from other wells are not inconsistent with this description.

Soil permeability tests at the site were conducted by Engineering Science in 1981 (see Appendix B of the Decontamination and Decommissioning Plan, Document G277-200). The soil samples were obtained at depths ranging from 3.5 to 11.0 feet during installation of monitoring wells and consisted primarily of clayey silt or silty sand. The permeability values range from 0.16×10^{-7} cm/sec to 49.1×10^{-7} cm/sec.

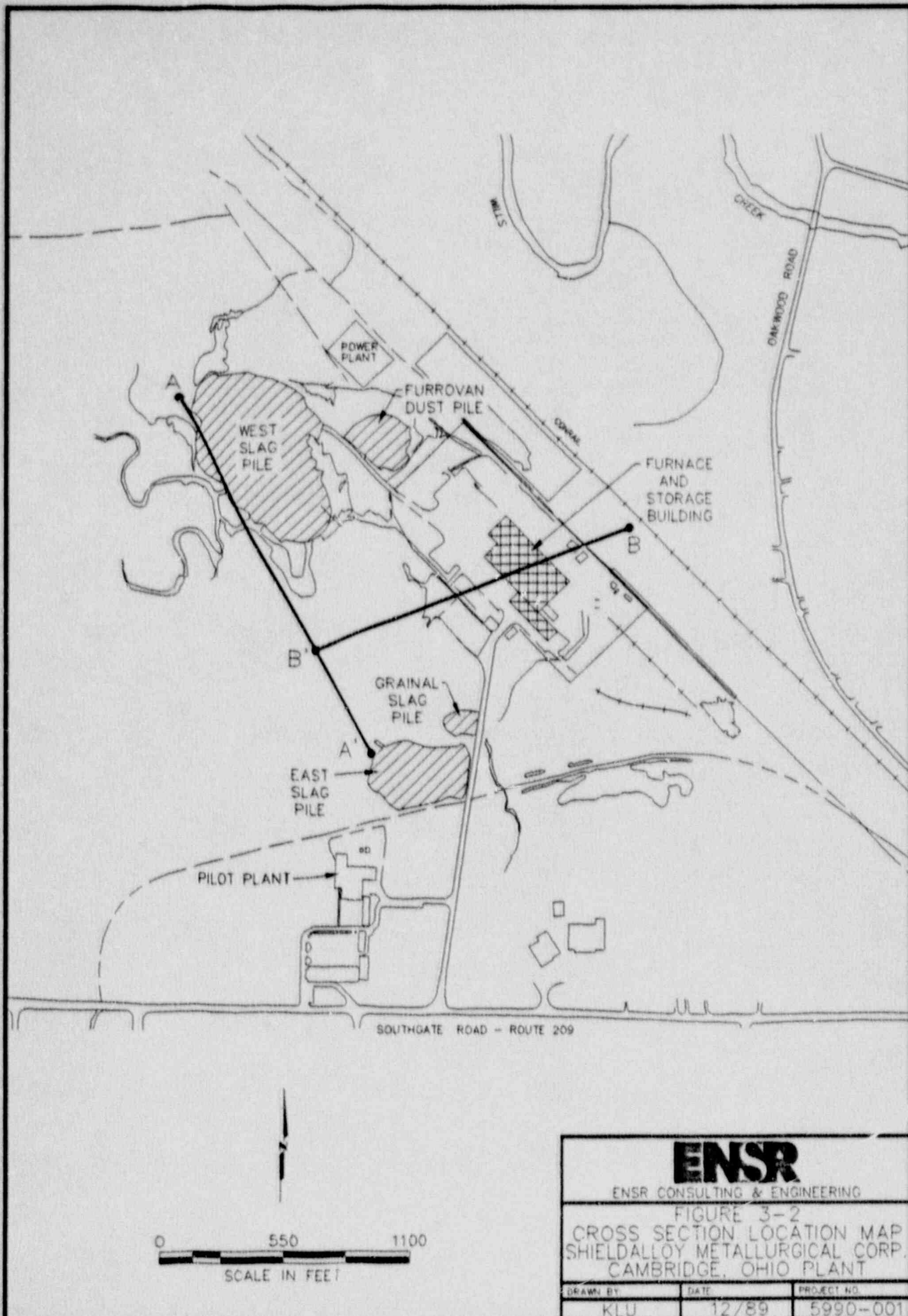
POWER PLANT
FURROVAN DUST PILE
WEST SLAG PILE
FURNACE AND STORAGE BUILDING
GRAINAL SLAG PILE
EAST SLAG PILE
PILOT PLANT
A
A'
B
B'
CREEK
OAKWOOD ROAD
CONRAIL
SOUTHGATE ROAD - ROUTE 209
0
550
1100
SCALE IN FEET
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FIGURE 3-2
CROSS SECTION LOCATION MAP
SHIELDALLOY METALLURGICAL CORP.
CAMBRIDGE, OHIO PLANT
DRAWN BY
KLU
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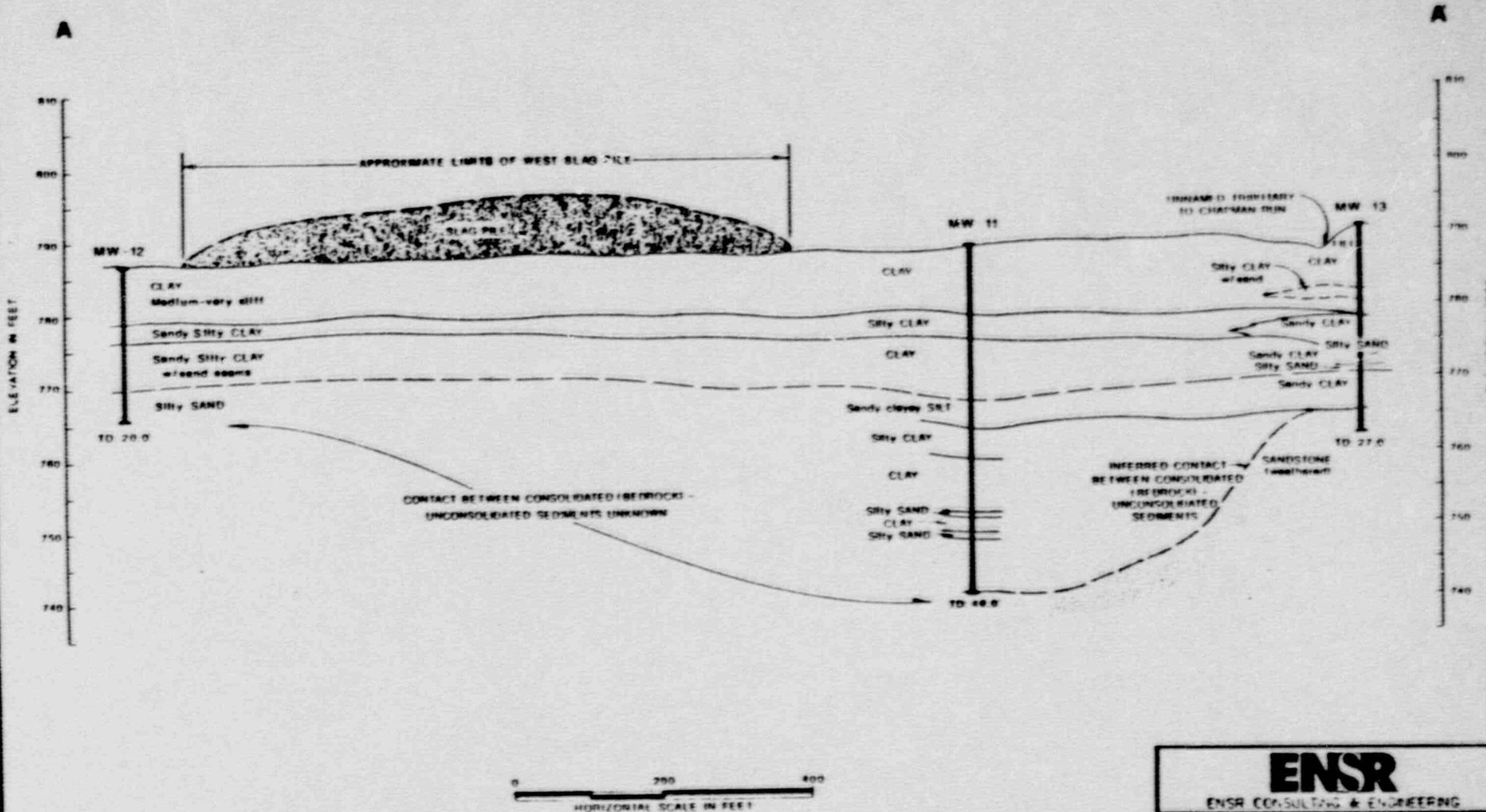

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FIGURE 3-3
CROSS SECTION A-A'
SHIELDALLOY METALLURGICAL CORP
CAMBRIDGE PLANT

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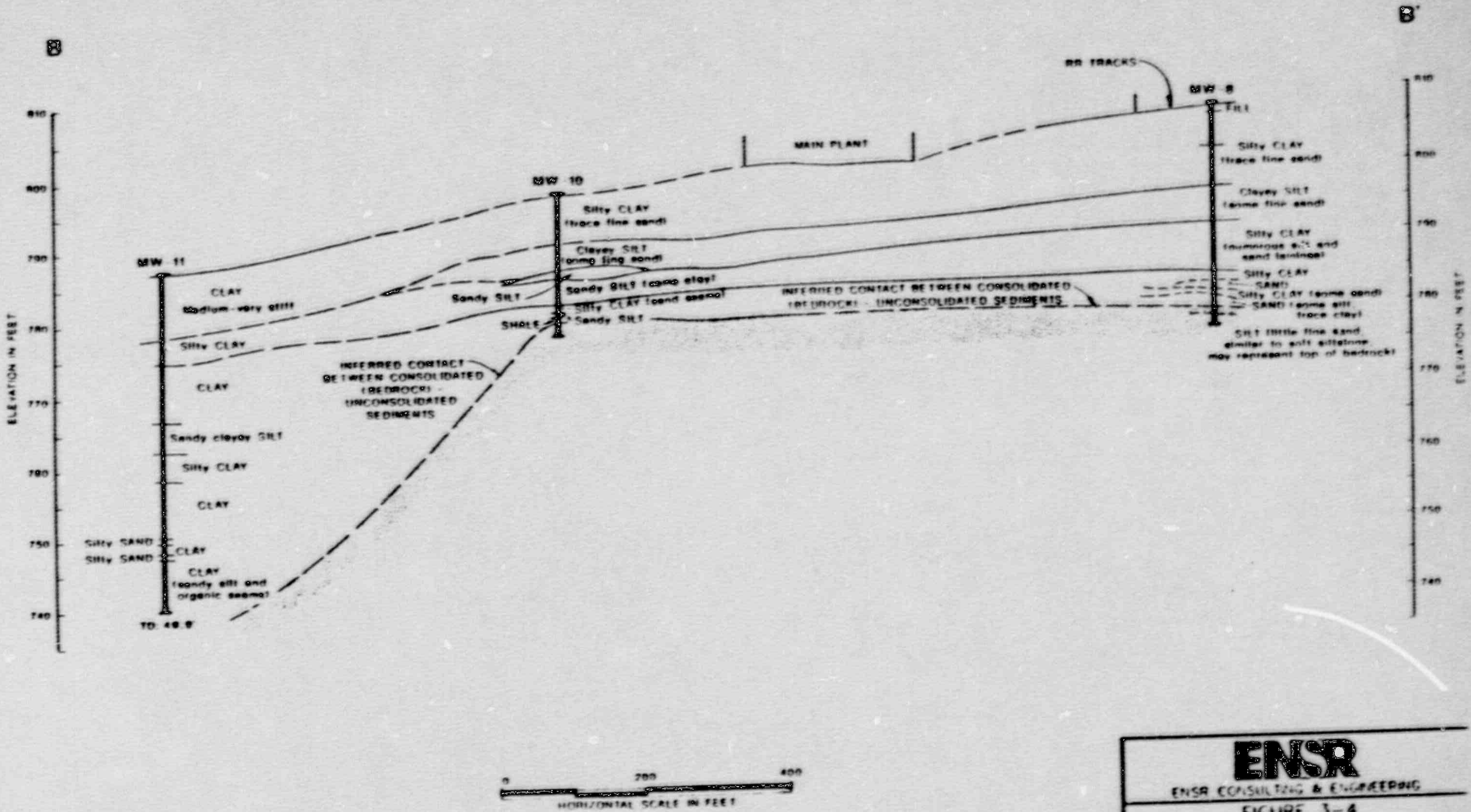

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FIGURE 3-4
CROSS SECTION B-B'
SHIELDALLOY METALLURGICAL CORP
CAMBRIDGE PLANT

DRAWN BY	DATE	PROJECT NO
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3.1.1.3 Surface Water

For the most part, the site was developed on the Wills Creek floodplain, hence the topography is generally flat. A U.S. Geological Survey topographic map of the facility is shown in Figure 3-1. The facility is bordered to the east by Wills Creek and to the west by Chapman Run. Surface drainage from these streams flows northward relative to the site.

The Byesville POTW, a secondary wastewater treatment facility, discharges to Wills Creek to the south of the Shieldalloy facility. To the north of the facility, Wills Creek is used as the potable water supply for the City of Cambridge.

Chapman Run is a meandering stream that bounds the western portion of the site. This stream flows through a low area located on the northwest portion of the site. Chapman Run and Wills Creek join roughly one-half mile northwest of the facility.

Stormwater at the site is collected in storm drains and is conveyed via a drainage ditch, located in the northeast section of the facility, to an intermittent stream. The unnamed stream flows from southeast to northwest and joins Chapman Run. Stormwater flowing overland is also collected by the intermittent stream and eventually conveyed to Chapman Run. A small railroad pond is located on the northern edge of the site. There is no record of flooding interfering with plant operations.

Surface water quality data is contained in Appendices C and E of the Decontamination and Decommissioning Plan, Document G277-200. The surface water results reveal no gross-alpha activity above detectable limits.

Surface sediments associated with the surface water samples were below detectable limits for gross-alpha except for one sample which was not significantly above the detectable limit.

3.1.1.4 Ground Water

In the area of the Shieldalloy site, a total of 14 monitoring wells have been installed to define ground water quality and flow directions. One of these wells (MW5) has been installed in the deep (bedrock) aquifer to a depth of 140 feet. The other monitoring wells range in depth from 14.5 to 45 feet. Based on the available boring logs, a "shallow" water-bearing zone exists in the silty sand, sand, and sandy silt layers.

Based on ground water level measurements taken on May 19-20, 1987, the ground water in the plant area appears to be flowing generally from east to west, towards Chapman Run and its unnamed tributary.

Monitoring wells MW1 through MW4 were installed in 1981 and wells MW5 through MW14 were installed in 1987. Wells MW1 through MW4 were not installed in accordance with recent policy and guidance on monitoring well construction. Ohio EPA has instructed Shieldalloy to disregard results from these wells as being unrepresentative. Appendix B of the Document G277-200 contains summarized ground water quality data to date for all currently existing monitoring wells starting with well MW5. Gross-alpha concentrations were below EPA drinking water standards of 15 pCi/l in all wells.

Two primary factors that could potentially affect the migration of any radioactive species into ground water are solubility and mobilization. EP Toxicity tests have been conducted on the slags and the solubility of these species was found to be so low that potential migration of soluble species is not a concern.

Data collected to date have been reviewed to determine if conditions are such that radioactive species could be mobilized. Tested waters were found to be within the range of 6.2 to 7.0 pH. At those levels, uranium and thorium compounds would not be aggressively dissolved. No evidence of complexing agents in ground water, which could mobilize radioactive species, has been found.

In summary, ground water quality measurements to date have shown no recognizable impact by radioactive compounds nor have data been found which show that alpha radioactive species at the site are being significantly mobilized.

3.1.1.5 Climatology

Cambridge is located in an area of changeable weather. Air masses from central and northwest Canada frequently invade the region. The tropical Gulf masses often reach central Ohio during the summer and to a much lesser extent in the fall and winter. Occasional weather changes are brought about by cool outbreaks from the Hudson Bay region of Canada, especially during the spring months. At infrequent intervals, the general circulation will bring showers or snow to the region from the Atlantic.

The records show a high frequency of calm or very low wind speeds during the late evenings and early morning hours. The rolling landscape is conducive to air drainage. Air drainage takes place at an average velocity of 4 mph in the winter and spring and 2 mph in the summer and fall. Predominant wind direction is to the northeast.

Although Cambridge does not have a "wet" or "dry" season as such, the month of October has a higher frequency of dry days than any other month and therefore comes closest to providing a normal dry period. Precipitation averages 39 inches per year, of which approximately 2-3/4 inches accumulate as snow fall (approximately 28 inches).

Temperatures are generally moderate, with values ranging from a mean of 87°F in the summer to a mean of 23°F in the winter. The average date of the last freezing temperature in the spring occurs in the first week of May and the average date of the first freezing temperature in the fall occurs in the second week of October.

3.1.1.6 Flood Hazard

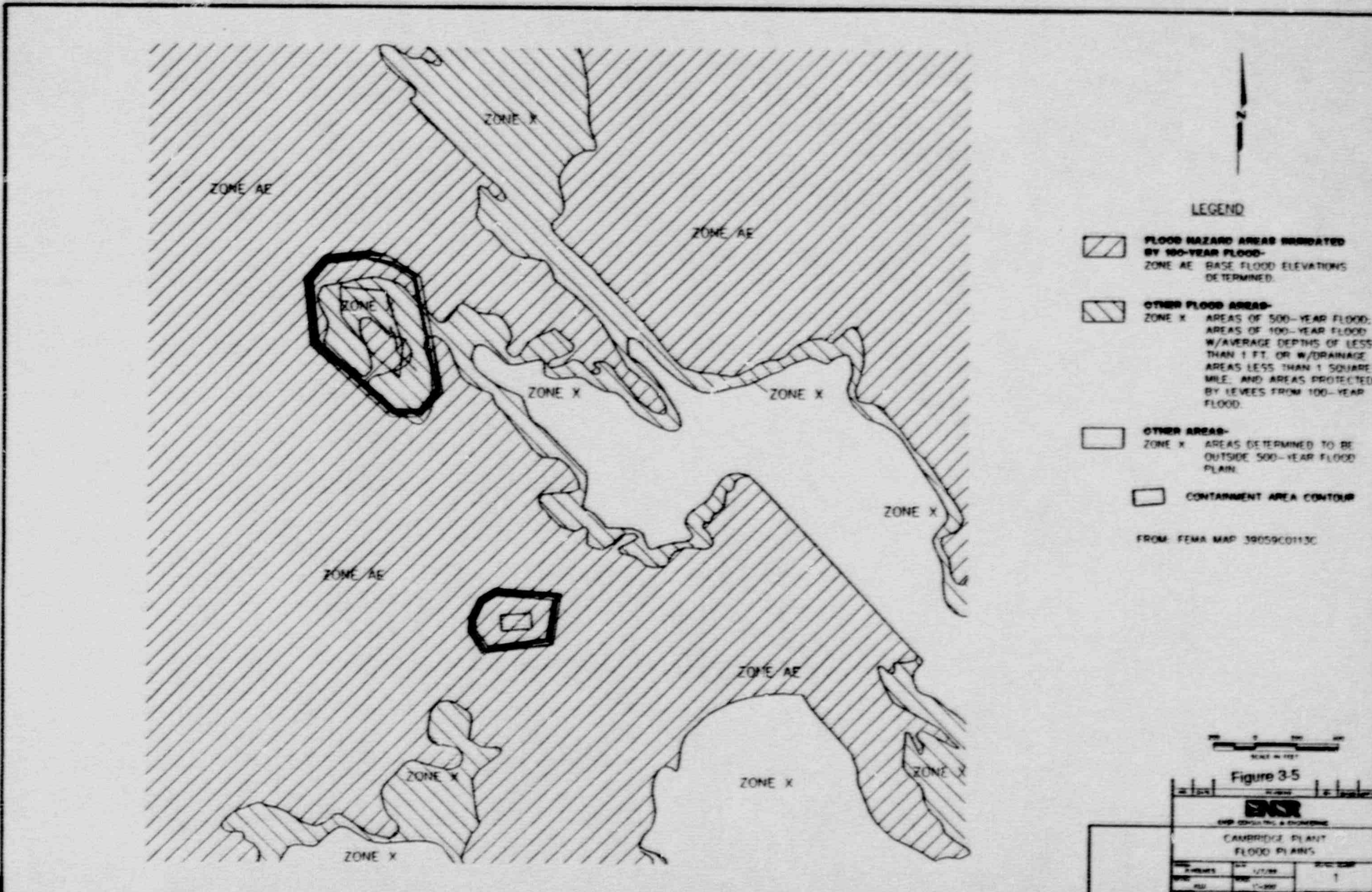
No structural damage to the pile nor any migration of radioactive slags is anticipated from a 100-year flood event. Any damage would be expected to be superficial and limited to the vegetative and clay cover. This could be rectified without significant radiological risk.

Approximately 90 percent of the perimeter of the West Pile is within the 100-year flood hazard area. According to the Flood Insurance Rate Map for Guernsey County, Ohio and Incorporated Areas, Panel 94, and 113 of 207 dated February 17, 1989, the West Pile is essentially within zone AE where base 100-year flood elevations have been determined. The pile itself is designated as Zone X, considered to be a 500-year flood area. The site is not adjacent to a Zone AE floodway. Figure 3-5 indicates the location of the West Pile within a flood hazard area map of the vicinity.

The nearest measured 100-year flood elevations are located at distances varying from 1,600 feet to 7,200 feet in a north, south, southwest and southeast direction. All of the nearest 100-year flood elevations are elevation 800 feet (NGVD). The predominant ground surface elevation around the West Pile is elevation 785 feet and represents slightly more than one-half of the pile perimeter. Therefore, a worst-case situation in a 100-year flood event would be a rise of 15 feet in water level to elevation 800 feet. For purposes of the decommissioning plan, the pile is not within a floodway and would not be subjected to erosion by currents.

3.1.1.7 Earthquake Hazard

An evaluation of the various sources of earthquake hazard information dating back to the 1800's indicates that the site area is seismically inactive for all practical purposes, and does not threaten the stability of the covered and closed pile.


N
ZONE AE
ZONE X
ZONE AE
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ZONE X
ZONE X
LEGEND
FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD-
ZONE AE BASE FLOOD ELEVATIONS DETERMINED.
OTHER FLOOD AREAS-
ZONE X AREAS OF 500-YEAR FLOOD; AREAS OF 100-YEAR FLOOD W/AVERAGE DEPTHS OF LESS THAN 1 FT. OR W/DRAINAGE AREAS LESS THAN 1 SQUARE MILE, AND AREAS PROTECTED BY LEVEES FROM 100-YEAR FLOOD.
OTHER AREAS-
ZONE X AREAS DETERMINED TO BE OUTSIDE 500-YEAR FLOOD PLAIN.
CONTAINMENT AREA CONTOUR
FROM: FEMA MAP 39059C0113C
ENSR
CAMBRIDGE PLANT
FLOOD PLAINS
1

Figure 3-5

Existing and available historical and current earthquake activity maps and documents have been obtained and evaluated to determine the probability of earthquake damage to the covered and secured West Pile. The Shieldalloy site is within the Appalachian Plateau which is characterized by very low seismicity. The nearest zone of significant seismic activity is within a northeast-southwest subsidence zone extending from Arkansas to Attica, New York passing through northwestern Ohio. The site is in the southeastern section of Ohio. The seismic frequency in the site area is estimated to be four per 100,000 square kilometers between the years of 1800 and 1972. The nearest active zone is the Anna area in northwestern Ohio where the frequency is 16 per 100,000 square kilometers.

The site is within a "VI" seismic zone as an indicator of maximum probable distant intensity. Zone VI on the Modified Mercalli Intensity Scale means that an earthquake event would be felt by all with slight damage in poorly built buildings, which is the maximum probable local intensity within a IV to VI range. The IV designation means that the earthquake would be less intense than V or VI, with it being felt by many as vibration like that of a passing loaded truck.

A general seismic risk map for conterminous United States, published by the Ohio Department of Natural Resources indicates that the damage risk for most of Ohio is "minor" with a potential for "moderate" in the western part of the state. As stated, the site is located in Southeastern Ohio.

3.1.2 Facility Description

The Vanadium Corporation of America began operations at the present Cambridge site in 1953 with a single electric furnace followed by the addition of chemical manufacturing operations and a chemical laboratory in 1956. In 1970, Foote Mineral (Newmont Mining) merged with the Vanadium Corporation of America. Shieldalloy acquired the facility in 1987, and manufactures ferrovanadium alloys and vanadium chemicals for use by the steel industry, a principal customer.

The facility operates 3 shifts per day, 5 days per week, and currently employs 90 persons. Thus, the Cambridge Plant is a major regional employer, making significant contributions to the economy of the region.

The production of ferrovanadium alloys ultimately results in two products, the alloy of commercial value and the slags. A more detailed review of the facility processes and slag generation is given in the Decontamination and Decommissioning Plan, Document G277-200. The processes that gave rise to the source material in the West Slag Pile are no longer in operation at the Cambridge plant.

3.1.3 Land Use Considerations

Land in the area of the Shieldalloy Cambridge plant is used for industrial and commercial purposes, with a few residential properties in the vicinity. The property in the vicinity is expected to remain industrial in nature for the foreseeable future. A major portion of the land around the plant lies in a flood plain. As a result, much of the available land already has been developed.

There are two industrial parks within the local area. They are the I70/I77 Industrial Park and the Byesville Industrial Park. The Colgate Palmolive Company operates a facility in the industrial area near the Shieldalloy plant. Approximately 200 residents live within one mile of the plant, most being beyond one-half mile.

3.1.4 Inventory of Pile Material

The processing of columbite ore or pyrochlore to make ferrocolumbium alloy* at the Cambridge plant was conducted from approximately 1962 to 1972, and the source of naturally occurring radioactivity in the slag piles is principally from this activity. The columbite ore contains minor quantities (discussed below) of natural thorium and uranium.

In this process, the feeds to the columbite reduction process were columbite ore (oxides of columbium, tantalum, tungsten, titanium, zirconium, uranium, and thorium), lime, fluorspar, iron, and aluminum. The product was a ferrocolumbian alloy, a button from detinning, and a $5CaO.3Al_2O_3$ slag matrix that also contained the unreduced, minor constituent metals in the columbite. This slag is not unlike spinel (also known as magnesium aluminate, $MgO.Al_2O_3$) which is a dense, hard, glass-like mineral. The process is carried out in an electric furnace with iron, in some instances, being the reductant for the tin contaminant, followed by aluminum being the reductant for the columbium. At metallurgical processing conditions, the oxygen activities (concentration) for the various oxides, ordered from highest to lowest potential, are: tin oxide (SnO), iron oxide (FeO), Niobium oxide (NbO), aluminum oxide (Al_2O_3), uranium oxide (UO_2), and thorium oxide (ThO_2). Since aluminum is reducing the niobium and the niobium oxide and the aluminum is found in the equilibrium with aluminum oxide, the uranium and thorium elements are not reduced to metallic form. Therefore, the uranium and thorium stay as oxides and are retained with the slag.

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*Niobium is the currently recognized name for columbium.

Dimensions of the slag piles, with resultant volumetrics, were estimated from 1:600 scale, 1-foot contour interval topographic mapping. The mapping was developed from stereographic models generated with aerial photography taken in October 1987. Plainmetric ground control was established with third order survey for the vertical axis and third order survey for the horizontal axis. Volumes were obtained using end-area averaging methods. Toe of slag pile limits were determined by changes in grade. Additional confirmation of slag pile limits were made visually by overlying topographic mapping on orthographic air photos of identical scale. The light-colored, barren surface of the slag piles provides a marked contrast to surrounding soils and vegetation, thereby ensuring a high degree of confidence in photo identification. The West Slag Pile represents an area of about 7.6 acres.

Between 1962 and 1970 all slags including the radioactive materials were sent to the East Slag Pile. Only detinning metal buttons, which contains quantities of the pyrochlore ore-lime melt, were known to be sent to the West Pile. These metal buttons could be radioactive because the ore-lime material included in the buttons can contain uranium and thorium oxides. No other known radioactive material was sent to the West Pile.

The average fractional composition of uranium and thorium in the West Pile was calculated to be 5.1×10^{-7} and 1.3×10^{-5} by weight, respectively (see Document No. G277-200). This is prior to addition of excavated materials from the 1989 decontamination activities.

3.2 Pile Configuration

3.2.1 Existing Condition

Prior to on-site excavation and filling remediation activities performed during the summer and fall of 1989, the slag pile configuration was characterized by steep slopes rising to approximately 20 feet above the surrounding ground surface. The slopes, consisting of sand size to boulder size angular hard slag fragments, were relatively steep varying from about 45° (1H:1V) to about 27° (2H:1V). These slopes have now been regraded to contours described in Section 3.2.2.

It is understood that the slag was dumped loosely on relatively soft wet clay. Most of the slag has been in place for 15 or more years. Typically, the slag would have superficially penetrated the soft clay and eventually settled and stabilized. The typical natural angle of repose for hard broken rock is 38° (1.3H:1V) which indicates that the slopes would be stable at angle less than 38°, and unstable at a steeper slopes, such as 45°.

Material excavated in the course of the decontamination program has been placed and compacted in the center of the West Pile.

It is apparent that the slag pile has stabilized with the weight of the slag acting as a surcharge on the underlying clay. There is no visual appearance of cracking or differential settlement on the pile surface. It is probable that whatever significant settlement that would occur due to surcharging would have occurred within the last 15 years. Therefore, it is reasonable to conclude that the pile is stable in its present condition.

3.2.2 Final Design Conditions

The criteria, rationale, and design information for the design conditions are explained in detail in this section. The completed and covered West Pile will blend well with surrounding topography. The overall shape will be somewhat "egg-shaped" with smooth rounded sides. The side slopes will be 33° (3H:1V) with an erosion control bench about 20 feet above the surrounding base topography. The side slopes then continue a further 12 feet in vertical elevation at a 3H:1V slope, and the surface will then slope upwards to the center at a slight angle of approximately 3 percent. The shape of the completed pile will drain precipitation in all directions, much like a small uniformly rounded hill.

The slope base will be protected from seasonal flooding and erosion with a rip-rap base. The rest of the pile will be covered with grass and legumes. Engineering Drawings Nos. 1-7 enclosed with this document illustrate the engineering design. Drawing No. 7 presents the final pile configuration representing moderate side slopes, a stable fill, and a low slope angle to the center to accommodate drainage. The final pile lateral limits will not encroach upon the flood plain any further than the original pile limits.

The design drawings, and the above description, represent the pile configuration as it was planned prior to completion of the decontamination activities. Due to the quantity of excavated material, the contours of the upper surface have been modified to allow for a 4H:1V slope with no significant modification to the overall shape or height of the pile. On completion of the decommissioning activities, an engineering drawing showing the completed pile configuration will be prepared and submitted to NRC along with the documentation described in Section 4.2.

3.3 Pile Cover Design

3.3.1 Design Criteria

The criteria developed for the pile cover were based on five major considerations which are as follows:

- Environmental - flood protection, radiological shielding, non-contact with humans and animals, avoidance of flood plains.

- Engineering - ease of construction, conformance to typical design standards for embankments and landfill covers, long-term stability, ease of maintenance, seismic risk.
- Economic - minimizing material handling, using locally available soil materials, utilization of treated ferrovanadium dust as part of the final cover, low maintenance vegetation.
- Construction Risk - ability to perform slope treatment without major risk to machinery and workers, avoidance of flood plains.
- Aesthetic - final topographic expression conforming to surrounding moderately sloped landforms, thick uniform vegetation.

From these considerations, the following guideline criteria were developed for the pile covering operation.

- Provide slope base protection (rip-rap) against seasonal fluctuations in water level in adjacent flood plain.
- Provide stable final slope from the toe of slope to at least elevation 800 ft (100-year flood elevation).
- Require a minimum thickness of three feet of very low permeability material over slag to minimize rainfall infiltration into slag and to provide radiological shielding. Such a cover will extend from within the clay surrounding and beneath the completed pile.
- Minimize the potential risk of intrusion, and thereby exposure to humans and animals, by placement of at least 4 ft of total cover materials over the slag, and adding a buried warning tape.
- Design the pile slopes to a commonly accepted angle (3 horizontal to 1 vertical). This allows heavy machinery to operate for construction and maintenance

in order to minimize slag pile slope cutting, and leaves a slope adequate for long-term vegetation with little or no maintenance.

- Design the final surface on top of the pile to a grade (3 percent) that will permit rainfall to flow off the covered pile slowly in all directions, and minimize the potential for erosion.
- Provide a geotextile barrier to stop volunteer brush and tree roots that may otherwise penetrate the low permeability layer.
- Provide a growing medium on the surface (9" topsoil or loam) for hardy non-woody vegetation species. The seeding mix will be a legume/grass combination conforming to recommendations by the USDA Soil Conservation Service for that specific area.
- Utilize locally available soil and rock materials for the final cover.
- Protect adjacent flood plains by avoiding all excavations and filling beyond the present pile edge.
- Install a silt fence to prevent sediment from the construction activities from flowing into flood plain.
- Provide an erosion control bench in the final slope for at least every 20 feet in elevation to minimize the potential for erosion.
- Provide an intermediate soil zone between the growing medium (topsoil) and the low permeability layer. Such a zone will allow a small percentage of rainfall infiltration to contact the clay or clay-like material to keep the material damp and minimize shrinkage cracking. The zone will also hold some moisture for use by the vegetation and yet allow excess moisture to drain. Such a material nearly duplicates the typical naturally occurring soil horizon beneath undisturbed wooded or meadow areas.
- Minimize excavation of slag.

3.3.2 Material Selection and Function

A review and analysis of the design criteria, an on-site analysis of existing conditions, a survey of local construction materials, and the overall design and closure goals indicated that ten naturally occurring and man-made materials are needed for the pile closure. Table 3-1 presents a list of the materials to be utilized with their key physical characteristics. The table also provides a brief description of the function each material has in the overall pile closure. All of the materials listed are permanent non-degradable materials except the silt fence. The silt fence will deteriorate within one or two years, but its primary function is for short-term erosion protection during and immediately following construction. Once the vegetation becomes well established within a year or two, the silt fence will not be needed. The grass and legume species selected are low maintenance varieties and are self-sustaining.

Drawings No. 2 through 5 graphically present the use and location of each of the materials described above.

Technical specifications for each of the materials, except for the treated ferrovanadium dust (referred to as "Chemfix® material"), have been prepared and are presented in Appendix G. For each specification the acceptable material characteristics are described, with a description of how each material will be placed or installed. These specifications will be used to purchase and place or install each material in accordance with the appropriate drawings.

Appendix G contains detailed descriptions of the following materials:

Geotextile fabric - Section 1

TABLE 3-1

CLOSURE MATERIALS

Material	Key Physical Characteristics	Function
Chemfix® Material	On-site processed ferrovan dust chemically combined with fixation agents to provide a low permeable clay-silt like material (see Note).	Beneficial use of ferovan dust in a chemically stable condition to prevent rain fall infiltration, act as radiation shielding, and minimize the risk of intrusion of slag.
Clay	Inorganic clay of low to high plasticity and very low permeability.	Prevent rainfall infiltration from penetrating slag and act as radiation shielding, also to minimize the risk of intrusion of slag.
Geotextile	Polypropylene woven fabric.	Prevent root penetration into clay/Chemfix® material, prevent silty sand from mixing with clay/Chemfix® material, provide structural strength for sand/topsoil overlying clay/Chemfix® material.
Silty Sand	Sound durable natural fine to medium sand with silt.	Transition between topsoil and clay/Chemfix® material. Moderate water retention for vegetation and clay/Chemfix® material dampening, allows excess water to drain.
Topsoil/Loam	Natural soil containing at least 2.75% organic matter.	Growing medium for vegetation.
Grass/Legumes	Hardy grass and legume seeds capable of withstanding drought and flooding.	Provide low, non-woody vegetation to preclude soil erosion following establishment. Also to provide a permanent feature blending with surrounding vegetative areas.

Note: The Chemfix® material proprietary process is based on the use of soluble silicates and silicious setting agents including cement, kiln dust and fly ash. The combination and proportions of reagents are specific to each waste treated and end-product characteristics desired. The two-part inorganic chemical system reacts with polyvalent-metal ions to produce a chemically and physically stable solid material having a friable texture similar to those of a clay-type soil.

TABLE 3-1 (Continued)

Material	Key Physical Characteristics	Function
Crushed Stone	Processed and graded durable aggregate.	Stabilize the slope base and act as a transition between the finer sand/topsoil and the original ground.
Riprap	Screened durable crushed rock fragments.	Prevent erosion of slope base due to seasonal flooding.
Silt Fence	Polypropylene filter fabric attached to stakes driven into underlying soil.	Prevent silt-laden rainfall runoff from leaving slope base.
Warning Tape	Vinyl covered worded warning tape	Warn individuals who inadvertently dig through topsoil that low-level radioactive slag is located below.

Final Cover - Section 2

- clay
- sand
- riprap
- crushed stone

Topsoil - Section 3

Seeding and Erosion Control - Section 4

- seeding
- silt fence

Buried Warning Tape - Section 5

Appendix H contains test data on material samples evaluated for use in the decommissioning program. Chemfix® is a proprietary process and is not described in this report as a technical specification. Generic characteristics of Chemfix® material are presented in Table 3-1. Tests on the material produced to date have shown permeabilities in the approximate range of 10^{-6} to 10^{-8} cm/sec, averaging well below 10^{-6} cm/sec. EP Toxicity tests have all shown negative results.

3.3.3 Cover Configuration

The final soil cover, previously described, forms the permanent barrier between the slag, contaminated soil from the plant site, and the environment. Thick naturally occurring clay underlies the site and the slope base will be keyed into the underlying clay with compacted clay as shown in the drawings. The pile will be covered with compacted clay and/or Chemfix® material. Clay will predominate on the side slopes. The clay or Chemfix® material will be at least 3 ft in thickness in its compacted state. The clay will be covered with a polypropylene filter fabric (geotextile) and pinned. The geotextile will then be covered with at least 12 in. in thickness of loosely placed silty sand and the warning tape indicating presence of radioactive materials. The graded silty sand will then be covered with at least 9 in. in thickness of topsoil or loam. The complete cover thickness will be at least 4 ft 9 in. Vegetation will then be established on the surface with a hardy grass and legume seed, fertilizer, and mulch mix. The mix design is based on the U.S.D.A. Soil Conservation Service guidelines and recommendations for Ohio. The vegetative species, as described in detail in Appendix G (Specifications) are for permanent vegetation establishment in critical areas, and require minimal maintenance. Drawing No. 4 presents the cover configuration in graphical terms.

3.4 Construction Operations

3.4.1 Impacts of Construction Operations

3.4.1.1 Public Health Impacts

The construction operations will have no impact on public health. The average airborne activity levels recorded during the decontamina[illegible] program were well below the limits established fo[illegible] respective radionuclides in 10 CFR Part 20. The [illegible]mmissioning program will entail no significant r[illegible]tion of slag materials. Slag relocation during the [illegible]amination phase resulted in insignificant radiological risk to the public (see submitted document No. 5990-001-230, December 1989).

3.4.1.2 Ecological Impacts

The decommissioning activities will not result in any encroachment of the flood plain areas bordering the West Pile. The described method of development of final pile contours will not result in an increase of the footprint of the pile on any part of the perimeter bordering the flood plain. The operations of keying into the clay subsurface and removal of slag material beyond the key have been designed to avoid disturbance of the flood plain. Precautions also include the provision of a silt fence to prevent runoff.

3.4.2 Protection of Worker Health and Safety

A Health and Safety Program will be established for the implementation of the decommissioning plan. This program will be based on the Health and Safety Plan utilized for the decontamination work. This involves:

- personnel training in accordance with the OSHA standards of 29 CFR 1910.120;
- personnel monitoring using thermoluminescent dosimeter badges;
- air monitoring;
- personnel protective equipment, including the availability of air purifying respirators
- decontamination procedures for personnel protective equipment;
- action levels to reduce exposure based on the limits of 10 CFR Part 20.

The Health and Safety Plan will be approved by a Certified Health Physicist, who will retain overall responsibility for worker health and safety at the site.

Based on the experience of the decontamination program, no hazards are anticipated to be present during the decommissioning process that would impact worker health and safety.

3.4.3 Phasing of Operations

In conjunction with the decontamination activities, it was necessary to reshape the outer slope of the slag pile. The slag pile was cut back to a 3-horizontal to 1-vertical slope with a hydraulic excavator and bulldozer. At the same time, a 15 ft bench along the toe of the slag pile was constructed (see Detail A, Step 1, Drawing 4). All construction activities associated with reshaping the slope were performed without encroachment into the flood plain area.

Simultaneously with the reshaping of the slag pile, the center surface area of the pile was being raised. This was done using the slag cut from the reshaping of the slope and the material excavated as part of the decontamination work performed elsewhere at the Shieldalloy site. The slag and soil material were placed in accordance with the design plans (see Cross-Sections, Drawing No. 3).

Treated ferrovanadium dust (Chemfix® material) was pumped from the processing area to the West Pile. On the West Pile, 60 foot x 100 foot bermed areas were created with clean compacted clay soil. The side walls of the berms are 5 ft high. The Chemfix® material was pumped into these bermed areas in a layer at least 3 ft thick.

After the Chemfix® material has cured and passed the quality control tests (see Section 3.4.5) it will be covered with the filter fabric (geotextile). The filter fabric will be factory fabricated into large panel sections (approximately 30 ft x 300 ft) which will be placed with light equipment and by hand over the cured Chemfix® material. The 12-in. silty sand layer (see Detail C, Drawing No. 4) will then be placed over the fabric filter. The sand will be dumped and spread by equipment travelling progressively over the sand and not travelling directly on the fabric filter and Chemfix® material.

The above interim measures render the pile in a stable condition for execution of the decommissioning program upon regulatory approval. Operations will begin with slope treatment procedures. These operations can begin only after the surface water level in the flood plain area has receded from winter rains and snowmelt and the potential for spring floods has passed.

The first operation to be performed will be excavating slag from the toe of the pile and then placing the clay "key" at the toe of the slag pile. This operation is shown as Step 2 of Detail A on Drawing No. 4. The clay key will be compacted in place with the bucket of the hydraulic excavator to seal the key into the existing soft clay of the flood plain. After the clay key is placed, any remaining slag on the outer side of the key will be excavated (Step 3, Detail A, Drawing 4). This slag, as well as that excavated from the key trench will be placed between the toe of the slag pile and the pile side of the key and compacted.

In conjunction with the placement of the clay in the key trench, clay will be placed and compacted on the slag pile slope (see Step 5, Detail A, Drawing No. 4). These operations are to be performed together so the clay layers in the key trench and those of the slope can be joined together to form an impermeable seal over the slag. After the clay layer is placed over the slope, the geotextile fabric will be placed down the slope and over the key trench and extended at least 6 feet into the flood plain (see Step 5, Detail D, Drawing No. 4). Placing the geotextile in the flood plain will provide a base for the stone riprap that will be placed in a later operation. The sand layer over the geotextile will be completed, and the warning tape will be fixed in position in a gridded pattern over the sand layer. The topsoil layer will then be placed on top of the sand and warning tape.

Riprap will be placed at the base of the pile up to the first bench. The slopes will be seeded and mulched according to the specifications outlined in Technical Specification 4 (Appendix G) within 48 hours of placement of the topsoil.

After the final cover has been placed on the slopes of the pile, final cover operations will begin on the top of the pile. Those areas covered in the fall with Chemfix® material, geotextile, and sand will be inspected for any damage caused by the winter and repaired. In particular, erosion of the sand layer will be repaired to ensure a sufficient cover

over the Chemfix® material. Spreading of the topsoil and seeding and mulching in accordance with Technical Specification 4 will complete the decommissioning operations of the West Pile.

3.4.4 Equipment Decontamination

Standard Operating Procedures (SOPs) will govern the survey of equipment used in the decommissioning program, and decontamination of equipment where action levels are exceeded. These SOPs will be the same as those followed for the decontamination program (see document No. 5990-001-230 dated January 1990). Equipment will be surveyed for direct and transferable alpha contamination, and the survey will be repeated as necessary until the equipment is within the specified limit. The limits specified are:

for fixed contamination:

- 5×10^{-3} μCi/cm^2 for alpha emitters, and

for smearable contamination:

- 1×10^{-3} μCi/cm^2 for alpha emitters.

These levels are based on the NRC document "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for Byproduct, Source, or Special Nuclear Material."

3.4.5 Quality Assurance/Auditing

To ensure that implementation of the decommissioning activities proceed in accordance with the design plans, a quality assurance/auditing program will be instituted as part of the construction activities. Such a program has been in place for the placement of the Chemfix® material.

Technical specifications for the pile cover materials are provided in Appendix G. The objective of this program is to verify the coverage, material type, permeability and placement of the various materials used to decommission the West Pile. This program will be accomplished by a variety of means including visual observation, laboratory analysis and field testing. Table 3-2 describes the auditing program for each of the materials used.

3.5 Radiological Impact of Decommissioned Pile

3.5.1 Exposure Rate Impact

Exposure rate measurements of the West Pile were made following the reshaping of the pile and placement of the excavated material on the pile. Measurements were taken at 10 cm and 1 m above the surface. This measurement program is reported in Appendix I. The average exposure rate value, including background, is 15.3 μR/hr at 10 cm above the surface, and 14.7 μR/hr at 1 m above the surface. The recorded background exposure rate is 11 μR/hr. The average exposure rate at 10 cm above the surface of the pile is therefore only 39 percent above background.

The effect of shielding is calculated in Table 3-3. The minimum attenuation of exposure rate is shown to be greater than 10^5. This factor is applied to the exposure rate at 10 cm above the surface of the slag materials to give the expected exposure rate at the exterior of the pile, with cover in place, due to the activity of the original pile and excavated material. The result is a computed exposure rate of less than 1.5×10^{-4} μR/hr, an insignificant level in comparison with background.

The treated ferrovanadium baghouse dust (Chemfix® material) contains certain non-licensable materials (i.e. not source materials) that exhibit low levels of natural radioactivity. Prior to treatment, an exposure rate survey of

TABLE 3-2

QUALITY ASSURANCE MEASURES

Material	Factor To Be Inspected	Method of Inspection
Clay	Soil type	Grain size analysis - conformance with specifications Collect and analyze one sample per 2,000 cubic yards placed.
	Coverage	Visual observation, conformance with design plans
	Placement	Visual observation, grade stakes, conformance with specifications
Sand	Soil type	Grain size analysis, conformance with specifications Collect and analyze one sample per 2,000 cubic yards placed.
	Coverage	Visual observation, conformance with design plans
	Thickness	Visual observation; grade stakes
Rip Rap	Material Type	Visual observation; sieve analysis, conformance with specifications Collect and analyze one sample per 2,000 cubic yards placed.
	Placement	Visual observation, grade stakes conformance with specifications
Topsoil	Soil Type	Visual observation, analysis for pH, organic content, sieve analysis. Four representative samples to be analyzed before delivery. Conformance with specifications.
	Coverage	Visual observation, conformance with design plans
	Placement	Visual observation, grade stakes conformance with specification

TABLE 3-2 (Continued)

QUALITY ASSURANCE MEASURES

Material	Factor To Be Inspected	Method of Inspection
Geotextile	Material Type	Manufacturer's certification, conformance with specification.
	Coverage	Visual observation, conformance with design plans
	Placement	Visual observation, conformance with specifications

TABLE 3-3

SHIELDING CALCULATIONS FOR ADDED COVER

(9 in. LOAM, 1 ft SILTY SAND, AND 3 ft CLAY)

	Thorium (Natural)	Uranium (Natural)
Covering material	SiO_2	SiO_2)
Mean photon energy (KeV)[a]	8.80E+02	8.10E+02
Attenuation coefficient (CM**2/G)[b]	6.80E-02	7.00E-02
Thickness (ft)	4.75E+00	4.75E+00
Thickness (cm)	1.45E+02	1.45E+02
Density (G/CM**3)	1.65E+00	1.65E+00
Exponential argument (negative)	1.62E+01	1.67E+01
Buildup factor (water assumed)[b]	4.52E+01	5.40E+01
Dose reduction multiplier	4.16E-06	3.09E-06

(a)Beck, H.L. The Physics of Environmental Gamma Radiation Fields, NTIS CONF-720805-P-1.

(b)Radiological Health Handbook. U.S. Department of Health, Education, and Welfare. January 1970.

Note: Covering the slag with soil will reduce the gamma ray flux associated with the Uranium 232 radioactive decay chains. The ratio of the shielded flux to the unshielded flux, D_R (dose reduction factor), is given by the following equation:

$$D_R = B_F \exp(-\alpha\ d\ x)$$

where

x = thickness of the soil (cm)
d = density of the soil (g/cm^3)
α = attenuation coefficient (cm^2/g)
B_F = buildup factor

TABLE 3-3 (Continued)

Note: (Continued)

The attenuation coefficient is a function of the gamma ray energy and the type of material. The intensity weighted gamma ray energies are 880 and 810 KeV for the Thorium 232 and Uranium 238 chains, respectively. Attenuation coefficients were selected for silicon dioxide. There is not a significant variation between the attentuation coefficients for the other constituent elements of the soil. In fact, the attentuation coefficients for pure magnesium and aluminum are slightly lower than the coefficient for silicon dioxide.

The buildup factor accounts for the fact that some fraction of the scattered primary gamma rays find their way back into the beam due to multiple scattering. Of the 5 substances listed in Reference (b) (water, iron, tin, lead and uranium) the highest buildup factors were for water. These buildup factors were used in the calculation of the dose reduction factor for soil. The buildup factor is a function of the gamma ray energy and the product (α.d.x).

the ferrovanadium dust pile was carried out. The survey results approximate the exposure rate which will be experienced from similar material on a semi-infinite plane, i.e., when used as a cover material on the West Pile. The results of this survey are contained in Appendix D. The average exposure rate value, including background, is 6.6 μR/hr at 1 m above the surface. The effect of shielding by the layers above the treated dust is calculated and the result is shown in Table 3-4. A conservative attenuation factor is 10. This factor is applied to the measured exposure rate to give the expected maximum exposure rate at the exterior of the pile, with cover in place, due to the activity of the treated cover material. The result is an exposure rate of 0.66 μR/hr. This is an insignificant level in comparison with natural background. The natural activity exhibited by the silty sand and soil cover materials is expected to exceed this value. In consequence, the gamma exposure rate at the surface of the completed pile will not be significantly in excess of the natural background for the area.

Exposure risks resulting from accidental intrusion are considered to be minimal. The probability of accidental intrusion as far as, or into, the impermeable layer, is very low. This alone would not result in any impact. In order for the exposure rate to exceed the background level, nearly all of the impermeable layer would need to be penetrated and removed. This would require the extremely unlikely excavation of over 5 feet of material, plus the biological barrier, over a significant area. An identifying tape is being provided on top of the sand layer to alert other parties of the presence of radioactive materials. The warning tape is 6 in. wide vinyl film tape printed with the words "Caution, Low-Level Radioactive Slag Buried Below", and also bears the international radiation symbol between each group of words. The tape is resistant to acids and alkalis. This warning tape will be buried beneath the 9 in. layer of topsoil in a grid pattern across the entire pile. In the very unlikely event

TABLE 3-4

SHIELDING CALCULATIONS FOR ADDED COVER

(9 in. LOAM PLUS 1 ft SILTY SAND

	Thorium (Natural)	Uranium (Natural)
Covering material	SiO_2	SiO_2)
Mean photon energy (KeV)[a]	8.80E+02	8.10E+02
Attenuation coefficient (C.**2/G)[b]	6.80E-02	7.00E-02
Thickness (ft)	1.75E+00	1.75E+00
Thickness (cm)	5.33E+01	5.33E+01
Density (G/CM**3)	1.44E+00	1.44E+00
Exponential argument (negative)	5.23E+00	5.39E+00
Buildup factor (water assumed)[b]	9.83E+00	1.09E+01
Dose reduction multiplier	5.24E-02	5.00E-02

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[a] Beck, H.L. The Physics of Environmental Gamma Radiation Fields, NTIS CONF-720805-P-1.

[b] Radiological Health Handbook. U.S. Department of Health, Education, and Welfare. January 1970.

Note: Covering the slag with soil will reduce the gamma ray flux associated with the Uranium 232 radioactive decay chains. The ratio of the shielded flux to the unshielded flux, D_R (dose reduction factor), is given by the following equation:

$$D_R = B_F \exp(-\alpha\ d\ x)$$

where

x = thickness of the soil (cm)

d = density of the soil (g/cm^3)

α = attenuation coefficient (cm^2/g)

B_F = buildup factor

Note: (Continued)

The attenuation coefficient is a function of the gamma ray energy and the type of material. The intensity weighted gamma ray energies are 880 and 810 KeV for the Thorium 232 and Uranium 238 chains, respectively. Attenuation coefficients were selected for silicon dioxide. There is not a significant variation between the attentuation coefficients for the other constituent elements of the soil. In fact, the attentuation coefficients for pure magnesium and aluminum are slightly lower than the coefficient for silicon dioxide.

The buildup factor accounts for the fact that some fraction of the scattered primary gamma rays find their way back into the beam due to multiple scattering. Of the 5 substances listed in Reference (b) (water, iron, tin, lead and uranium) the highest buildup factors were for water. These buildup factors were used in the calculation of the dose reduction factor for soil. The buildup factor is a function of the gamma ray energy and the product (α.d.x).

that this warning is completely ignored, the exposure rate experienced would be not significantly greater than background, and comparable with the exposure rate experienced due to background sources in some parts of the country.

3.5.2 Direct and Indirect Pathway Impact

The natural thorium and uranium containing materials are tightly bound within the hard rock-like slag material. This material is not susceptible to powdering, and therefore airborne particulate generation, and subsequent exposure, is not considered to be a factor. No significant airborne activity levels were found during the decontamination activities, see Section 3.4.1. The presence of the cover will eliminate even this minimal pathway.

The potential for ingestion of contaminated food crops is considered to be minimal. Shieldalloy has no intention to plant or harvest crops on the West Pile. Even if such crops were grown, the purpose of the geotextile biobarrier is to prevent roots from extending into the slag material. The insolubility of the slag will further limit the take up of radionuclides by biological systems.

Measurements of the flux of radon from the pile were made before addition of cover materials. These results were utilized to evaluate the potential hazard from exposure at the surface and in the unlikely event of accidental intrusion. The radiological risk is shown in both circumstances to be small. These results are presented in Appendix J.

Minimal potential for leaching has been found to exist for this material which has successfully undergone EP Toxicity tests (see document G277-200). The capping of the pile with a low permeability layer will eliminate both the potential for leachate generation and contaminant pathways. The potential activity levels arising from indirect pathways will be far below background.

4. COMPLETION OF DECOMMISSIONING

4.1 Radiological Survey

As described in the Radiological Characterization Plan, Document 5990-001-225C, a 10-meter grid was established at the site for the characterization activities. Using this established site reference grid, an exposure rate survey will be conducted of the pile upon completion of the decommissioning work. The exposure rate measurements will be conducted in accordance with a Standard Operating Procedure using a gamma scintillation probe attached to a ratemeter, cross-calibrated with a pressurized ion chamber. Measurements will be taken over 10 meter intervals within 1 meter of the perimeter of the pile, and at the grid intersection points on the pile. A representative number of measurements will also be taken adjacent to the pile to determine the potential for exposure. The results will be tabulated and included in a report on the decommissioning plan implementation for submission to NRC.

4.2 Completion Certification

On completion of the planned site activities, including the radiological survey, the field notes, laboratory data and other documentation will undergo a final review and an inspection will be conducted of the completed cover in accordance with the Post-Decommissioning inspection plan described in Section 4.5. Subsequently, a summary report will be prepared describing the plan implementation and certifying completion. This report and certification will be submitted to NRC, along with a request of release of this area from control under the license.

4.3 Ground Water/Surface Water Monitoring Plan

4.3.1 Introduction

Sections 3.1.1.2, 3.1.1.3 and 3.1.1.4 describe the hydrogeological conditions in the West Pile area. The data indicates that ground and surface water flow is in a general East to West direction toward Chapman's Run. The ground water data further suggests that there are two modes of occurrence. Ground water occurs in the upper clayey deposits consisting of clay, sandy silty clay with sand seams from ground surface to about 40 feet below ground surface. Borings completed by others also indicate that the clay deposits extend to at least 70 feet or more below surface. For determining long term ground water quality trends related to pile closure, a shallow and a deep monitoring well will be installed and maintained at two down-gradient and two upgradient locations near the outer edges of the pile. Drawing No. 2 indicates the location of the monitor wells. A shallow monitor well at a depth of 20 feet and a deeper well at 70 feet will be installed at each of the four locations. The shallow well would indicate the changes in water quality in the upper saturated zone where the greatest quality impact would be revealed. The deeper well would provide a basis of comparison for the impact of thick clay underlying the pile and its effectiveness in containing constituents of concern.

Surface water in the West Pile area flows via intermittent and permanent creeks adjacent to the pile on the west, south and east sides. These creeks flow easterly toward the meandering Chapmans Run. Surface water leaving the West Pile vicinity by creeks and ditches flows to a central point on the west side of the pile. This location will be a surface water sampling point, as shown on Drawing No. 2. Also, a second sampling station is proposed for the southern end of the pile as shown on Drawing No. 2. Locations were not only selected for representation of conditions, but also for accessibility by sampling personnel. It is recognized that the locations for the surface water monitoring stations are within soft wet clay in flood plain areas where access by machine and sampling personnel is difficult and precarious unless major bridging structures are constructed. Therefore, the selected locations are placed as close to a stable ground surface as possible. However, it may be necessary for a small short bridge-type structure to be constructed for sampling personnel to reach the surface water monitoring station.

The water quality parameters of concern are identified as pH, gross-alpha and gross-beta activity.

4.3.2 Responsibilities

Shieldalloy Metallurgical Corporation, as the owner, will perform the sampling and analysis program. A copy of the plan will be kept at the Cambridge plant. The program will include the following:

- engaging a qualified well driller or boring contractor to install the monitor wells;
- selecting a qualified representative to inspect the installation of the monitor wells.
- sampling, analysis, and evaluation of ground and surface water samples;
- maintaining all records of the monitoring program;
- certification of monitor well installations.

4.3.3 Monitor Well and Surface Water Sampling Locations

Drawing No. 2 indicates the location of the four ground water monitor well locations (MW). The locations were determined by an evaluation of the ground water condition described in this document. A shallow (20 ft) and a deep (70 ft) monitor well will be constructed at each location. Two surface water sampling stations are also shown.

4.3.4 Monitor Well Construction

The monitor well construction details are as follows:

- Using conventional well drilling or boring equipment, develop a boring hole at least 8 inches in diameter using auger, casing, or mud drilling techniques to a depth of 20 feet below ground surface for the shallow monitor wells and 70 feet for the deep wells. Standard soil sampling techniques will be utilized to classify soil types and prepare a driller's log. Soil samples will normally be obtained by driving a standard 1-3/8" I.D. split spoon sampler 18 inches into undisturbed soil, using a 140 lb hammer falling 30 inches. Samples will be obtained at the ground surface and at 5-foot vertical intervals to the bottom of the boring.
- The driller and/or inspector will prepare a log of the subsurface conditions and well construction details.
- When the bottom of the boring is reached, any existing wash water in the casing will be evacuated. A base layer of clean coarse sand or pea gravel will be placed at the bottom and will be not less than 6 inches in thickness.
- A capped 4 in. I.D. PVC well screen, 10 feet in length, will be placed in the cased hole and attached to solid 4 in. I.D. PVC pipe to the top of the hole and extending not more than 2 feet above the ground surface. Joints between pipe lengths are to be screw-type and no PVC cement will be used. The annular space between the PVC pipe and the casing will then be filled with clean coarse sand or pea gravel to the top of screened pipe section. The casing will be partially withdrawn during the

filling. The space from the top of the sand or gravel filter will then be pressure grouted or tremied bentonite grout to within 3 feet of the ground surface. The remaining casing will then be withdrawn.

- The well will then be pumped upon completion for a minimum of 1 hour to yield a turbid-free discharge.
- Permanent monitor well protection will be provided by installing a 48-in. I.D. pre-cast concrete manhole and cone with a steel frame and cover over the monitor well pipes. Detail G on Drawing No. 6 presents the construction detail and procedure. The basic well completion and security procedure is as follows:
  - install wells to top of slag;
  - add 6-foot extension to each well pipe and cap;
  - place concrete manhole pipe and cone;
  - fill around well pipes with sand;
  - place final cover around outside of manhole; and
  - install throat rings, steel frame and cover for completion.

- The surface water sampling stations will be marked adjacent to the creek using a steel rod, at least 3/4 inches in diameter and 10 feet in length. The steel rod will be driven into the soil at least 7 feet and will have a stickup not less than 2 feet. Each rod will be marked indicating the sample station number. The rod will be fitted with a permanent metallic tag with the well number.

4.3.5 Sample Collection

Ground water samples will be collected in accordance with the procedure described in the ENSR Standard Operating Procedures (SOP's) #7130 "Groundwater Sample Collection from

Monitoring Wells". Surface water samples will be collected in accord.nce with ENSR SOP #7120.

The Standard Operating Procedures (SOP's) #7130 and #7131 Field Filtration of Water Samples for Inorganics" will be used, as modified below, for the collection and field filtration of groundwater samples for radionuclide analysis. The SOP's are includes in Appendix K.

The methods to be utilized for this specific radionuclide sampling program are identified in the following text. These methods are selected for compatability with established analytical procedures for water and filtrate samples. Modifications to specific sections of the SOP's to fulfill the requirements of the Shieldalloy monitoring are detailed.

Procedure 7130 Groundwater Sample Collection from Monitoring Wells

Modifications are made to the following sections of the SOP.

Section 6.0 Well-Purging Methods

The wells shall be purged with a pump prior to sampling to remove stagnant water. Bailing is not to be used as the turbulence generated raises the level of suspended solids and would bias the required analysis of filtered solids.

Section 7.0 Sample Collection Analysis

The samples may be collected with either a low volume peristaltic pump or one of the higher volume pumps recommended. The vertical distance guidelines established in the SOP shall be used to determine the type of pump to be used.

If the well purging uses a peristaltic pump, filtration is to be performed directly into the sample bottle as the sample is pumped.

If a high volume pump is used, the sample is to be collected in a clean intermediate container. Filtration is to be performed in the field with a peristaltic pump prior to sample shipment.

Subsequent to the filtration step, the water sample should be preserved with nitric acid to a pH <2.

Procedure 7131: Field Filtration of Water Samples for Inorganics

Modifications are made to the following section of the SOP:

Section 2.3 Filters

A nitrocellulose or methylester 0.45 micron filter shall be substituted for the SOP specific Teflon filter. This filter shall be removed from the filter cartridge and placed in a wide mouth jar.

The tare weight of the filter must be determined prior to filtration if the analysis will count the material in a solid state instead of using the acid dissolution method. The tare weight must be determined to a minimum of four decimal places to allow correct calculations for self-absorption to be made.

4.3.6 Sample Preservation, Shipment, and Chain of Custody

Ground and surface water samples collected in accordance with the instructions described in ENSR SOP's previously described will be delivered or shipped directly to an NRC approved analytical laboratory.

4.3.7 Analytical Testing

All ground and surface water samples will be analyzed by an NRC approved analytical testing laboratory. Analyses will be performed using EPA analytical methods, detection limits, preservatives, and holding times for ground water samples as designated in EPA Manual 600/4-82-029, entitled "Handbook for Sampling and Sample Preservation of Water and Wastewater" Tables 17.1 and 17.2. Analytical parameters will be pH, gross-alpha and gross-beta activity.

4.3.8 Water Quality Assessment and Frequency of Sampling

The program will comprise sampling and analysis for ground and surface water at a frequency of 4 times per year for 2 years after completion, and thereafter annually for or further 3 years.

The ground and surface water quality assessment activities are based on existing hydrogeological information described in this report. The assessment program is presented as an itemized list in the order of performance.

- An initial sampling of all monitor wells and surface water sampling locations will be made following installation of the new wells. Samples will be analyzed for pH, gross-alpha and gross-beta activity.
- Sampling will be performed at four monitor wells and two surface water monitoring points.
- The Shieldalloy Metallurgical Corp. will maintain a file of the test results at the Cambridge Plant. They will be available for viewing by regulatory agency personnel.
- Annually, for 5 years, a qualified hydrogeologist representing the Shieldalloy Metallurgical Corp. will review the ground and surface water quality data to determine if any trends in water quality exist and determine the potential impacts of such trends. A report of this technical review will be submitted to the corporate environmental manager. The report will be available to regulatory agencies upon request.

This technical review will evaluate all the parameters analyzed and determine if further sampling and analysis is necessary to establish the validity of prior test data.

- If the hydrogeologist determines that indicator levels are increasing substantially with time, the test data will be evaluated based on the geologic setting and site conditions. The potential long term impact on ground and surface water resources will be determined. The hydrogeologist will make a professional judgment and a recommendation as to whether further action is necessary.

4.4 Post-Decommissioning Inspection/Maintenance Plan

4.4.1 Purpose

The purpose of the post-closure inspection and maintenance plan is to assure the structural integrity of the closed pile on a long-term basis. Acts of man and nature can theoretically result in disruption of the closed pile that may expose the slag.

Prior experience with closed piles and landfills indicates that the first two to three years following closure are the years when disruption is most likely to happen. This primarily occurs as a result of heavy rainfall on slopes where the vegetation is not firmly established, where initial waste settlement results in gullies or depressions or where illegal dumping or site vandalism occurs. The purpose of the program is primarily to address the first issue, as the subsequent factors are extremely unlikely to be significant at the Shieldalloy site. The post-decommissioning maintenance program described in the following subsections is intended to provide information concerning routine inspection items and remedial action.

4.4.2 Responsibilities

Shieldalloy Metallurgical Corp. (Shieldalloy) will be responsible for initiating and performing the post-decommissioning maintenance program. Shieldalloy will assume responsibility for periodic site inspections and any repair or maintenance of the landfill.

4.4.3 Schedule

A detailed site inspection of the decommissioned pile will be made by an authorized representative of Shieldalloy. Site inspections will be made semi-annually, preferably in the months of April and October. The month of April was selected as the first inspection each year, to determine damage done by rainfall/snowmelt erosion and settling. The April inspection will allow sufficient time to perform any filling, regrading or seeding at the beginning of the growing season.

The month of October provides an opportunity for inspection of the site for vehicle rutting, illegal dumping or other detrimental activities that may have taken place. Repair work can then be performed while the surface soils in the area are relatively dry and stable, and will allow time for maintenance prior to heavy rain and/or snowfall during the winter.

The program will be operated for 5 years after completion.

4.4.4. Site Inspection

Table 4-1 presents a post-decommissioning inspection form to be used for each site inspection. The form will require the site inspector to carefully perform a reconnaissance of the site and note observations relative to all 11 items. The types of problems associated with each item are listed as a reminder to the inspector. The form also requires a check as to whether each inspected item is acceptable or unacceptable. In

TABLE 4-1

POST-DECOMMISSIONING INSPECTION FORM FOR WEST PILE

Inspector's Name/Title________________________________ Shieldalloy Metallurgical Corp.

Date of Inspection____________________Month/Day/Year Cambridge, Ohio

Time of Inspection____________________(AM) (PM)

Inspection Report No. _______

Item No.	Inspection Item	Types of Problems	Observations	Status: Acceptable	Status: Unacceptable	Date and Type of Repair/Remedial Action
1	Final Cover	Removal, holes, slag exposure				
2	Settling	Settlement, depressions				
3	Erosion	Gullies, wash outs, slag exposure				
4	Rip-rap	Removal, settlement in flood plain				
5	Vegetation	Grass, legumes dead, thin growth				
6	Seeps	Visible seeps at base				
7	Vandalism	Removal of cover, killing of vegetation				
8	Illegal Dumping	Debris, trash				
9	Monitor Wells	Bent, broken, removed, plugged, locks broken or missing				
10	Signs, Fences	Removed, defaced				
11	Rutting	Deep vehicle ruts, waste exposure				

Remarks/Other Observations____

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addition, a space is provided for actions taken to repair any of the unacceptable stated items.

4.4.5 Inspection Report Location

Shieldalloy will maintain a complete file of inspection reports at the Shieldalloy Cambridge plant for 10 years after the 5 year inspection period.

4.4.6 Remedial Action Response

Upon discovery of an unacceptable status for any one or more of the inspection items, Shieldalloy will schedule and implement the appropriate remedial action. When the action is satisfactorily completed, the type of action and the date completed will be entered on the inspection form where the unacceptable item was first noted.

4.4.7 Remedial Action

Appropriate remedial actions for each unacceptable condition listed in Table 4-1 are presented on Table 4-2. Table 4-2 will be used a guideline.

4.5 Radon Monitoring Plan

4.5.1 Purpose

The measurement of radon emanation from the pile will be performed in order to ensure that the generation of radon within the pile is stable and does not give rise to any significantly higher levels of radon emanation than is anticipated in this document.

TABLE 4-2

REMEDIAL ACTION RESPONSE FOR POST-DECOMMISSIONING PROBLEMS

Item No.	Inspection Item	Types of Problems	Appropriate Remedial Actions
1	Final Cover	Removal, holes, slag exposure	Fill voids with final cover soil, compact, add topsoil and seed (see Tech. Spec.)
2	Settling	Settlement, depressions	Same as above.
3	Erosion	Gullies, wash outs, slag exposure	Same as above.
4	Rip-rap	Removal, settlement in flood plain	Place and shape additional rip-rap.
5	Vegetation	Grass, Legumes dead, thin growth	Scarify soil and/or add topsoil, then re-seed using seed mix.
6	Seeps	Visible seeps at base	If minor, add hay bales to stimulate vegetative growth and reduce volume. If major break-out, a supplemental collection or in-situ mitigation system may be required.
7	Vandalism	Removal of cover, killing of vegetation	Fill voids with final cover soil, compact, add topsoil and seed.
8	Illegal Dumping	Debris, trash, slag	Remove debris and trash from site and dispose of properly.
9	Monitor Wells	Bent, broken, removed, plugged locks broken or missing	Repair if damage above ground; if plugged or removed then install new well after filling void with cement/bentonite grout.
10	Signs, Fences	Removed, defaced	Repair fences, replace signs.
11	Rutting	Deep vehicle ruts, waste exposure	Fill voids with final cover soil, compact, add topsoil and seed.

4.5.2 Responsibilities

Shieldalloy Metallurgical Corporation will conduct radon monitoring in accordance with this plan. A copy of this plan will be kept at the Cambridge plant. Shieldalloy will also make any necessary notification to NRC in connection with results obtained from this program.

4.5.3 Schedule

The radon detectors will be employed to obtain integrated does measurements over successive three month periods. All of the radon monitoring devices should be exchanged within three working days of the last calendar day of each calendar quarter. If this changeout is not possible, then the changeout must occur at approximately the same point in the quarter for the duration of the monitoring period.

The monitoring plan shall be implemented for an initial period of five years. If at the completion of this period the monitoring data shows a stable or downward trend in radon concentration, the program will not be extended, unless specifically required by the U.S. NRC. If the monitoring data shows an upward trend or abnormalities, the extension of the program will be determined in discussion with NRC.

4.5.4 Monitoring Well Construction

Four radon gas monitoring locations have been designated on Drawing No. 2. The radon gas monitoring station consists of a 48-in. I.D. precast concrete manhole installed to a depth of approximately 3 feet below the slag surface. The concrete pipe extends through the slag and final cover soil to the final graded surface. The top of the manhole will be approximately 12-in. above the final surface. The manhole will be covered and protected by a steel watertight manhole frame and covered with a bolted lid. Detail H on Drawing No. 5 presents the gas monitoring well structure details.

4.5.5 Detector Replacement Procedure

Alpha track detectors consist of a small sheet of a special plastic material. The material is permanently marked when exposed to alpha particles such as those emitted by the decay of radon or some of the short lived radon decay products.

The manhole will be evacuated to ensure a complete exchange of air prior to deployment, and each time that a detector is to be replaced. This will be accomplished using a small vacuum pump with tygon tubing fed through the top of the manhole cover. Depending on the flow rate, the complete exchange of air within the cell will take 5 to 10 minutes. At this point, a new detector will be suspended within the manhole.

The detectors will be placed in each of the four manholes. The detectors will be suspended by a wire or other secure means from the manhole covers. The radon detectors are supplied in a sealed aluminum package. The package is cut open immediately below the narrow seal, the detector removed and placed in position.

The detectors will be collected each quarter and replaced with another prepared detector. Upon removal of the detector, the removal date will be noted and the detector returned to the aluminum package. The package shall be sealed with tape and returned with the original box to the analytical facility for analysis.

4.5.6 Chain of Custody

A record of the chain of custody of the radon detectors shall be maintained by completing the sample log form. The sample log form shall include all the detector information as well as the initials of the sample collector and other pertinent comments as to the condition of the detector. If the lid is punctured, the sample is invalid and is to be noted as such. The samples shall be packaged to avoid damage and returned to the vendor for analysis.

4.5.7 Analytical Parameters

Measurement will be made of the passive integration of alpha particle tracks on the detector. Results will be presented as a time weighted value based on the length of the sampling duration.

4.5.8 Quality Control

A quality control field replicate will be deployed bi-annually. This replicate will be suspended adjacent to an existing detector and sent in for analysis. The results will be reported by detector number only. The laboratory will not know the difference between the replicate and actual measurement detectors.

4.5.9 Baseline Monitoring

A detector shall be deployed and collected at the site fire main manhole following the procedure described in Section 4.5.5. Records and analysis will follow the procedures of Sections 4.5.6 and 4.6.7. This procedure will serve to provide data on background levels of radon at the site.

4.5.10 Notification

Shieldalloy Metallurgical Corporation shall retain records for 10 years after completion of the program and shall make these records available on request to the NRC.

5. DECOMMISSIONING COSTS

5.1 Cost Estimates

The estimated costs for implementation of the plan as described in Sections 3 and 4 are summarized as follows:

Capital Cost of Decommissioning: $1,800,000

Annual Monitoring/Maintenance Cost: $20,000

These costs are expressed in 1990 dollars. The annual costs are anticipated to be incurred over an initial period of 5 years, after which the necessity of annual inspection and monitoring will be reevaluated.

5.2 Funding Program

A detailed cost estimate, and the funding plan designed to addressed the financial requirements established in Section 5.1, are being submitted to NRC, concurrently with this document, under separate cover.

APPENDIX A

ENSR

Formerly ERT

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508-635-9500

ENSR Document No.: 5990-001-200
ENSR Ref. No.: 51-REH-381

July 10, 1989

Mr. Leland Rouse
Chief Fuel Cycle Safety Branch
Division of Industrial and Medical Nuclear Safety
Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, Maryland 20852

RE: EVALUATION OF MATERIAL STOCKPILE CHARACTERIZATION DATA AT THE SHIELDALLOY CAMBRIDGE PLANT, CAMBRIDGE, OHIO, PRELIMINARY ANALYTICAL RESULTS

Dear Mr. Rouse:

The purpose of this correspondence is to provide preliminary slag stockpile characterization data.

Characterization Methodology

As we had previously discussed in our meeting of May 8, 1989, the slag samples were obtained using a specialty drilling technique. This selected technique involved the use of a dual-wall reverse circulation system and an innovative state-of-the-art down-hole hammer drill. This technique was successful because the hammer drill efficiently collected and returned the cuttings to the surface. The design of the hammer drill created a strong vacuum at the bottom of the inner tube and the center of the hammer bit. This design, utilizing air forced down the outer annulus, diverted and injected air to the inner pipe to create the vacuum. The individual borings were stopped when clay or silt material was encountered.

The total number of samples collected was 66. This number is comprised of 30 samples from the West Pile, 30 samples from the East Pile, and 6 samples from the Grainal Pile. duplicate samples were obtained at every fifth sampling location. These duplicates were forwarded to Jim Berger of ORAU for comparative analysis. Sample locations were selected using a random number generated corresponding to the total number of 10 meter grid intersections for each pile. Generally, the total number of sampling locations defined by this system exceeded the available sampling locations

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because the shape of the slag piles was irregular, and the shape and arrangement of the slag piles made many grid points inaccessible to the drilling equipment.

Radionuclide Analyses

Each core of sample material was individually mixed and a single composite sample obtained, labeled, and sent to TMA/Eberline for radiochemical analysis. The samples were analyzed for the radionuclides Thorium-232 (Th-232), Radium-226 (Ra-226), and Uranium-238 (U-238). Two techniques were utilized to obtain accurate analytical results for these samples. Gamma spectrometry was the method selected to provide data for the nuclides of Th-232 and Ra-226. SU-238 values were also obtained using this technique, but the U-238 gamma emitter utilized in the spectrometry analytical technique suffered interference in this case with the higher intensity gamma emissions present from Th-232. Data obtained for the U-238 nuclide (using the gamma spectrometry technique) were therefore artificially low. ENSR therefore had each sample analyzed utilizing alpha spectroscopy to obtain accurate U-238 values. The Uranium-234 (U-234) values are also presented to demonstrate equilibrium with U-238 within the samples. The values for these nuclides are presented in Tables 1-1 through 1-4.

The sample mean activity for each specific radionuclide in the respective piles was calculated. Table 1-5 shows the mean activity values and standard deviations along with the highest and lowest value found for each radionuclide in each respective pile. The table shows the final results for the Grainal Pile analysis, for the East Pile analysis, and for the West Pile analysis. Of note are the large variances, or standard deviations, associated with the mean activity values. These large variances do not arise, in our view, as a result of any deficiency in the sampling method, or because insufficient samples were collected; they rather reflect the wide range of activity that will be found to occur in the piles, regardless of the number of samples. Therefore, the mean activity values can be taken, in our view, as "genuine" mean results, where the standard deviation is a measure of the inhomogeneity of the slag piles. The subtotal values approximate the total activity present for these specific radionuclides.

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Volume of Slag Piles

Data derived from the characterization drilling program have determined that each of the three slag material stockpiles is deeper than originally estimated. Slag pile surface areas (derived from the November 1987 decommissioning plan) were combined with the drilling program data to recalculate the slag pile volumes. These revised numbers were estimated and are compared to previously reported estimates (in parenthesis) as follows:

- West Pile - 282,000 tons (243,000 tons)
- East Pile - 77,100 tons (77,100 tons)
- Grainal Pile - 10,000 tons (10,000 tons)

This data has been provided to you for your evaluation and consideration prior to our meeting scheduled for July 11, 1989. It is hoped that you will have had the opportunity for brief review of this information. This information will form a basis for discussion concerning the possible disposition of the material stockpiles at the Shieldalloy Cambridge facility.

I look forward to the opportunity to meet with you concerning this matter. ENSR will be able to answer any questions you may have regarding this information.

Very truly yours,

Raymond Holmes

Dr. Raymond E. Holmes
Vice President
Chief Engineer

REH/r

Enclosure

TABLE 1-1

BACKGROUND SOIL ACTIVITY

Sample Identification	Uranium-238[1] (pCi/gm)	Uranium-234[1] (pCi/gm)	Radium-226[2] (pCi/gm)	Thorium-232[3] (pCi/gm)
SMC-001	1.8 ± 0.3	1.7 ± 0.3	1.1 ± 0.1	1.3 ± 0.2
SMC-002	1.3 ± 0.2	1.4 ± 0.2	1.3 ± 0.2	1.6 ± 0.3
SMC-004	1.7 ± 0.3	1.4 ± 0.2	1.6 ± 0.2	1.4 ± 0.3
SMC-005	2.0 ± 0.3	2.0 ± 0.3	2.7 ± 0.2	2.1 ± 0.2
SMC-006	1.5 ± 0.2	1.6 ± 0.2	1.4 ± 0.2	1.7 ± 0.3
SMC-007	1.8 ± 0.3	1.7 ± 0.3	1.0 ± 0.2	0.9 ± 0.2
SMC-008	1.9 ± 0.2	1.8 ± 0.2	1.3 ± 0.1	1.6 ± 0.1

[1]Analysis performed via alpha spectrometry for isotopic uranium in soil.

[2]Analysis performed via gamma spectrometry based on Pb-214 and Bi-214 daughters.

[3]Analysis performed via gamma spectrometry based on TI-208 and Ac-228 daughters.

TABLE 1-2

WEST PILE CHARACTERIZATION RESULTS

Sample Identification	Uranium-238[1] (pCi/gm)	Uranium-234[1] (pCi/gm)	Radium-226[2] (pCi/gm)	Thorium-232[3] (pCi/gm)
SMC-008				
SMC-009	1.5 ± 0.4	1.2 ± 0.3	0.6 ± 0.1	0.7 ± 0.1
SMC-010	2.6 ± 0.4	2.3 ± 0.4	1.9 ± 0.2	0.6 ± 0.2
SMC-011	1.8 ± 0.3	1.9 ± 0.3	0.9 ± 0.1	0.5 ± 0.1
SMC-012	1.3 ± 0.2	1.5 ± 0.2	1.3 ± 0.1	0.6 ± 0.1
SMC-013	0.8 ± 0.2	1.9 ± 0.2	0.6 ± 0.1	0.6 ± 0.1
SMC-015	1.6 ± 0.5	1.9 ± 0.3	1.8 ± 0.2	1.2 ± 0.2
SMC-017	3.3 ± 0.5	3.5 ± 0.5	9 ± 1	1.8 ± 0.3
SMC-019	2.6 ± 0.5	3.1 ± 0.3	4.9 ± 0.2	2.0 ± 0.2
SMC-021	1.8 ± 0.2	2.1 ± 0.3	3.5 ± 0.3	1.5 ± 0.3
SMC-022	3.5 ± 0.4	3.9 ± 0.6	4.7 ± 0.2	3.1 ± 0.2
SMC-023	13 ± 1	13 ± 1	3.4 ± 0.2	0.8 ± 0.2
SMC-030	3.2 ± 0.4	3.4 ± 0.3	1.5 ± 0.1	1.1 ± 0.1
SMC-031	3.2 ± 0.4	3.1 ± 0.4	2.2 ± 0.1	1.7 ± 0.1
SMC-076	3.7 ± 0.3	3.8 ± 0.3	3.0 ± 0.8	1.4 ± 0.1
SMC-077	1.3 ± 0.2	1.8 ± 0.3	1.2 ± 0.8	0.4 ± 0.1
SMC-078	1.6 ± 0.2	1.6 ± 0.3	1.7 ± 0.1	0.7 ± 0.1
SMC-079	1.9 ± 0.3	1.7 ± 0.2	1.3 ± 0.8	0.4 ± 0.1
SMC-081	1.8 ± 0.3	2.0 ± 0.4	8.5 ± 0.2	0.7 ± 0.1
SMC-082	3.8 ± 0.3	4.0 ± 0.3	5.1 ± 0.1	1.6 ± 0.1
SMC-083	3.2 ± 0.5	3.5 ± 0.5	2.2 ± 0.1	1.0 ± 0.1
SMC-084	0.9 ± 0.2	1.0 ± 0.2	0.5 ± 0.1	0.4 ± 0.1
SMC-085	1.7 ± 0.4	1.6 ± 0.4	1.4 ± 0.1	0.7 ± 0.1
SMC-087	1.9 ± 0.3	2.3 ± 0.3	0.7 ± 0.1	0.5 ± 0.1
SMC-088	1.8 ± 0.4	2.2 ± 0.4	1.4 ± 0.1	0.7 ± 0.1
SMC-089	1.6 ± 0.3	1.7 ± 0.3	0.8 ± 0.1	0.4 ± 0.1

[1]Analysis performed via alpha spectrometry for isotopic uranium in soil.

[2]Analysis performed via gamma spectrometry based on Pb-214 and Bi-214 daughters.

[3]Analysis performed via gamma spectrometry based on TI-208 and Ac-228 daughters.

TABLE 1-2 (Cont'd.)

Sample Identification	Uranium-238 (pCi/gm)	Uranium-234 (pCi/gm)	Radium-226 (pCi/gm)	Thorium-232 (pCi/gm)
SMC-090	2.1 ± 0.3	2.2 ± 0.3	1.4 ± 0.1	0.7 ± 0.1
SMC-091	2.2 ± 0.2	2.2 ± 0.2	1.8 ± 0.1	1.5 ± 0.1
SMC-093	0.8 ± 0.1	0.9 ± 0.1	0.5 ± 0.1	0.3 ± 0.1
SMC-094	2.0 ± 0.2	2.2 ± 0.2	2.8 ± 0.1	1.5 ± 0.1
SMC-095	1.4 ± 0.2	1.3 ± 0.2	0.9 ± 0.1	0.5 ± 0.1

TABLE 1-3

GRAINAL PILE CHARACTERIZATION RESULTS

Sample Identification	Uranium-238[1] (pCi/gm)	Uranium-234[1] (pCi/gm)	Radium-226[2] (pCi/gm)	Thorium-232[3] (pCi/gm)
SMC-069	8.4 ± 0.5	9.0 ± 0.5	65 ± 1	3.7 ± 0.2
SMC-070	11 ± 1	11 ± 1	8.6 ± 0.3	4.2 ± 0.3
SMC-071	9.5 ± 0.1	9.3 ± 0.5	75 ± 1	3.9 ± 0.2
SMC-072	85 ± 0.5	8.3 ± 0.5	6.5 ± 0.2	3.5 ± 0.3
SMC-073	4.1 ± 0.4	4.2 ± 0.4	5.6 ± 0.2	3.5 ± 0.2
SMC-074	5.8 ± 0.4	5.8 ± 0.4	6.3 ± 0.2	4.0 ± 0.3

---

[1]Analysis performed via alpha spectrometry for isotopic uranium in soil.

[2]Analysis performed via gamma spectrometry based on Pb-214 and Bi-214 daughters.

[3]Analysis performed via gamma spectrometry based on TI-208 and Ac-228 daughters.

TABLE 1-4

EAST PILE CHARACTERIZATION RESULTS

Sample Identification	Uranium-238[1] (pCi/gm)	Uranium-234[1] (pCi/gm)	Radium-226[2] (pCi/gm)	Thorium-232[3] (pCi/gm)
SMC-032	24 ± 1	25 ± 1	54 ± 1	2.8 ± 0.5
SMC-033	34 ± 1	33 ± 1	27 ± 1	2.9 ± 0.3
SMC-034	16 ± 1	17 ± 1	24 ± 1	3.0 ± 0.3
SMC-035	29 ± 1	30 ± 1	66 ± 1	2.4 ± 0.4
SMC-036	50 ± 1	49 ± 1	1000 ± 100	<0.4
SMC-037	20 ± 1	20 ± 1	19 ± 1	2.4 ± 0.4
SMC-038	15 ± 1	15 ± 1	18 ± 1	2.1 ± 0.2
SMC-039	10 ± 1	11 ± 1	2.4 ± 0.1	2.3 ± 0.2
SMC-040	20 ± 1	20 ± 1	32 ± 1	12 ± 1
SMC-041	16 ± 1	18 ± 1	64 ± 1	2.1 ± 0.5
SMC-042	73 ± 1	71 ± 1	27 ± 1	15 ± 1
SMC-043	21 ± 1	20 ± 1	25 ± 1	2.7 ± 0.3
SMC-044	31 ± 1	31 ± 1	17 ± 1	1.5 ± 0.2
SMC-045	14 ± 1	14 ± 1	11 ± 1	3.2 ± 0.2
SMC-046	24 ± 1	25 ± 1	20 ± 1	4.7 ± 0.2
SMC-047	13 ± 1	15 ± 1	21 ± 1	2.4 ± 0.2
SMC-048	21 ± 1	21 ± 1	28 ± 1	3.0 ± 0.3
SMC-049	38 ± 2	37 ± 2	30 ± 1	1.0 ± 0.2
SMC-050	16 ± 1	17 ± 1	24 ± 1	1.9 ± 0.3
SMC-051	21 ± 1	19 ± 1	37 ± 2	6.0 ± 0.4
SMC-052	4.0 ± 0.4	4.0 ± 0.7	45 ± 1	<1
SMC-053	11 ± 1	11 ± 1	17 ± 1	3.5 ± 0.3
SMC-059	21 ± 1	21 ± 1	11 ± 1	6.1 ± 0.2
SMC-060	16 ± 1	16 ± 1	13 ± 1	1.6 ± 0.2
SMC-061	25 ± 1	24 ± 1	51 ± 1	2.7 ± 0.5

[1]Analysis performed via alpha spectrometry for isotopic uranium in soil.

[2]Analysis performed via gamma spectrometry based on Pb-214 and Bi-214 daughters.

[3]Analysis performed via gamma spectrometry based on TI-208 and Ac-228 daughters.

TABLE 1-4 (Cont'd.)

Sample Identification	Uranium-238 (pCi/gm)	Uranium-234 (pCi/gm)	Radium-226 (pCi/gm)	Thorium-232 (pCi/gm)
SMC-063	12 ± 1	13 ± 1	110 ± 1	<1
SMC-064	22 ± 1	22 ± 1	48 ± 1	3.7 ± 0.4
SMC-065	14 ± 1	15 ± 1	46 ± 1	2.0 ± 0.5
SMC-066	15 ± 1	16 ± 1	17 ± 1	0.9 ± 30.2
SMC-067	19 ± 1	20 ± 1	59 ± 1	2.8 ± 0.8

TABLE 1-5

	Highest Value pCi/gm	Lowest Value pCi/gm	Mean Value and Standard Deviation pCi/gm
West Pile			
Th-232	3.1	0.4	1.40 ± 1.52
U-238	13	0.9	3.00 ± 2.00
Ra-226	8.5	0.5	2.38 ± 2.15
Subtotal			6.73
Grainal Pile			
Th-232	4.2	3.5	3.80 ± 0.28
U-238	11	4.1	8.00 ± 3.00
Ra-226	75	5.6	27.8 ± 32.8
Subtotal			39.6
East Pile			
Th-232	15	<0.4	3.30 ± 3.09
U-238	73	4	21.0 ± 14.0
Ra-226	1000	2.4	66.0 ± 178
Subtotal:			90.3

APPENDIX B

Note: Sample I.D. numbers 13, 19, 23, 79, 85, 91 and 95 pertain to the West Pile.

Oak Ridge Associated Universities Post Office Box 117 Oak Ridge, Tennessee 37831-0117

August 15, 1989

Dr. Germain LaRoche
Office of Nuclear Materials Safety
and Safeguards
Nuclear Regulatory Commission
Mail Stop 6H3
Washington, DC 20555

Subject: CROSS-CHECK ANALYSES OF SLAG SAMPLES FROM SHIELDALLOY CORPORATION - CAMBRIDGE, OH

Dear Dr. LaRoche:

Attached are the results of our program's analyses on 15 samples of slag from the Shieldalloy/Cambridge site, provided to ORAU by ENSR. The ENSR data for these same samples are also included for comparison. As noted from these results there appears to be general agreement between the ORAU and ENSR data. Twenty three of the 42 data pairs agree within their associated 95% confidence levels.

The greatest differences appear in the RA-226 values at concentrations above 20 pCi/g; the ORAU measurements for these samples are 20-30% higher than those provided by ENSR.

Sincerely,

James D. Berger, Director
Environmental Survey and
Site Assessment Program

JDB:jws

Attachment

COMPARISON OF ANALYSES ON SAMPLES
FROM SHIELDALLOY
CAMBRIDGE, OH

Sample ID	Analyzed by	Concentrations (pCi/g ± 2σ)		
		Th-232	U-238	Ra-226
013	ENSR	0.6 ± 0.1	0.8 ± 0.2	0.6 ± 0.1
	ORAU	0.5 ± 0.3	2.1 ± 1.1	0.6 ± 0.2
019	ENSR	2.0 ± 0.2	2.6 ± 0.3	4.9 ± 0.2
	ORAU	2.1 ± 0.7	3.5 ± 2.2	7.0 ± 0.6
023	ENSR	0.8 ± 0.2	13 ± 1	3.4 ± 0.2
	ORAU	1.3 ± 0.3	31.1 ± 3.8	4.0 ± 0.4
079	ENSR	0.7 ± 0.1	1.9 ± 0.3	1.3 ± 0.5
	ORAU	1.4 ± 0.5	2.3 ± 1.4	1.5 ± 0.3
085	ENSR	0.7 ± 0.1	1.7 ± 0.4	1.4 ± 0.1
	ORAU	2.0 ± 0.4	2.3 ± 1.4	1.8 ± 0.3
091	ENSR	1.5 ± 0.1	2.2 ± 0.2	1.8 ± 0.1
	ORAU	3.0 ± 0.7	3.2 ± 1.6	3.1 ± 0.4
095	ENSR	0.5 ± 0.1	1.4 ± 0.2	0.9 ± 0.1
	ORAU	0.7 ± 0.3	1.3 ± 0.8	1.1 ± 0.2
032	ENSR	2.8 ± 0.5	24 ± 1	54 ± 1
	ORAU	2.1 ± 1.5	37.1 ± 5.8	69.6 ± 1.6
041	ENSR	2.1 ± 0.5	16 ± 1	64 ± 1
	ORAU	3.5 ± 1.3	22.4 ± 5.4	89.4 ± 1.7
046	ENSR	4.7 ± 0.2	24 ± 1	20 ± 1
	ORAU	4.7 ± 1.0	25.4 ± 4.4	26.8 ± 0.9
051	ENSR	6.0 ± 0.4	21 ± 1	37 ± 2
	ORAU	2.2 ± 0.9	20.7 ± 3.5	52.3 ± 1.3
061	ENSR	2.7 ± 0.5	25 ± 1	51 ± 1
	ORAU	2.7 ± 1.2	23.3 ± 4.0	60.4 ± 1.3
067	ENSR	2.8 ± 0.2	19 ± 1	59 ± 1
	ORAU	1.1 ± 1.3	25.4 ± 6.7	81.5 ± 1.8
073	ENSR	3.5 ± 0.2	4.1 ± 0.4	5.6 ± 0.2
	ORAU	5.5 ± 0.7	8.3 ± 1.7	7.5 ± 0.5

APPENDIX C

ALBUQUERQUE LABORATORY

CUSTOMER ENSR-Shield Alloy — Attn: Jeff Brown

ADDRESS

CITY

PRELIMINARY DATA REPORT

E 0770

75-581 ERT # 23983

Project #5990-001-225 For Cambridge-Ohio

5

1.	5	Soil - Gamma, Isotopic Uranium (SPL)

RUSH - 21 DAY T.A.T.

pCi/g (dry)

LAB NO.	CUSTOMER IDENTIFICATION					U-234	Ra-226 / U-235	Th-232 / U-238
E 7907	SMC-320 - OR Excavation Samples "Composite Area E"		09-26-89	γ / I50U	507/422	20±1	30±3 / 1.0±0.3	1.6±0.4 / 14±1
08	SMC-321 - OR area "M" Composite		09-28	γ / I50U	610/588	69±3	68±7 / 2.8±0.6	1.0±0.5 / 68±3
09	SMC-322 - OR area "L" Composite		09-27	γ / I50U	831/806	35±3	23±2 / 1.8±0.5	28±3 / 35±3
10	SMC-323 area "H" Composite		09-28	γ / I50U	548/495	170±10	18±2 / 12±1	100±10 / 180±10
11	SMC-324 ~~Area I~~ "Composite" AREA J		09-27	γ / I50U	702/685	17±1	66±7 / 0.6±0.2	130±10 / 18±1

* Based on Pb-214 and Bi-214

** Based on Ac-228 and Tl-208

* INSERT UNITS

P FAX 10-25-89

FAX 11-1-89

10-10-89

BY B. Vern Lieberman DATE 10-06-89

TMA Eberline
Thermo Analytical Inc.
7021 PAN AMERICAN FREEWAY, N.E.
ALBUQUERQUE, NEW MEXICO 87109
PHONE (505) 345-3461

CUSTOMER

ADDRESS

CITY ENSR (SHIELD ALLOY)

[illegible] NO.

PRELIMINARY DATA REPORT E0698

[illegible] 2

Job# 75.582

[illegible]	[illegible]	[illegible]
1	2	Geli (Dry)
2	2	Iso U

Started 9/29/89 21 Day TAT

							pCi/g (dry)	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Alpha	[illegible]*	[illegible]**
E2169	SMC - 318 Area "F" Composite	N/A	9/26/89	γ Iso U	521 / 460	U-234 / 3.1±0.5	20±2 U-235 / 0.17±0.11	180±10 U-238 / 3.8±0.5
70	SMC - 319 Area "O" Composite	N/A	9/26/89	γ Iso U	69 / 644	35±1	27±2 / 1.3±0.2	2±1 / 35±1

* Based on Pb-214 and Bi-214.
** Based on Ac-228 and Tl-208.

* INSERT UNITS

TMA Eberline
Thermo Analytical Inc.
7021 PAN AMERICAN FREEWAY, N.E.
ALBUQUERQUE, NEW MEXICO 87109
PHONE (505) 345-3461

9-28-89

BY Andrew [signature] 9/27/89 DATE

PAGE 1 OF 1

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER: DNCR
ATTENTION: Shield Alloy
ADDRESS: Jeff Brown
CITY:
W.O. NO.: E-1005

Radiochemical Analysis of Solid

TYPE OF ANALYSIS

SAMPLES RECEIVED: 11/06/89

Project #5990-001-260
Project Loc: Cambridge, OH

Customer Identification	Date Collected	Type of Analysis	Total Wt. wet/dry (g)	pCi/g (dry)
SMC-382-Area "I"-OR	11/03/89	Ra-226*	528/470	32±3
SMC-382-Area "I"-OR		Th-232**		60±6
SMC-382-Area "I"-OR		U-234		44±1
SMC-382-Area "I"-OR		U-235		1.7±0.2
SMC-382-Area "I"-OR		U-238		44±1
SMC-383-Area "I"-OR	"	Ra-226*	533/469	28±3
SMC-383-Area "I"-OR		Th-232**		56±6
SMC-383-Area "I"-OR		U-234		21±1
SMC-383-Area "I"-OR		U-235		0.7±0.1
SMC-383-Area "I"-OR		U-238		22±1
SMC-384-Area "I"-OR	"	Ra-226*	565/501	30±3
SMC-384-Area "I"-OR		Th-232**		71±7
SMC-384-Area "I"-OR		U-234		28±1
SMC-384-Area "I"-OR		U-235		1.2±0.2
SMC-384-Area "I"-OR		U-238		28±1

* Based on Bi-214 and Pb-214 daughters.
** Based on Pb-212 daughter.

☐ REPORTED VIA TELEPHONE ☒ FAX 11/15/89

TMA Eberline
Thermo Analytical Inc.
7021 PAN AMERICAN FREEWAY, N.E.
ALBUQUERQUE, NEW MEXICO 87109
PHONE (505) 345 3461

APPROVED BY: R. Melgard
Rod Melgard, Mgr.

DATE: 12/12/89

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER Shield Alloy (ENSR)
ATTENTION Jeff Brown
ADDRESS
CITY
W.O. NO. E-1126

Radiochemical Analysis of Solid
TYPE OF ANALYSIS

ERT 22398
CUSTOMER ORDER NUMBER
#75-581
Project #5990-001-225-Loc: Cambridge, OH

SAMPLES RECEIVED 11/29/89

Customer Identification	Date Collected	Type of Analysis	Total Wt. g (dry)	pCi/g
SMC-413-OR	11/28/89	U-238*	506	4±2
Area "K" Composite		Ra-226**		3.1±0.2
		Th-232***		1.0±0.2
		U-234		2.3±0.2
		U-235		0.14±0.06
		U-238		2.1±0.2
SMC-14-OR	"	U-238*	587	9±2
Area "G" Composite		Ra-226**		6.3±0.3
		Th-232***		0.3±0.3
		U-234		2.1±0.2
		U-235		0.11±0.05
		U-238		2.1±0.2

REPORTED VIA ~~TELEPHONE~~ FAX 12/29/89, 01/08/90

PAGE 1 OF 1

TMA Eberline
Thermo Analytical Inc.
7021 PAN AMERICAN FREEWAY, N.E.
ALBUQUERQUE, NEW MEXICO 87109
PHONE (505) 345-3461

APPROVED BY R. Melgard
Rod Melgard, Mgr.

DATE 01/08/90

APPENDIX D

FERROVANADIUM DUST PILE ACTIVITY

Note:

U-238 values indicate the limit of detection for the analysis method employed. By correlation of these data with other site analytical results, the inference was made that actual U-23{ values are likely to be at or below the recorded background level of 1.7 pCi/gm.

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER ENSR
ATTENTION Shield Alloy
ADDRESS Jeff Brown
CITY
W.O. NO. E-0772

Gamma - Solid
TYPE OF ANALYSIS

75-581 ERT #23864-65
CUSTOMER ORDER NUMBER

SAMPLES RECEIVED 10/06/89

Project #5990-001-260
Loc: Cambridge, OH

Customer Identification	Date Collected	Type of Analysis	Total Wt. wet/dry (g)	pCi/g (dry)
SMC-343-OR-FVR-1	10/05/89	U-238*	337/194	<6
		Ra-226**		0.9±0.2
		Th-232***		0.9±0.3
SMC-344-OR-FVR-2	"	U-238*	325/165	<6
		Ra-226**		1.1±0.3
		Th-232***		1.1±0.4
SMC-345-OR-FVR-3	"	U-238*	319/181	<6
		Ra-226**		0.9±0.2
		Th-232***		1.5±0.3
SMC-346-OR-FVR-4	"	U-238*	380/222	<5
		Ra-226**		0.6±0.2
		Th-232***		0.8±0.3
SMC-347-OR-FVR-5	"	U-238*	379/229	<6
		Ra-226**		2.7±0.3
		Th-232***		1.8±0.4
SMC-348-OR-FVR-6	"	U-238*	386/239	<4
		Ra-226**		1.3±0.2
		Th-232***		0.6±0.2
SMC-349-OR-FVR-7	"	U-238*	400/228	<4
		Ra-226**		1.9±0.2
		Th-232***		0.6±0.2
SMC-350-OR-FVR-8	"	U-238*	394/271	<4
		Ra-226**		1.0±0.2
		Th-232***		1.8±0.3
SMC-351-OR-FVR-9	"	U-238*	340/166	<6
		Ra-226**		1.1±0.3
		Th-232***		1.2±0.4

☐ REPORTED VIA TELEPHONE ☐ FAX

TMA Eberline
Thermo Analytical Inc.

ALBUQUERQUE LABORATORY

REPORT OF ANALYSIS

CUSTOMER ENSR
ATTENTION
ADDRESS
CITY
W.O. NO. E-0772

TYPE OF ANALYSIS [illegible] CUSTOMER ORDER NUMBER [illegible] SAMPLES RECEIVED

Customer Identification	Date Collected	Type of Analysis	Total Wt. wet/dry (g)	pCi/g (dry)
SMC-352-OR-FVR-10	10/05/89	U-238*	444/278	<4
		Ra-226**		0.9±0.2
		Th-232***		0.5±0.3

* Based on Th-234 daughter.
** Based on Bi-214 and Pb-214 daughters.
*** Based on Pb-212 daughter.

☐ REPORTED VIA TELEPHONE ☐ FAX

TMA Eberline
Thermo Analytical Inc

FERROVANADIUM EXPOSURE RATE SURVEY

To: Dr. Ray Holmes
ENSR Chief Health Physicist

From: Doug Davis
TMA/Eberline Site Manager - Shieldalloy

Date: September 29, 1989

Subject: Gamma-Ray Exposure Rate Survey on The Ferrovan Pile (Area "B")

Attached is the gamma-ray exposure rate survey of Area "B" that you requested in our telephone conversation dated 9-28-89. The locations for our measurements were selected so that any contribution to the exposure rate due to the West Pile would be minimized. If you have any questions or would like more measurement please contact me.

Thank You.

Douglas M Davis

TMA/Eberline
GAMMA-RAY EXPOSURE RATE SURVEY

SITE SHIELDALLOY LOCATION AREA "B" (FeV Pile)

DATE 9-28-89 SURVEY NO. ______ SURVEYED BY D BEARD / B. COLE
Calculated by D. DAVIS

PIC CALIBRATION FACTOR

SERIAL NO. V-4017 N/A mR/hr/cpm

INSTRUMENT AND DETECTOR

SCALER MODEL PRS-2 DETECTOR MODEL SPA-3
SERIAL NO. 523 cal. due 1-10-90 SERIAL NO. 80 cal. due 10-25-89

* GRID POINT	µR/hr @ 10 cm	* GRID POINT	µR/hr @ 1 meter	GRID POINT	µR/hr	GRID POINT	µR/hr
1	7.2	1	7.3				
2	6.8	2	7.1				
3	6.1	3	6.4				
4	6.3	4	6.7				
5	6.6	5	6.5				
6	6.5	6	6.5				
7	6.8	7	6.7				
8	6.3	8	6.4				
9	5.9	9	6.1				
10	6.8	10	6.6				
11	7.1	11	6.9				
12	7.4	12	6.7				

BACKGROUND OFF-SITE COUNT TIME
11.0 µR/hr 1.0 minute

3.17

* SEE MAP

µR/hr calculated from the equation:
$y = 5.67E{-}4\,x + 3.08$; $r = 0.993$
where y = µR/hr (PIC V-4017)
x = cpm (SPA-3 #80)
r = correlation coefficient

FORM SC 3

TMA/Eberline
GAMMA - RAY EXPOSURE RATE SURVEY

SITE SHIELDALLOY LOCATION Fe V Pile

DATE 9-28-89 SURVEY NO. ______ SURVEYED BY B. Cole, D. Beard

PIC

CALIBRATION FACTOR

SERIAL NO. ______ ______ mR/h/cpm

INSTRUMENT AND DETECTOR

SCALER MODEL PRS-2 DETECTOR MODEL SPA-3

SERIAL NO. 523 DUE 1-10-90 SERIAL NO. 80 DUE 10-25-89

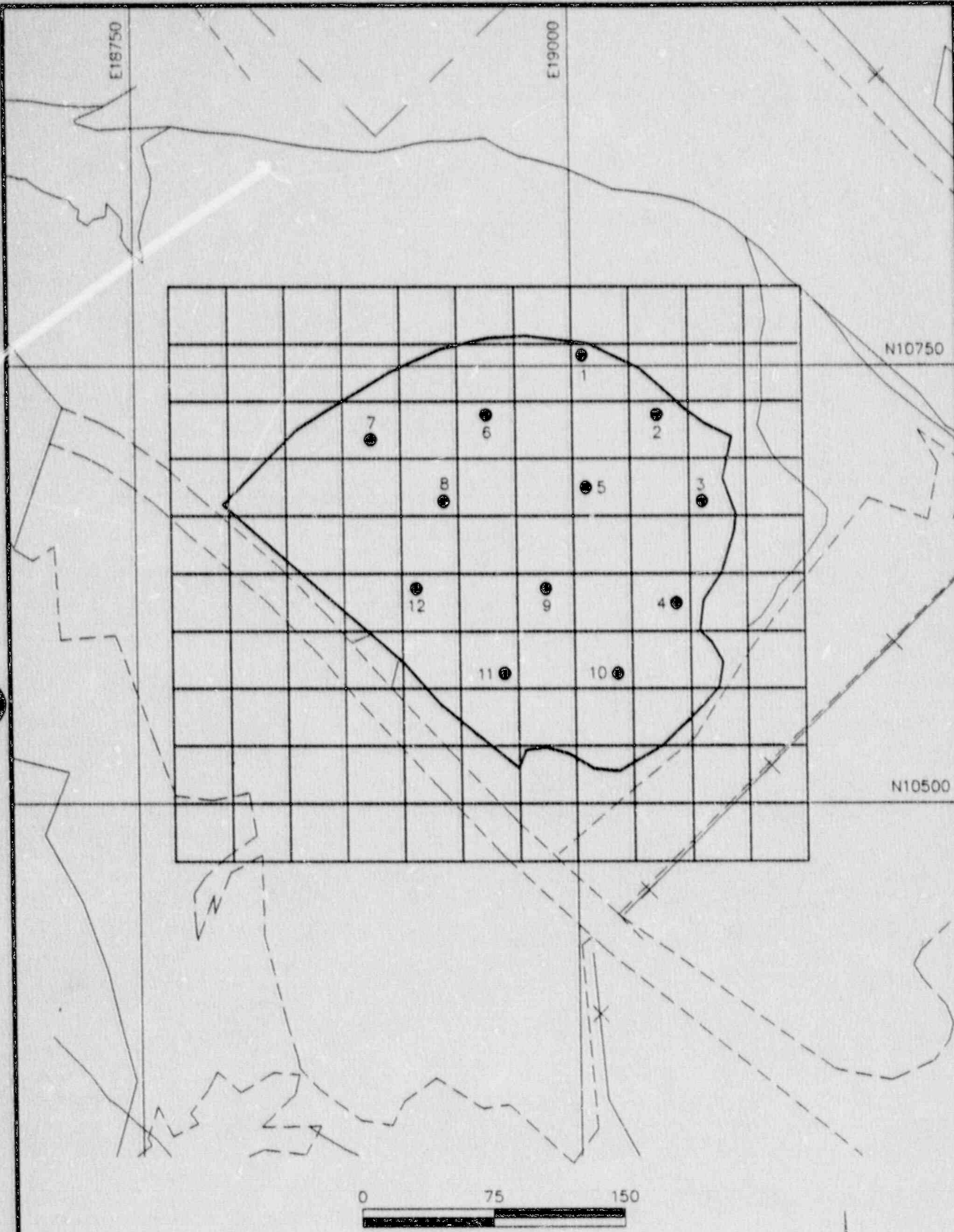
* GRID POINT	4" ~~µR/h~~ cpm	GRID POINT	1m ~~µR/h~~ cpm	GRID POINT	µR/h	GRID POINT	µR/h
1	7282		7394				
2	6529		7003				
3	5384		5777				
4	5679		6391				
5	6178		6067				
6	6104		6018				
7	6537		6386				
8	5681		5927				
9	4970		5253				
10	6573		6122				
11	7148		6730				
12	7699		6454				

BACKGROUND OFF - SITE ______ µR/h

COUNT TIME 1.0 minute

073.17

* SEE MAP



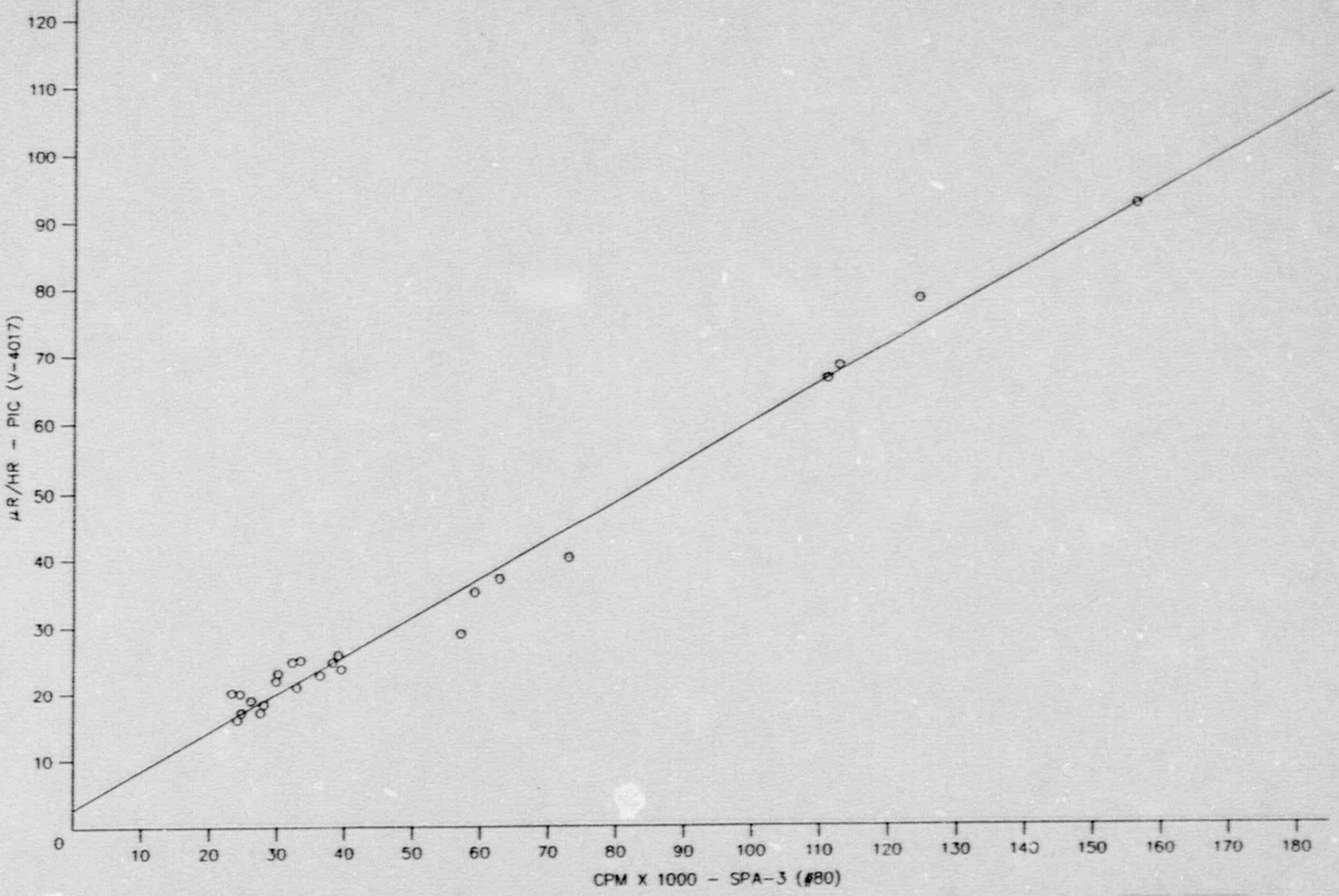
NOTE: GRID INTERVALS AT 10 METERS

FEROVAN DUST PILE – LOCATION OF GRID POINTS
GAMMA EXPOSURE RATE SURVEY 9/28/89

ENSR

599012

5990221A



SOURCE: TMA/EBERLINE 5/1/89

ENSR

CALIBRATION CHART CPM TO µR/HR

APPENDIX E

Ohio EPA
State of Ohio Environmental Protection Agency
P.O. Box 1049, 1800 WaterMark Dr.
Columbus, Ohio 43266-0149

Toward A Cleaner Environment

Richard F. Celeste
Governor

February 23, 1989

Dr. George T. Campbell
Shieldalloy Metallurgical Corporation
P.O. Box 768
Newfield, NJ 08344

Dear Dr. Campbell:

The Ohio EPA's Division of Solid and Hazardous Waste and Division of Water Pollution Control have reviewed Shieldalloy Metallurgical Corporation's proposal for the decommissioning of their Cambridge, Ohio facility. At this time I concur with your proposal for the decommissioning and decontamination at the facility.

However, given the nature of the materials located at the site this concurrance does not release Shieldalloy Metallurgical Corporation from the obligation to correct any future problems detected thru ground or surface water monitoring. To monitor the impact of the decommissioned and decontaminated facility on surface and ground water at the facility, Shieldalloy Metallurgical Corporation shall prepare a surface and ground water monitoring plan. This plan shall be submitted to Ohio EPA for approval and be implemented when the project is completed. If you have any questions regarding this approval please contact Vaughn Laughlin at (614) 644-2782.

Sincerely,

Richard L. Shank

Richard L. Shank, Ph.D.
Director

RLS/EK/pas

cc: Ed Kitchen, DSHWM, Ohio EPA
Paul Flanigan, DSHWM
Matt Tin, DWPC
George Elmarahgy
Bob Cottrill
Vaughn Laughlin
Rich Fahey, Arter and Hadden

APPENDIX F

SHIELDALLOY METALLURGICAL CORPORATION

DAVID R. SMITH
DIRECTOR OF ENVIRONMENTAL SERVICES

WEST BOULEVARD
P.O. BOX 768
NEWFIELD, NJ 08344

TELEPHONE (609) 692-4200
TWX (510) 687-8918
FAX (609) 692-4017

April 11, 1989

Mr. Michael D. Gheen
U.S. Army Corps of Engineers
Huntington District
502 Eighth Street
Huntington, West Virginia 25701-2070

RE: Decontamination and Decommissioning Plan for Shieldalloy Metallurgical Corporation Facility in Cambridge, Ohio

Dear Mr. Gheen:

As agreed during our telephone conversation of today, please find enclosed a copy of Ohio EPA's letter of February 23, 1989, in which they concurred with Shieldalloy Metallurgical Corporation's subject plan. After talking with you, I contacted Mr. Glatzel, Region 5 EPA, and discussed the referenced decontamination and decommissioning plan with him. I agreed to forward a copy of Ohio EPA's letter for his use and information, also. In addition, I had spoken with Ms. Crook, Ohio EPA, regarding the subject matter and status of the agency's response to your letter of March 21, 1989. She indicated that the letter had been forwarded to Rick Sahli who is assembling the requested information and will respond to your letter within the next couple of weeks.

If there are any questions or additional information, which would assist you or the other two agencies in defining the jurisdictional responsibilities, please do not hesitate to call me.

Sincerely,

David R. Smith

David R. Smith

DRS:tmc
Enclosure

cc: Mr. Rich Fahey, Arter and Hadden
Dr. John Fillo, ENSR Environmental Services
Dr. George T. Campbell, V.P. Technology - SMC
Mr. Michael R. Morgenstern, Envir. Mgr. - SMC

OhioEPA
State of Ohio Environmental Protection Agency
P.O. Box 1049, 1800 WaterMark Dr.
Columbus, Ohio 43266-0149

Toward A Cleaner Environment

February 23, 1989

Richard F. Celeste
Governor

Dr. George T. Campbell
Shieldalloy Metallurgical Corporation
P.O. Box 768
Newfield, NJ 08344

Dear Dr. Campbell:

The Ohio EPA's Division of Solid and Hazardous Waste and Division of Water Pollution Control have reviewed Shieldalloy Metallurgical Corporation's proposal for the decommissioning of their Cambridge, Ohio facility. At this time I concur with your proposal for the decommissioning and decontamination at the facility.

However, given the nature of the materials located at the site this concurrance does not release Shieldalloy Metallurgical Corporation from the obligation to correct any future problems detected thru ground or surface water monitoring. To monitor the impact of the decommissioned and decontaminated facility on surface and ground water at the facility, Shieldalloy Metallurgical Corporation shall prepare a surface and ground water monitoring plan. This plan shall be submitted to Ohio EPA for approval and be implemented when the project is completed. If you have any questions regarding this approval please contact Vaughn Laughlin at (614) 644-2782.

Sincerely,

Richard L. Shank

Richard L. Shank, Ph.D.
Director

RLS/EK/pas

cc: Ed Kitchen, DSHWM, Ohio EPA
Paul Flanigan, DSHWM
Matt Tin, DWPC
George Elmarahgy
Bob Cottrill
Vaughn Laughlin
Rich Fahey, Arter and Hadden

SHIELDALLOY METALLURGICAL CORPORATION

DAVID R. SMITH
DIRECTOR OF ENVIRONMENTAL SERVICES

WEST BOULEVARD
P O BOX 768
NEWFIELD, NJ 08344

TELEPHONE (609) 692-4200
TWX (510) 687-8918
FAX (609) 692-4017

April 11, 1989

Mr. Thomas Glatzel
USEPA Region 5 WQS-TUB8
230 South Dearborn Street
Chicago, Il 60604

RE: Decontamination and Decommissioning Plan for Shieldalloy Metallurgical Corporation facility in Cambridge, Ohio

Dear Mr. Glatzel:

Please find enclosed a copy of Ohio EPA's letter of February 23, 1989, in which they concur with Shieldalloy Metallurgical Corporation's referenced proposal for decontamination and decommissioning at the Cambridge facility. As discussed during our telephone conversation today, the overall lead agency for this action is the U.S. Nuclear Regulatory Commission. Shieldalloy Metallurgical Corporation has and will continue to coordinate with U.S. Army Corps of Engineers and Ohio EPA as necessary to ensure that any work performed by Shieldalloy Metallurgical Corporation and its contractor is conducted in compliance with the provisions of the Clean Water Act.

If there are any questions which you may have regarding this matter, please do not hesitate to contact me.

Sincerely,

David R. Smith

David R. Smith

DRS:tmc
Enclosure

cc: Mr. James Blake, U.S. Army Corp of Engineers
Mr. Michael Gheen, U.S. Army Corp of Engineers
Mr. Richard Fahey, Arter and Hadden
Dr. John Fillo, ENSR Environmental Services
Dr. George T. Campbell, V.P. Technology - SMC
Mr. Michael R. Morgenstern, Envir. Mgr. - SMC

FEB 23 '89 13:53 OHIO EPA CO -- 89 15:16 P. 2

P.2/2

Ohio EPA

State of Ohio Environmental Protection Agency
P.O. Box 1049, 1800 WaterMark Dr.
Columbus, Ohio 43266-0149

Toward A Cleaner Environment

February 23, 1989

Richard F. Celeste
Governor

Dr. George T. Campbell
Shieldalloy Metallurgical Corporation
P.O. Box 768
Newfield, NJ 08344

Dear Dr. Campbell:

The Ohio EPA's Division of Solid and Hazardous Waste and Division of Water Pollution Control have reviewed Shieldalloy Metallurgical Corporation's proposal for the decommissioning of their Cambridge, Ohio facility. At this time I concur with your proposal for the decommissioning and decontamination at the facility.

However, given the nature of the materials located at the site this concurrance does not release Shieldalloy Metallurgical Corporation from the obligation to correct any future problems detected thru ground or surface water monitoring. To monitor the impact of the decommissioned and decontaminated facility on surface and ground water at the facility, Shieldalloy Metallurgical Corporation shall prepare a surface and ground water monitoring plan. This plan shall be submitted to Ohio EPA for approval and be implemented when the project is completed. If you have any questions regarding this approval please contact Vaughn Laughlin at (614) 644-2782.

Sincerely,

Richard L. Shank

Richard L. Shank, Ph.D.
Director

RLS/EK/pas

cc: Ed Kitchen, DSHWM, Ohio EPA
Paul Flanigan, DSHWM
Matt Tin, DWPC
George Elmarahgy
Bob Cottrill
Vaughn Laughlin
Rich Fahey, Arter and Hadden

DEPARTMENT OF THE ARMY
HUNTINGTON DISTRICT, CORPS OF ENGINEERS
502 EIGHTH STREET
HUNTINGTON, WEST VIRGINIA 25701-2070

REPLY TO ATTENTION OF:

March 21, 1989

Operations and Readiness Division
Regulatory Functions Branch
Chapman Run Wetland-Solid Waste Dump

David R. Smith
Director of Environmental Services
Shieldalloy Metallurgical Corporation
Post Office Box 768
Newfield, NJ 08344

Dear Mr. Smith:

Reference is made to your recent letter concerning your Decontamination and Decommissioning Plan for a 12.85 acre solid waste disposal site located in a wetland area adjacent to Chapman Run, a water of the United States.

It would appear that the fill you propose to place over the contaminated solid waste piles would be an integral part of the disposal process of the industrial waste. Also, it appears that your solid waste disposal requires authorization from the US Environmental Protection Agency and the Ohio Environmental Protection Agency under the provisions of the Clean Water Act. I have contacted both of these agencies concerning jurisdiction and status of your solid waste dumped in the wetlands.

Until we know the status and jurisdictional responsibility of the solid waste material discharged into the wetlands, we cannot make a final determination on the necessity for a 404 permit from this office. After coordination with the other agencies, you will be notified of the authorizations required for the project.

If you have any questions concerning the above, please contact James L. Blake of our Muskingum Basin Permit Office at 216-364-6177 or Michael D. Gheen at 304-529-5210.

Sincerely,

Gary D. Watson
Chief, Regulatory Functions
Branch

SHIELDALLOY METALLURGICAL CORPORATION

DAVID R. SMITH
DIRECTOR OF ENVIRONMENTAL SERVICES

WEST BOULEVARD
P O BOX 768
NEWFIELD, NJ 08344
TELEPHONE (609) 692-4200
TWX (510) 687-8918
FAX (609) 692-4017

February 27, 1989

Mr. Michael Gheen
U.S. Army Corps of Engineers
Huntington District
502 - 8th Street
Huntington, WV 25701-2070

RE: **DECONTAMINATION AND DECOMMISSIONING PLAN FOR THE SHIELDALLOY METALLURGICAL CORPORATION FACILITY IN CAMBRIDGE, OHIO**

Dear Mr. Gheen:

Shieldalloy Metallurgical Corporation (SMC) had submitted the referenced plan to the U.S. Nuclear Regulatory Commission (USNRC) on November 27, 1987 for their concurrence and approval. USNRC responded to this submittal in July 1988 with a number of comments and a request that SMC review these items and respond back with a revised decommissioning plan for their approval once more

One of their comments concern the possibility that approval by other agencies; local, state, and federal, may be necessary for other aspects of the site; such as disposal within the flood plain. Mr. Richard Fahey of Arter & Hadden representing SMC, has spoken with you and, on February 8, 1989, Mr. Fahey, Mr. Michael Morgenstern of SMC, and myself met with Mr. James L. Blake of your New Philadelphia, Ohio office at our Cambridge Plant. The purpose of this meeting and previous discussions, was to describe the locations of these NRC regulated materials with respect to the flood plain; describe, generically, the overall intent of in-situ decontamination of these materials and determine if a Section 404 Permit was required to be obtained from the Corps for past activities at the site. We informed Mr. Blake that SMC was working with the Ohio EPA regarding this matter to address any environmental concerns posed by these materials. Mr. Blake indicated that the Corps' position most likely would be that they would not require a 404 Permit since the slag disposal by the former owner of the plant had not been done for beneficial use. Mr. Blake, however, recommended that SMC write and formally request a determination from the Corps as whether or not a Section 404 Permit is required for these materials, which have been deposited within the 100 year flood plain by SMC's predecessor. Enclosed, for your use and information in this determination, is a copy of Document # 5990001-210 "Site and Flood Plain Maps for Shieldalloy Metallurgical Corporation, Cambridge Plant, Ohio" prepared by ENSR dated January 1989.

If you have any questions or need additional information concerning this matter, please do not hesitate to call me. Your expeditious review and decision concerning this matter will be greatly appreciated. In addition, I would like to personally thank Mr. Blake for his time and effort to meet with us at our Cambridge Plant and the assistance which he provided.

Sincerely yours,

SHIELDALLOY METALLURGICAL CORPORATION

David R. Smith

David R. Smith / jbh
Director of Environmental Services

DRS:jbh

Enclosures

CC: Mr. James Blake, US Army Corps of Engineers-New Philadelphia, OH
Mr. Rich Fahey, Arter & Hadden-Columbus, OH
Dr. John Fillo, ENSR - Pittsburgh, PA
Dr. George T. Campbell, V.P. Tech.-SMC
Mr. Michael R. Morgenstern, Env. Mgr.-SMC

APPENDIX G
TECHNICAL SPECIFICATION FOR PILE COVER MATERIALS

SECTION 1
GEOTEXTILE FABRIC

1.01 SCOPE

A. Furnish labor, materials and equipment necessary for placing geotextile filter fabric at designated fill area.

1.02 GENERAL

A. Following are major items of work included:

B. Furnishing and installing approved Geotextile Fabric at the locations and in the manner shown on the Drawing or as directed by the Engineer.

C. Protect`_n of Geotextile Fabric, both before and after placement, to prevent tearing or punctures.

1.03 MATERIALS

A. General. The Geotextile Fabric shall be of the woven type appropriate for the intended use as shown on the Drawings and shall be Nicolon 500, or approved equal.

B. Minimum Properties. The Geotextile Fabric shall have the following minimum properties:

- Standard Sieve (SW02215) 30-40
- Permeability (ASTM D4491) .152 cm/sec
- Flow Rate (ASTM-D4491) 130 gpm/ft^2

Fabric Weight	7.8 oz/sq yd
Thickness (ASTM D1777)	32 mils
Tensile Strength (ASTM D-4632)	460 lbs (warp)
	390 lbs (fill)
Puncture Strength (ASTM D-3787)	200 lbs
Burst Strength (ASTM D-3786)	700 psi
Trapezoid Tear (ASTM D-4533)	140 lbs (warp)
	125 lbs (fill)
Elongation at Break (ASTM D-4632)	29 lbs (warp)
	24 lbs (fill)

C. The Geotextile shall be free of any treatment or coating which might significantly alter its physical properties, and be dimensionally stable so that the fibers maintain their relative position with respect to each other. Storage and handling of the Geotextile Fabric shall be in accordance with the manufacturer's recommendations. In no case shall the Geotextile be exposed to direct sunlight, ultraviolet rays, temperature greater than 40°C (104°F), mud, dirt, dust, and debris to the extent that its strength, toughness, or permeability requirements would be diminished. Any Geotextile Fabric torn or punctured before placement shall not be used and shall be immediately removed from the project site.

1.04 CONSTRUCTION DETAILS

A. General. The Geotextile Fabric shall be protected from exposure to sunlight during transport and storage. After placement, the Geotextile shall not be left uncovered for more than three (3) working days.

B. Construction equipment shall not operate directly upon the Geotextile Fabric. Geotextile shall be joined only by overlapping, with a minimum overlap of 18 inches. All seams shall be subject to the approval of the Engineer. Geotextile which becomes torn or damaged shall be replaced or patched, as directed by the Engineer. The patch shall extend at least three (3) feet beyond the perimeter of the tear or damage.

C. The Geotextile Fabric shall be placed and anchored on the prepared subgrade surface as approved by the Engineer. The Geotextile shall be laid loosely so that placement of the overlying cover materials will not stretch or tear the Geotextile. The placement of cover materials shall begin at the toe and proceed up the slope. The Geotextile placement shall not progress more than fifty (50) feet ahead of the placement of cover materials.

D. The Geotextile shall be placed with the machine direction of fabric normal to the slope, and shall be placed upwards from the toe of the slope. The minimum dimensions of the fabric overlaps at ends and sides and the offset between adjacent roll ends shall be as indicated on the Drawings. Steel securing pins, 3/16-in diameter by 18-in long, pointed at one end and fitted with 1.5-in diameter metal washers on the other end, shall be used for securing the fabric to the subgrade surface. The pins shall be placed at overlap points of the fabric, and shall conform to the following spacing requirements:

Spacing per Row	4 feet
Spacing between Parallel Rows	8 feet

1.05 CLEAN UP

A. On completion of work, thoroughly clean area and remove surplus materials.

END OF SECTION

SECTION 2
FINAL COVER AND
SLOPE BASE PROTECTION

2.01 SCOPE

A. Furnish labor, materials and equipment necessary for placing final cover materials within the designated fill area.

2.02 GENERAL

A. Following are major items of work included:

B. Filling necessary for furnishing and placing to grade the final cover materials over the previously placed and compacted subgrade surface of excavated waste materials, and the excavated fill area.

C. Grading the final cover materials to the thicknesses and the lines, grades and elevations shown in the Drawings or as directed by the Engineer.

D. Compacting the final cover materials, and if necessary the final subgrade surface of the excavated waste materials previously placed within the designated fill area.

2.03 MATERIALS

A. Materials for the fine textured final cover shall be sound and durable natural soil free of stones and boulders, brush, stumps, waste or debris, and similar materials. Fine

---

*includes clay, sand, and rip rap only.

textured final cover materials shall be broadly defined as either clay or silt or sand, and shall conform to one or more of the following soil groups as defined by the Unified Soil Classification System and as follows:

(1) Clay

Symbol	Description
CL	Inorganic clays (low to medium plasticity), gravelly clay, sandy clay, or silty clay
CH	Inorganic clays (high plasticity)

Materials shall have at least 90% passing the #200 sieve, and not more than 5% organic content as shown by the loss on ignition test.

(2) Sand

Symbol	Description
SM	Silty sand, sand-silt mixtures

Material shall have at least 90% passing the 1/2" sieve, and not more than 20% passing the #200 sieve.

Materials for coarse textured slope base protection shall be as follows:

(3) Rip Rap (for toe of final slope in wetlands)

Material shall consist of rock, stone, cobbles or coarse gravel substantially free of shale or other soft, poor durability particles.

(a) Broken or blasted unweathered rock shall be well-graded, having no particles greater than 12 inches in maximum dimension, and substantially free from particles greater than 6 inches in maximum dimension, and containing less than 10 percent passing the 1/4 inch sieve.

(b) All materials other than broken or blasted unweathered rock shall meet the following gradation requirements:

Material Size	Percent Passing by Weight
12 inch maximum dimension	100
6 inch maximum dimension	90 to 100
2 inch square sieve	0 to 30
1/4 inch sieve	0 to 10

(4) Crushed Stone (for toe of slope outside wetlands)

Material shall consist of rock, stone, or coarse gravel substantially free of shale or other soft, poor durability particles.

(2) Crushed stone or gravel shall not have particles greater than 4 inches in maximum dimension and containing less than 10 percent less than the 1 inch sieve.

2.04 PLACEMENT

A. The placement of the final cover material of clay within the designated fill area shall be in lifts not exceeding 18 inches in thickness and shall conform to the lines, grades, and sections as shown on the Drawings or as otherwise directed by the Engineer. Clay material shall be compacted by not less than three (3) passes with an appropriate tracked vehicle or rubber-tired roller weighing not less than 20,000 pounds. A complete pass shall consist of the entire coverage of the filled area with one trip of the tracked vehicle or compactor. Each trip shall overlap the adjacent trip by not less than two (2) feet. Sand shall be spread uniformly in a single layer and shall not be compacted. Placing, spreading, and compacting of final cover materials may be performed at the same time at different points within the designated fill area when there is sufficient are to permit these operations to proceed simultaneously and in a satisfactory manner.

B. Rip-rap and crushed stone shall be placed uniformly at the location and dimensions shown on the drawings without compaction.

2.05 FINAL CONTOURS

A. The final grading of final cover materials shall conform as nearly as practical to the design pattern and shape as indicated on the Drawings. It should be recognized that the actual volume of materials to be excavated and hauled from the removal areas to the designated fill area may vary from that initially estimated, and also that the final volume of compacted waste materials may vary depending upon the results of actual compactive effort and final density of such materials. In the event that the final surface of waste materials placed is either higher or lower than the design grading, the final subgrade surface shall be governed by the shapes and slopes shown on the Drawings rather than by the indicated specific elevations of the final surface.

2.06 CLEAN UP

A. On completion of work, thoroughly clean area and remove surplus materials.

END OF SECTION

SECTION 3
TOPSOIL

3.01 SCOPE

A. Furnish labor, materials and equipment necessary to place topsoil upon previously placed and compacted subgrade of final cover materials within the designated fill area.

3.02 GENERAL

A. Following are major items of work included:

B. Furnishing, placing, and grading topsoil over the surface of the compacted final cover materials.

C. Topsoil to be graded to the thickness and the lines, grades and elevations shown on the Drawings or as directed by the Engineer.

3.03 SOIL TESTING

A. Prior to the delivery of any topsoil to the project site, soil tests shall be conducted by the Contractor on all materials proposed to be utilized for topsoil. At least four (4) representative samples of the materials to be tested shall be collected by the Contractor according to standard practice and as directed by the Engineer. The testing shall include the acidity and fertility of each sample, and also a sieve analysis to include the percentage of silt.

B. All testing shall be performed by a commercial testing laboratory approved in advance by the Engineer. Copies of the laboratory report including their findings and recommendations for seeding and fertilization shall be furnished to the Engineer within three (3) working days after receipt of said report by the Contractor.

3.04 MATERIALS

A. Topsoil shall be fertile and natural, friable and loamy, free of debris, stumps, brush, noxious weeds, litter, and stones larger than 1 inch in diameter. The topsoil shall not contain toxic substances that may be harmful to plant growth. A pH range of 5.0 to 7.5 is acceptable. Topsoil shall have a minimum organic content of 2.75%. Organic matter content may be raised by additives to achieve this minimum.

3.05 PLACEMENT

A. Topsoil shall be evenly placed and smoothly spread over the surface of the compacted final cover materials within the designated fill area and upon the perimeter berm shown on the Drawings. The final thickness of topsoil shall not be less than nine (9) inches after firming. Topsoil shall not be placed while frozen, excessively wet and soft, or in any other condition that may otherwise be detrimental to proper placing and grading of topsoil.

3.06 CLEAN UP

A. On completion of work, thoroughly clean area and remove surplus materials.

END OF SECTION

SECTION 4
SEEDING AND EROSION CONTROL

4.01 SCOPE

A. Furnish labor, materials and equipment necessary for seeding, fertilizing, mulching topsoiled areas within the designated fill areas, furnish labor, materials and equipment necessary to install a silt fence.

4.02 GENERAL

A. Following are major items of work included:

B. Application of lime or sulfur and fertilizer upon all topsoiled areas indicated on the Drawings or as directed by the Engineer.

C. Spreading the approved seed mixture(s) at the specified application rates upon all topsoiled areas.

D. Application and maintenance of mulch upon all topsoiled areas.

E. Installation of a silt fence around the site perimeter.

4.03 MATERIALS

A. General The Engineer may direct the Contractor to perform such tests as are deemed necessary to assure that these specifications are met.

B. Lime shall be agricultural ground, or pulverized calcareous or dolomitic limestone conforming to the standards of the Association of Official Agricultural Chemists, and complying with all existing State and Federal Regulations. The materials shall also comply with the following gradation:

Square Mesh Sieve	% Passing by Weight
#10	100
#20	90
#200	50

The minimum calcium carbonate equivalent shall be 90% by weight. Lime shall be applied to achieve a pH of 6.0.

C. Sulfur shall be unadulterated commercial or flour sulfur, and shall be delivered to the site in the original unopened containers or in bulk lots with the name of the manufacturer, material analysis and net weight specified.

D. Fertilizer shall be an acceptable commercial fertilizer containing 5% nitrogen, 10% potash, and 10% phosphorous, and commonly referred to as 5-10-10. The total nitrogen content shall either be derived from natural organic sources or be an urea-form fertilizer. The commercial fertilizer shall be delivered to the site in the original unopened containers which shall bear the guaranteed statement of analysis of the manufacturer. Fertilizer shall be applied at a rate of 500 lbs per acre.

E. Seed Mixture: The seed mixture shall be delivered to the site in new, clean, sealed containers. Labels and contents shall conform to all State and Federal regulations. Seed shall be subject to the testing procedures of the Association of Official Seed Analysis. The seed shall be delivered to the site accompanied by a properly executed certificate from the supplier of each type of seed attesting to its freshness, components, proportion (if mixed), minimum purity, and minimum germination. The seed quality and certificates are subject to approval by the Engineer prior to their use.

The Seed Mixtures for seeding shall conform to the following:

<u>For Slopes Flatter Than 8%</u>

Seed Name	Application Rate
Orchard Grass	8 lbs/acre
Red Clover	8 lbs/acre

<u>For Slopes Steeper Than 8%</u> (includes 3:1 side slopes)

Crownvetch*	10 lbs/acre
Tall fescue	20 lbs/acre

F. <u>Mulch</u> for seeding purposes shall be unweathered small grain staw (preferably wheat or barley) or good quality hay. The rate of application shall be 2 1/2 tons per acre.

G. <u>Water</u> used in this work will be furnished from approved off-site sources by the Contractor and will be suitable for irrigation and free from oil, acid, alkali, salt and other substances in quantities considered harmful to plant life. Hoses, pressure distributors, and other equipment required for the work shall also be furnished by the Contractor.

*Crownvetch seed shall be inoculated in accordance with the manufacturers instructions supplied with the seed.

H. Asphalt Emulsion shall be used for mulch anchoring on slopes 3 horizontal to 1 vertical or steeper. The asphalt emulsion shall conform to the requirements of ASTM D977 "Emulsified Asphalt". The application rate shall conform to the manufacturers' recommendations.

4.05 SEASON OF SEEDING

A. The dates for seeding shall be from March 15 to May 30 or from August 1 to September 30.

4.06 APPLICATION

A. Application of Lime or Sulfur: When applied dry, the limestone or sulfur shall be spread evenly and then thoroughly incorporated by approved means into the top three (3) inches of the topsoil to produce a roughened seedbed. When applied hydraulically, discing will not be necessary.

B. Application of fertilizer and seed: The preferred method of applying fertilizer and seed shall be hydraulic; however, any agronomically acceptable and reasonable method of uniformly applying the seed mixture and/or the fertilizer separately or together may be utilized if approved by the Engineer. The Engineer may direct the Contractor to temporarily halt any operation during the presence of strong winds, rains or other unacceptable conditions.

C. Application of Mulch: The mulch shall be applied by hydraulic methods. Mulching shall be performed as a separate operation after fertilization and seeding.

4.07 MAINTENANCE OF SEEDED AREAS

A. The Contractor shall replant any areas damaged by wind, erosion, or construction equipment during the life of the Contract to the satisfaction of the Engineer, using full amounts of all specified materials and all of the complimentary procedures.

B. Clean up and remove all debris resulting from the seeding operations on areas within and immediately adjacent to the project within five (5) days after completing the seeding and mulching operations.

4.08 SILT FENCE

A. Sedimentation control barrier (silt fence) shall consist of non-biodegradable woven polyproplyene fabric, 36 inches in width, and shall be attached to metal posts with chicken wire or wire fabric (hogwire) backing. An acceptable alternate is a pre-assembled sedimentation control barrier, consisting of woven polypropylene fabric 36 inches in width, with industrial netting and pre-stapled to wood poles.

B. Installation of silt fence to control erosion and surface run-off shall be at locations indicated on the drawings and as directed. Poles shall be set firmly in the soil at intervals varying from six (6) inches to ten (10) feet. Wire backing, then the fabric shall be attached to poles using "hog rings", nails, or staples. The bottom six (6) inches of fabric shall be placed in a narrow trench six (6) inches deep, on the upgradient side of the barrier and covered with soil. Pre-assembled sedimentation barriers shall be installed by first excavating a six (6) inch by six (6) inch trench. The unrolled barrier shall then be positioned in the back wall of the trench (downgradient side). The poles shall then be driven until the fabric is approximately two (2) inches from the bottom, then the toe-in flap shall be laid out on the trench bottom, and then covered with soil. Barrier sections shall be joined together in accordance with the manufacturer's instructions.

END OF SECTION

SECTION 5
BURIED WARNING TAPE

5.01 SCOPE

A. Furnish labor, materials and equipment necessary for installing a buried warning tape within the final cover of the slag pile.

5.02 GENERAL

Following are major items of work including:

A. Laying out a grid pattern prior to placing topsoil

B. Installing and anchoring warning tape

C. Covering of warning tape is considered to be part of the work called for in Section 3.

5.03 MATERIALS

A. Material for buried warning tape shall be colored yellow .004 mil. vinyl film, six (6) inches wide, in rolls of 1,000 l.f., as manufactured by Carlton Industries, Inc., Box 280, La Grange, Texas (1-800-231-5988) called "Smart Tape" or approved equivalent.

B. The tape shall be custom printed with the words "Caution, Low-Level Radioactive Slag Buried Below". The tape shall also bear the standard Radiation Symbol as shown on Attachment 5-1. The Radiation Symbol shall be printed between each group of the words printed. The tape and the print shall be resistant to acids and alkalis.

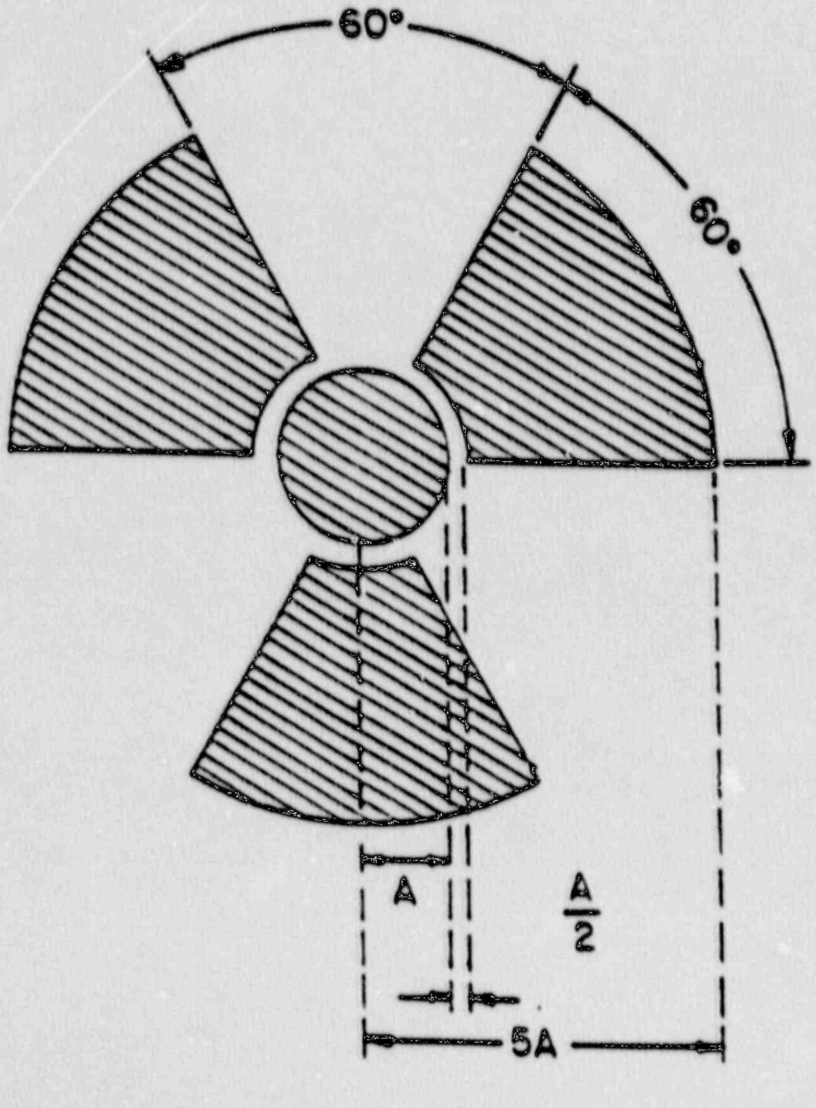
5.04 INSTALLATION

A. The tape shall be placed on the completed geotextile surface prior to placing the twelve (12) inches of sand and nine (9) inches of topsoil. The tape shall be at the base of the sand layer. The tape shall be laid flat, with the printed side up on a square grid pattern of 30 by 30 feet over the entire pile within the limits shown on the drawings. The tape shall be anchored temporarily by placing small piles of sand over the tape and/or pinned with long nails or wire pins. As the grid pattern is established and the tape installed and anchored, the sand shall be placed as soon as possible to prevent distortion by wind, and pedestrian or vehicle use.

END OF SECTION

RADIATION SYMBOL

1. CROSS-HATCHED AREA IS TO BE MAGENTA OR PURPLE.
2. BACKGROUND IS TO BE YELLOW.



APPENDIX H

SHIELDALLOY - CAMBRIDGE, OHIO

SOIL TEST DATA

CLAY

1) Messerschmidt Construction

Analysis by Mid-Eastern GeoTech

Material: Silty Clay

Sample No.: 1

Maximum Density ASTM D-698-A	91.8 pcf
Optimum Moisture	26.6
Permeability	4.9×10^{-8} cm/sec.
Liquid Limit	50.2
Plastic Limit	27.7
Plastic Index	22.5
Natural Water Content	40.0

Grain Size %

Gravel	0%
Sand	10%
Silt, Clay	90%

2) Clay sample sent by Pete Lewis - October 1989

Analysis by GZA

Material: Red-brown clay and silt

Grain Size %

Gravel	0%
Sand	12%
Silt	65%
Clay	23%

Liquid Limit	36
Plastic Limit	20
Single Point Density ASTM D-698-A	105.1 pcf
Water Content	20.8%
Permeability	9.5×10^{-6} cm/sec.

SAND

1) Stocker Sand and Gravel

Analysis by Ohio DOT Testing Lab

Grain Size %

Gravel	1%
Sand	97%
Silt, Clay	2%

2) Sand sample sent by Pete Lewis - October 1989

Analysis by GZA

Material: Brown fine to coarse sand

Grain Size %

Gravel	0%
Sand	99%
Silt	1%
Clay	0%

RIP-RAP

1) Chesterhill Stone Co.

Grain Size %

100% passing 12"
58% passing 6"
34% passing 4"
3% passing 2"

APPENDIX I

TMA
Thermo Analytical Inc.

TMA
Thermo Analytical Inc.
TMA/Eberline
Post Office Box 3874
Albuquerque, NM 87190 3874

TO CHRIS KEYWORTH
ENSR
ACTON, MA

FROM DOUG DAVIS
TMA/E
SHIELDALLOY

DATE

WE ARE SENDING YOU THE FOLLOWING ITEMS: ☒ ATTACHED ☐ UNDER SEPARATE COVER VIA:

- ☐ INTEROFFICE MEMO
- ☐ FINAL DATA REPORT
- ☐ LETTER
- ☒ OTHER (SPECIFY) SEE BELOW
- ☐ PRELIMINARY DATA REPORT
- ☐ SAMPLES (SPECIFY)
- ☐ SPECIFICATIONS/PROCEDURES

ITEM NO.	DATE	COPIES	DESCRIPTION
1	Various	15 pages	Air Particulate Sample Reporting Logs Samples AR-1 thru AR-210
2	6/6/89	4 pages	Gamma Ray Exposure Rate Survey - Around Area "A" perimeter
3	9/28 - 9/29/89	3 pages	" " - on Area "A"
4	9/28/89	4 pages	" " - on Area "B"

THESE ARE TRANSMITTED AS CHECKED BELOW:

- ☐ For Approval
- ☒ For Your Use
- ☒ As requested by John E
- ☐ For Analysis
- ☐ For Review and Comment
- ☐ Other (Specify)

TRANSMITTED VIA:

☒ Air Express ☐ UPS ☐ U.S. Mail ☐ Telefax ☐ Other (Specify)

REMARKS: Please return a signed copy of this sheet. Thanks
DD

RECEIPT ACKNOWLEDGEMENT
SIGNATURE [signature]

DATE

SIGNED [signature]

TMA/Eberline

GAMMA - RAY EXPOSURE RATE SURVEY

[SIT]E SHIELDALLOY LOCATION AREA "A"

DATE 9-28-89 SURVEY NO. ______ SURVEYED BY B. COLE

PIC

CALIBRATION FACTOR

SERIAL NO. V-4017

N/A mR/hr/cpm

INSTRUMENT AND DETECTOR

SCALER MODEL PRS-2 DETECTOR MODEL SPA-3

SERIAL NO. 523 Due: 1-10-90 SERIAL NO. 80 Due: 10-25-89

GRID POINT	μR/hr (10cm)	GRID POINT	μR/hr (1M)	GRID POINT	μR/hr (10cm)	GRID POINT	μR/hr (1M)
1	19.9		17.2	13	13.1		14.5
2	13.6		12.3	14	18.6		16.4
3	10.6		9.6	15	12.4		12.7
4	14.4		12.6	16	12.5		12.8
5	11.4		11.5	17	12.3		12.2
6	12.5		11.6	18	17.6		19.2
7	12.1		11.3	19	20.4		20.6
8	24.5		18.3	20	17.4		22.1
9	12.3		12.3	21	16.0		13.2
10	13.7		13.4	22	13.0		13.0
11	15.4		15.6	23	20.8		20.1
12	19.2		17.6	24	13.0		13.3

BACKGROUND OFF - SITE

______ μR/hr

COUNT TIME

0.5 minutes

L[...]3.17

FORM SC-3

TMA/Eberline
GAMMA - RAY EXPOSURE RATE SURVEY

SITE: SHIELDALLOY LOCATION: AREA "A"

DATE: 9-28-89 SURVEY NO. ______ SURVEYED BY: B COLE / D BEARD

PIC

CALIBRATION FACTOR

SERIAL NO. ______ ______ mR/hr/cpm

INSTRUMENT AND DETECTOR

SCALER MODEL: PRS-2 DETECTOR MODEL: SPA-3

SERIAL NO.: 523 DUE: 1-10-90 SERIAL NO.: 80 DUE 10-25-89

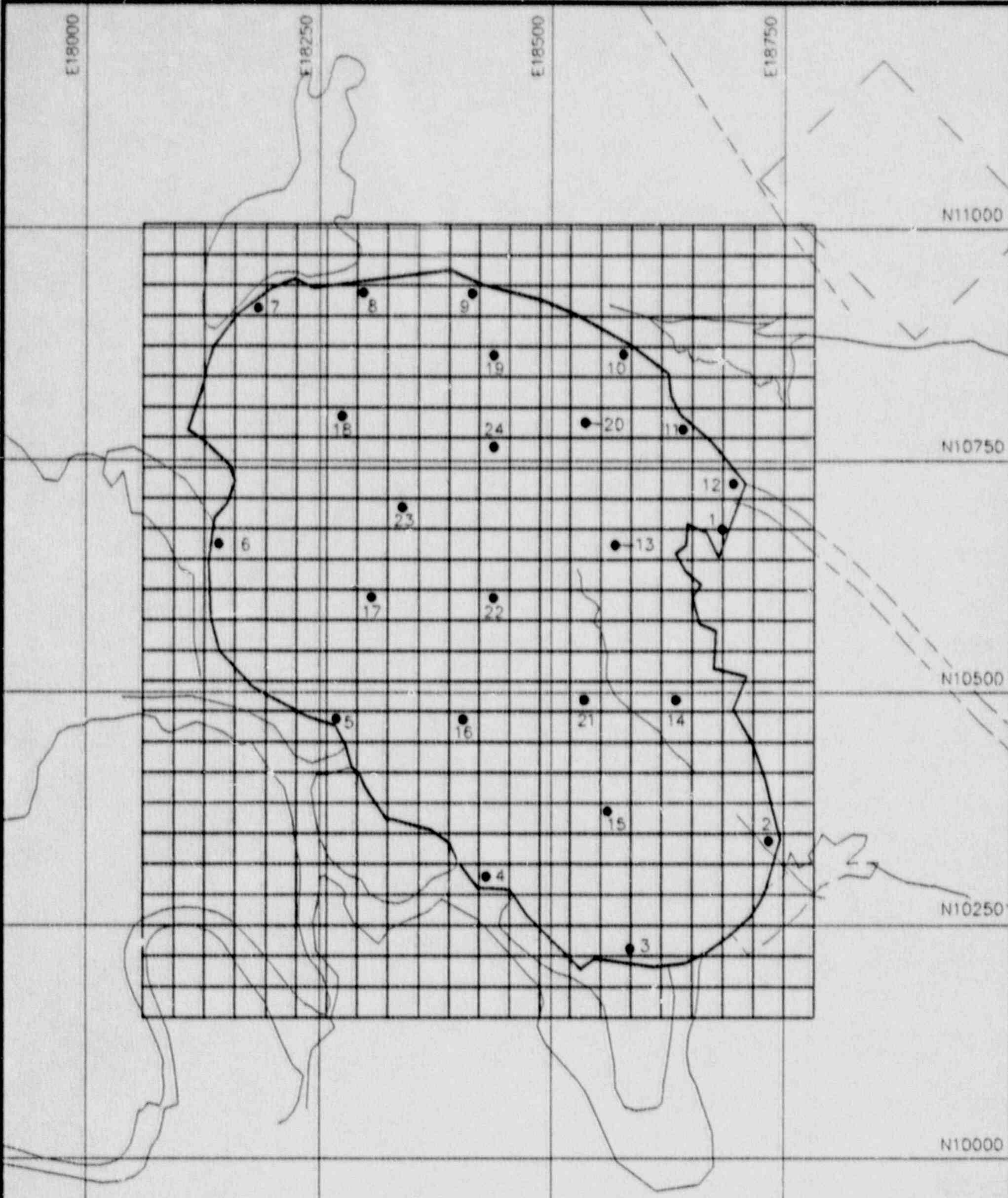
GRID POINT	10cm ~~μR/hr~~ cpm	GRID POINT	1M ~~μR/hr~~ cpm	GRID POINT	10cm ~~μR/hr~~ cpm	GRID POINT	1M ~~μR/hr~~ cpm
1	29712		24826	13	17708		20,140
2	18570		16330	14	27,300		23,462
3	13196		11536	15	16,452		17,034
4	19966		16754	16	16,526		17,164
5	14634		14870	17	DB ~~22,786~~ 16,278		~~17,912~~ 16,164 DB
6	16682		14984	18	25,656		28,386
7	15916		14562	19	30,614		30,978
8	37748		26818	20	25,230		33,482
9	16324		16308	21	22,786		17,912
10	18728		18234	22	17,530		17,504
11	21774		22108	23	31,2[illegible]4		30,030
12	28436		25550	24	17,460		17,976

BACKGROUND OFF - SITE ______ μR/hr

COUNT TIME: 0.5 MINUTES

…073.17

NOTE GRID POINTS 13-24 READINGS WERE TAKEN 9-29-89



9/28 (1-12) 3' UP FROM THE TOE OF THE PILE
9/29 (12-24) ON TOP OF PILE

0 150 300

SCALE IN FEET

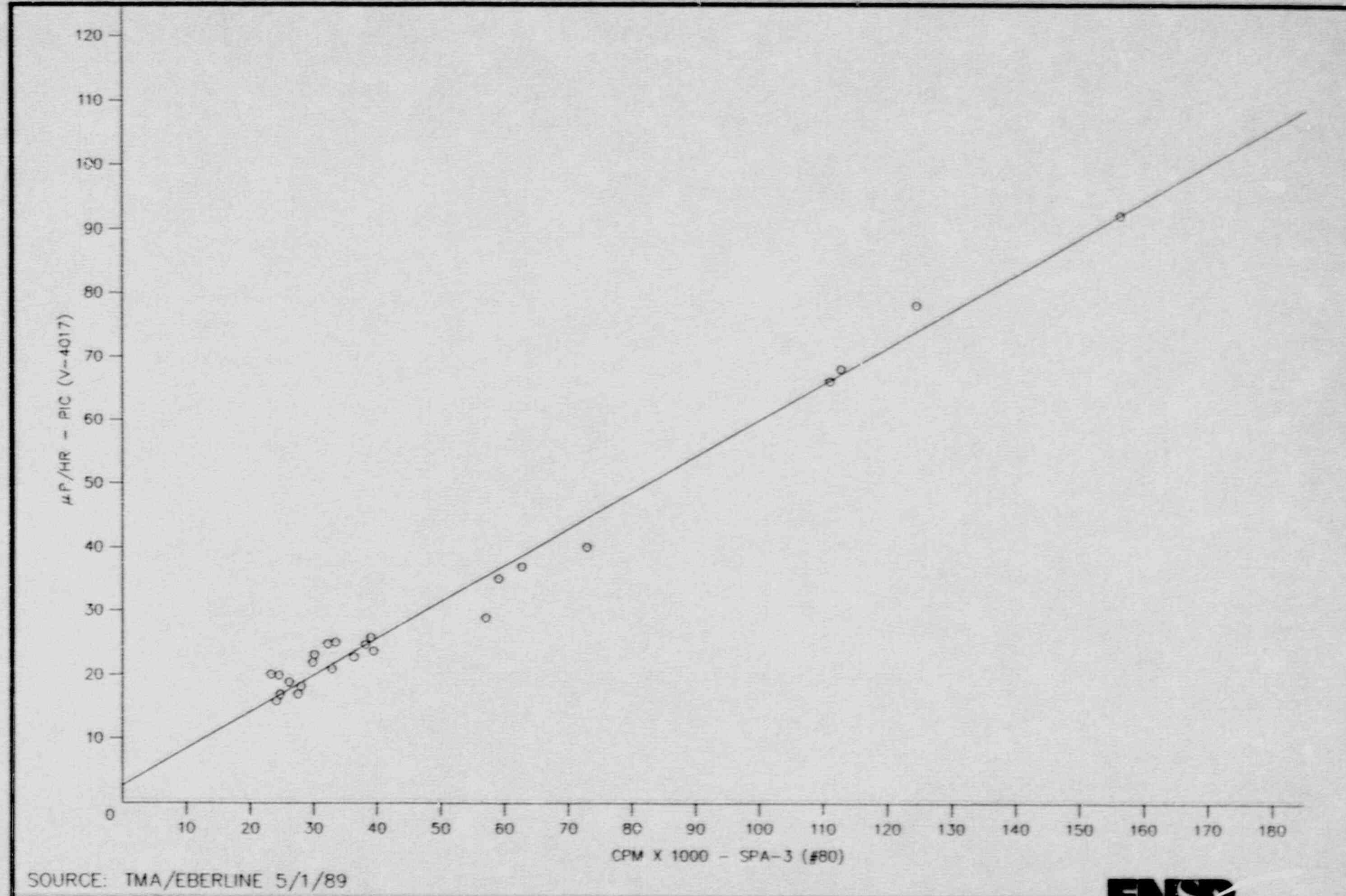
NOTE: GRID INTERVALS AT 10 METERS

WEST PILE - LOCATION OF GRID POINTS
GAMMA EXPOSURE RATE SURVEY 9/28/89

ENSR

599011A

5990221A



ENSR

CALIBRATION CHART CPM TO μR/HR

APPENDIX J

APPENDIX J

RADON MEASUREMENTS AND CALCULATIONS

Assessment of the Consequences of Radon Emanation from the West Pile

The Shieldalloy West Pile contains Radium-226, a source of Radon-222. The Radon-222 produced within this material can migrate to the ground surface by means of diffusion. At the ground surface it can be introduced to the ambient air or structures potentially located at the site. An analysis has been performed to estimate the risks associated with these two exposure pathways.

For the evaluation of both pathways, the key parameter is the flux of Radon-222 from the surface. The theoretical calcualation of the flux, and comparison with measured values, are presented below.

1.0 Background

This study presents analytical and numerical solutions to a radon transport model for several different boundary conditions. The model describes the physical processes governing radon production, decay, and diffusive transport through slag and soil. The model is able to deal with both the Radon-222 ("Radon") and Radon-220 ("Thoron") isotopes. Convective transport driven by pressure differences is not addressed in the model. Solutions are presented for steady state conditions for a single medium and for multiple layers. Computer programs have been developed to solve the transport equation for these configurations. These programs can be used to estimate the diffusive flux of radon from the surface of a Radium-226 or Thorium-232 bearing medium and the reduction of this flux resulting from the addition of overburden.

2.0 Equation for Diffusive Transport of Radon

The equation for the time-dependent diffusive transport of radon gas through slag or soil is given by:

$$\frac{dC}{dt} = D_e \frac{d^2C}{dx^2} - L\,C + G \qquad (1)$$

where

- t = time(s)
- x = distance(m)
- C = radon gas concentration in soil pores (pCi/m^3),
- D_e = effective diffusivity in the soil pores (m^2/s),
- L = radioactive decay constant (sec^{-1})
  = $\ln(2)/t_{1/2}$
- $t_{1/2}$ = radon isotope half-life(s)
- G = volumetric radon generation rate ($pCi/(m^3\ s)$)

The generation term, G, is given by:

$$G = E\, d_m\, A\, L\, (1 - \epsilon) / \epsilon \qquad (2)$$

where

- E = emanation coefficient (0-1)
- d_m = media density (kg/m^3)
- A = Radium-226 or Thorium-232[1] activity (pCi/kg)
- ϵ = media porosity (0-1)

Equation (1) is a second order, non-homogeneous partial differential equation (PDE) with constant coefficients. The independent variables are x (space) and t (time), and the

---

[1] Assuming secular equilibrium within the Th-232 chain.

dependent variable is C(x,t). The radon temporally and spatially varying flux through the medium is given by:

$$F(x,t) = \epsilon \, D_e \frac{dC(x,t)}{dx} \qquad (3)$$

where

F(x,t) = radon flux at (x,t) (pCi/(m^2sec))

2.1 Solution for a Semi-Infinite Medium

Assume that medium containing Radium-226 or Thorium-232 extends downward an "infinite" extent from a surface at the point x=0, with x increasing in the downward direction. The medium is assumed to be uniform in terms of porosity, effective diffusivity, emanation coefficient, and the activity of Radium-226 or Thorium-232. Methods for calculating the radon flux and pore concentration are presented below.

If one assumes that enough time has passed for steady state conditions to be attained, then Equation (1) reduces to:

$$D_e \frac{d^2C}{dx^2} - L\,C = -\,G \qquad (4)$$

Equation (4) is a second-order, non-homogeneous, ordinary differential equation with constant coefficients. The independent variable is x and the dependent variable is C(x). The flux is given by Equation (3) but is not a function of time. The analytical solution of the non-homogeneous Equation (4) was obtained by first solving the homogeneous version of Equation (4) (i.e., G = 0), and then applying the mathematical technique called the Method of Undetermined Coefficients. The resulting solution was derived as:

$$C = A \exp(M_1 x) + B \exp(M_2 x) + G / L \tag{5}$$

where

A, B, M_1 and M_2 are constants to be determined from the boundary conditions.

Assuming that the x axis is oriented into the ground surface (with x = 0 at the ground surface), and the following boundary conditions:

$$C(x = 0) = 0 \tag{6}$$

$$\epsilon D_e \frac{dC}{dx} = 0 \quad \text{at } x = \infty \tag{7}$$

the constants A, B, M_1, M_2 were evaluated for these boundary conditions. After some algebraic manipulation, Equation (5) was reduced to the following expression:

$$C = C_0 \left(1 - \exp(-\alpha x) \right) \tag{8}$$

where

$C_0 = G / L$
$\alpha = (L / D_e)^{1/2}$

The corresponding steady state flux was derived as:

$$F = \epsilon D_e \alpha \exp(-\alpha x) \tag{9}$$

A computer program was written to compute the steady-state radon concentration and flux given by Equations (8) and (9). This program was used to calculate the Radon-222 and Radon-220 fluxes for the Shieldalloy West Pile. For this calculation, the activities of Radium-226 and Thorium-232 were taken to be 15.5 and 15 pCi/g, respectively. These activities are based upon a weighting by mass of the mean activity of the "original" West Pile material and the mean activity of the excavated material that was placed on the West Pile as part of the decontamination program (see Tables 2-1 and 2-2 of the plan). The effective diffusivity for both radon isotopes was chosen to be 6.3×10^{-6} m^2/s, which is an average of the 2 values for mill tailings presented in Table 2.3 of (Nazaroff, 1988). A porosity value of 0.5 was selected for the slag material based upon the large fraction of "air bubbles" observed for this material. An emanation coefficient of 0.02 was used, which is the value quoted for lava fields in Table 2.6 of (Nazaroff, 1988). The average slag density was measured to be 1.6 g/cm^3. The calculated Radon-222 and Radon-220 fluxes, as a function of depth below the slag surface, are displayed in Figures 1 and 2, respectively. The surface flux for Radon-222 was calculated to be about 0.9 $pCi/(m^2\ s)$. Although the calculated flux of Radon-220 (68 $pCi/(m^2\ s)$) is much higher than the value for Radon-222, it poses less of a hazard due to its much shorter half life (55.6 seconds vs 3.82 days for Radon-222).

2.2 Steady-State Solution of the Transport Equation for Multiple Layers

In addition to determining the concentration and flux of radon within the Radium-226 or Thorium-232 bearing media, it is also useful to calculate the reduction in flux at the ground surface when overburden is placed over the radioactive medium.

For multiple layers (e.g., layers with different properties), the derivations of Section 2.1 were extended to derive ordinary non-homogeneous equations for each of the layers, i.e.,

$$D_e(k) \frac{d^2C(k,x)}{dx^2} - L\,C(k,x) = -\,G(k) \qquad (15)$$

where k = layer number, k = 1..N, with k = 1 for the top layer, k = N for the bottom layer, and N = number of layers. The bottom layer (k = N) is assumed to extend into the ground to infinity. Similarly, for each layer, the general solution was obtained as:

$$C(k,x) = A(k)\cdot\exp(\alpha(k)\cdot x) + B(k)\cdot\exp(-\alpha(k)\cdot x) + G(k)/L \qquad (16)$$

where

> $A(k)$, $B(k)$, and $\alpha(k)$ are constants within each layer, k
> $\alpha(k) = (L\ /\ D_e(k))^{1/2}$

The flux in each layer is given by:

$$F(k,x) = \alpha(k)\cdot A(k)\ \exp(\alpha(k)\cdot x) - \alpha(k)\cdot B(k)\ \exp(-\alpha(k)\cdot x) \qquad (17)$$

The boundary conditions were derived in a similar manner as:

Top layer (k = 1):

$$C(1, x = 0) = 0 \qquad (18)$$

Bottom Layer (k = N):

$$F(N, x = \infty) = 0 \qquad (19)$$

N-1 Layer Interfaces (k = 1..N-1):

$$C(k,\ x = X(k)) = C(k + 1,\ x = X(k)) \qquad (20)$$

$$F(k,\ x = X(k)) = F(k + 1,\ x = X(k)) \qquad (21)$$

where X(k) is the location of the interface between layer k and layer k + 1. Equations (18) through (21) provide a consistent set of boundary conditions that conserve both concentration and flux at the layer interfaces. In addition, the boundary conditions reduce to the single layer boundary conditions for N = 1. Equations (18) through (21) result in 2 x N equations in 2 x N unknowns (i.e., the layer constants A(k) and B(k)). Once the layer constants are known, the concentration and flux profiles through the individual layers can be computed.

The equations were solved using a high-accuracy matrix solver: the IMSL routine "LSARG". The accuracy is required because the governing equations and boundary conditions result in very ill-conditioned matrices. The results were verified by comparing the multi-layer solution with the single layer solution described by Equations (8) and (9). When all the layers were provided with the same properties, the results were identical.

The computer program was used to evaluate the reduction of Radon-222 and Radon-220 fluxes due to the placement of cover material on the West Pile slag. For this calculation, the slag parameters were the same ones used in the steady state calculation of flux from the slag itself. The basis of the calculation was a cover of 3 feet of clay, 1 foot of silty sand and 9 inches of topsoil. The parameters used for the cover materials are given in Table 1. The reduction in Radon-222 flux was from 0.9 to 0.05 pCi/(m^2 s) - a reduction of 94 percent, and the Radon-220 flux was reduced from 68 pCi/(m^2 s) to virtually zero. This reduction of Radon-220 flux is due to its short half-life.

2.3 Field Measurement of Radon Flux

A series of measurements of radon flux were made on the surface of the West Pile, prior to the addition of cover material. Based upon an analysis of these 29 measurements (see Attachment J-1), the average Radon-222 flux from the surface was

Table 1

Soil Properties Used in the Calculation of Radon Flux Reductions

Soil	Diffusivity (m^2/s)	Density (g/cm^3)[a]	Porosity
Topsoil	8×10^{-7} [b]	1.44	0.5[c]
Silty Sand	3×10^{-6} [d]	1.44	0.4[e]
Clay	7×10^{-7} [f]	1.85	0.55[g]

(a) Measured values

(b) Table 2.3 from (Nazarzoff, 1988) - average of values for loams

(c) Table 2.4 from (Freeze, 1979) - average for silt and clay

(d) Table 2.3 from (Nazaroff, 1988) - average of values for silty sands

(e) Table 2.4 from (Freeze, 1979) - average for silt and sand

(f) Table 2.3 from (Nazaroff, 1988) - average of values for clays

(g) Table 2.4 from (Freeze, 1979) - average for clay found to be 2.0 pCi/(m^2 s). This value is approximately twice the value obtained by theoretical calculation, providing support for the methodology used.

3.0 Consequences of Radon Emanation

3.1 Consequences of Emanation from the Engineered Pile Design

The Radon-222 flux emanating from the slag contained in the decommissioned pile can be derived by multiplying the measured radon flux by the flux reduction factor, calculated in Section 2.2, resulting from the addition of the cover material.

$$\text{Net flux} = \frac{2.0\ \text{pCi}/(\text{m}^2\ \text{s}) \times 0.05\ \text{pCi}/(\text{m}^2\ \text{s})}{0.9\ \text{pCi}/(\text{m}^2\ \text{s})}$$

$$= 0.1\ \text{pCi}/(\text{m}^2\ \text{s}).$$

This flux is 25 percent of the average of 5 background measurements taken in the area and also 25 percent of the average worldwide flux of 0.4 pCi/(m^2 s) (see page 86 of Nazaroff, 1988). This flux value is taken as the basis for examination of two situations:

- potential exposure due to ambient airborne radon concentrations, and
- potential exposure due to indoor concentrations of radon in a structure postulated to be constructed on the pile.

<u>Ambient Airborne Concentration</u>

To calculate the ambient radon concentration over the decommissioned pile, consider the area of the slag to be a rectangle with a length, L, along the wind and a width, W, perpendicular to the wind. As the wind blows across this area (L x W), the radon emitted from the slag will be mixed to an increasing height. The plume height at the upwind edge of the slag will be zero and the height at the downwind edge will be some value, H_{max}. Let the average height of this plume be H_m. The radon concentration within the volume ($L \times W \times H_m$) is given by:

$$C = F \cdot L \cdot W/(W \cdot H_m \cdot u) \quad (22)$$

where

C = radon concentration (pCi/m^3)
F = radon flux ($pCi/(m^2\ s)$)
u = wind speed (m/s)

The highest concentrations will occur under light wind ($u \approx 1$ m/s) and stable conditions in a rural setting. Under these conditions, the average plume height, H_m, can be expressed in terms of L as follows (Briggs, 1973):

$$H_m = (\pi/2)^{1/2} \cdot 0.016 \cdot (L/2) \quad (23)$$

Equation 22 can then be written as:

$$C \approx 100 \cdot F \quad (24)$$

Using the calculated radon flux of 0.1 $pCi/(m^2\ s)$, the radon concentration in the air is found to be 10 pCi/m^3 or 0.01 pCi/liter.

Summarizing, if one assumes worst-case dispersion conditions (1 m/s wind speed and Class F atmospheric stability), then the calculated ambient Radon-222 concentration associated with the measured flux is 0.01 pCi/l, which is well below the 3 pCi/l level recommended for unrestricted areas.

Indoor Concentration

A knowledge of the Radon-222 flux does not by itself allow one to calculate the Radon-222 concentration within a structure. Variables such as basement integrity and building ventilation will strongly influence the actual concentration. One can, however, make an estimate for an average house. A study by Andreas C. George, et al. (George, 1978) estimated the average indoor radon concentration to be about 0.8 pCi/l. This study served as the basis for the risk levels found in the "Citizen's Guide to Radon" (EPA, 1986). The estimated radon concentration for a house situated on the pile is therefore given by:

$$\frac{0.1\ pCi/m^2/s}{0.4\ pCi/m^2/s} \times 0.8\ pCi/l = 0.2\ pCi/l$$

This concentration is well below the EPA suggested "no action" level of 4 pCi/l (EPA, 1986)

3.2 Consequences of Accidental Intrusion

The probability of accidental intrusion is very low. An identifying tape is being provided below the topsoil layer to alert other parties to the presence of radioactive materials. For the purposes of the following discussion, the assumption is made that the entire cover, consisting of approximately 5 ft of material, plus the geotextile biobarrier, is removed from a significant portion of the pile. This is in itself an extremely unlikely occurrence. For the indoor exposure analysis, it must further be assumed that a home is constructed directly on the slag of the West Pile after removal of cover material.

The flux value taken as the basis for examination of the two situations, ambient and indoor Radon-222 concentrations is the average measured flux on the surface of the slag prior to addition of cover material - 2.0 pCi/(m^2 s). This flux is 5 times the average of the 5 background measurements taken in the area and 5 times the average worldwide flux of 0.4 pCi/(m^2 s).

Ambient Airborne Concentration

If one assumes the same worst-case dispersion conditions as applied previously (1 m/s wind speed and Class F atmospheric stability), then the calculated ambient Radon-222 concentration associated with the measured flux is 0.2 pCi/l, which is well below the 3 pCi/l level recommended for unrestricted areas.

Indoor Concentration

Using the estimation methodology for indoor radon concentration previously described, concentration for a house situated on the slag is therefore given by:

$$\frac{2.0 \text{ pCi/m}^2\text{/s}}{0.4 \text{ pCi/m}^2\text{/s}} \times 0.8 \text{ pCi/l} = 4.0 \text{ pCi/l}$$

This concentration is equal to the EPA suggested "no action" level of 4 pCi/l (EPA, 1986) and indicates an acceptable level of risk for this low probability occurrence.

APPENDIX J REFERENCES

Briggs, G.A., 1973. "Diffusion Estimation for Small Emissions," ATDL Contribution File No. 79, Atmospheric Turbulence and Diffusion Laboratory, Oak Ridge Tennessee.

EPA, 1986. "A Citizen's Guide to Radon," Office of Air and Radiation, U.S. Environmental Protection Agency, OPA-86-004.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater, ISBN 0-13-365312-9, Prentice-Hall, Inc., Englewood Cliffs, NJ.

George, A.C. and A.J. Breslen, 1978. "The Distribution of Ambient Radon and Radon Daughters in Residential Buildings in the New Jersey-New York Area." The National Radiation Environment III, Houston, TX.

Nazaroff, W.W. and A.V. Nero, 1988. Radon and its Decay Products in Indoor Air, ISBN 0-471-62810-7, John Wiley and Sons.

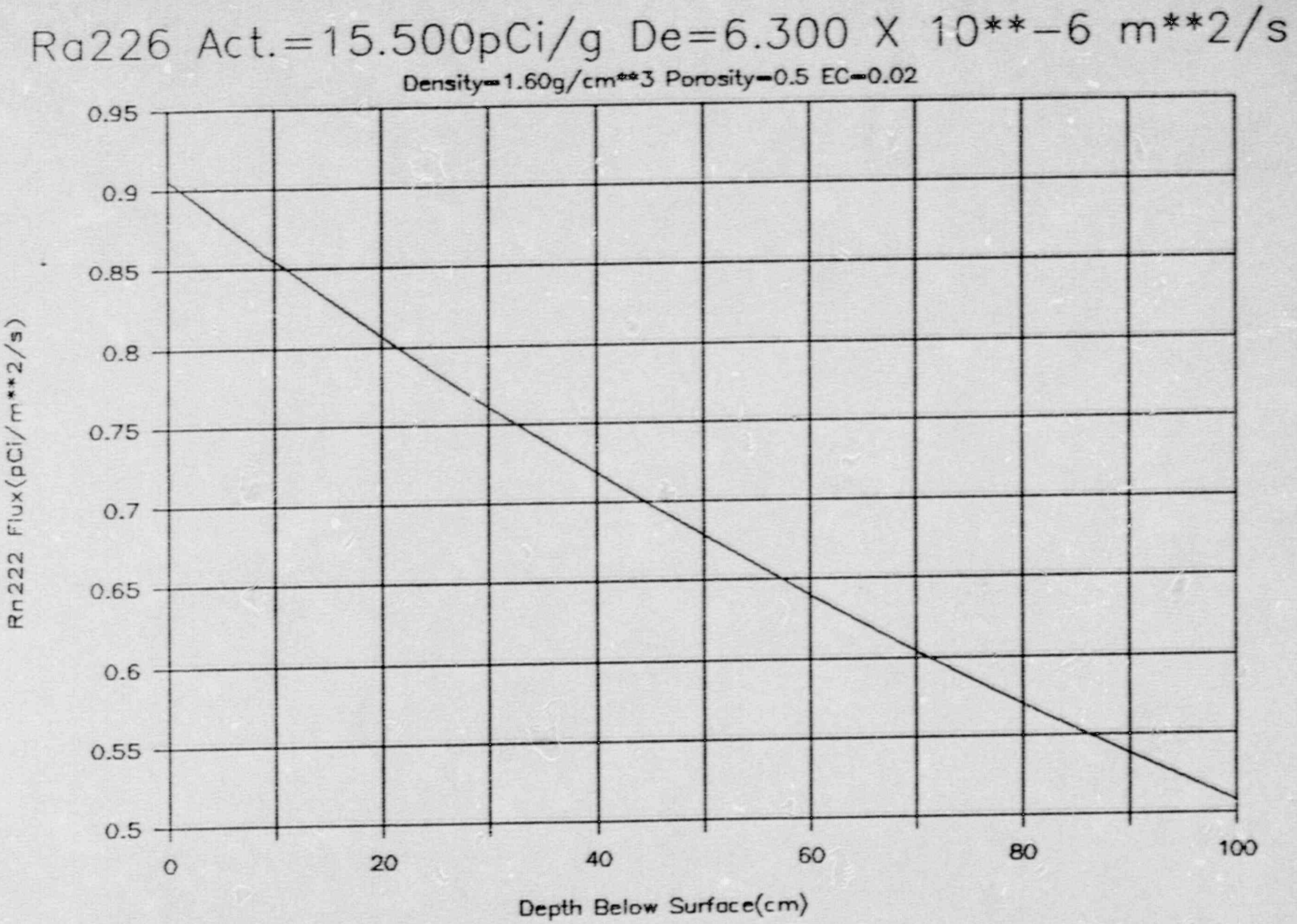


Figure 1. Calculated Radon 222 Flux for the West Pile Slag as a Function of Distance Below the Surface of the Slag

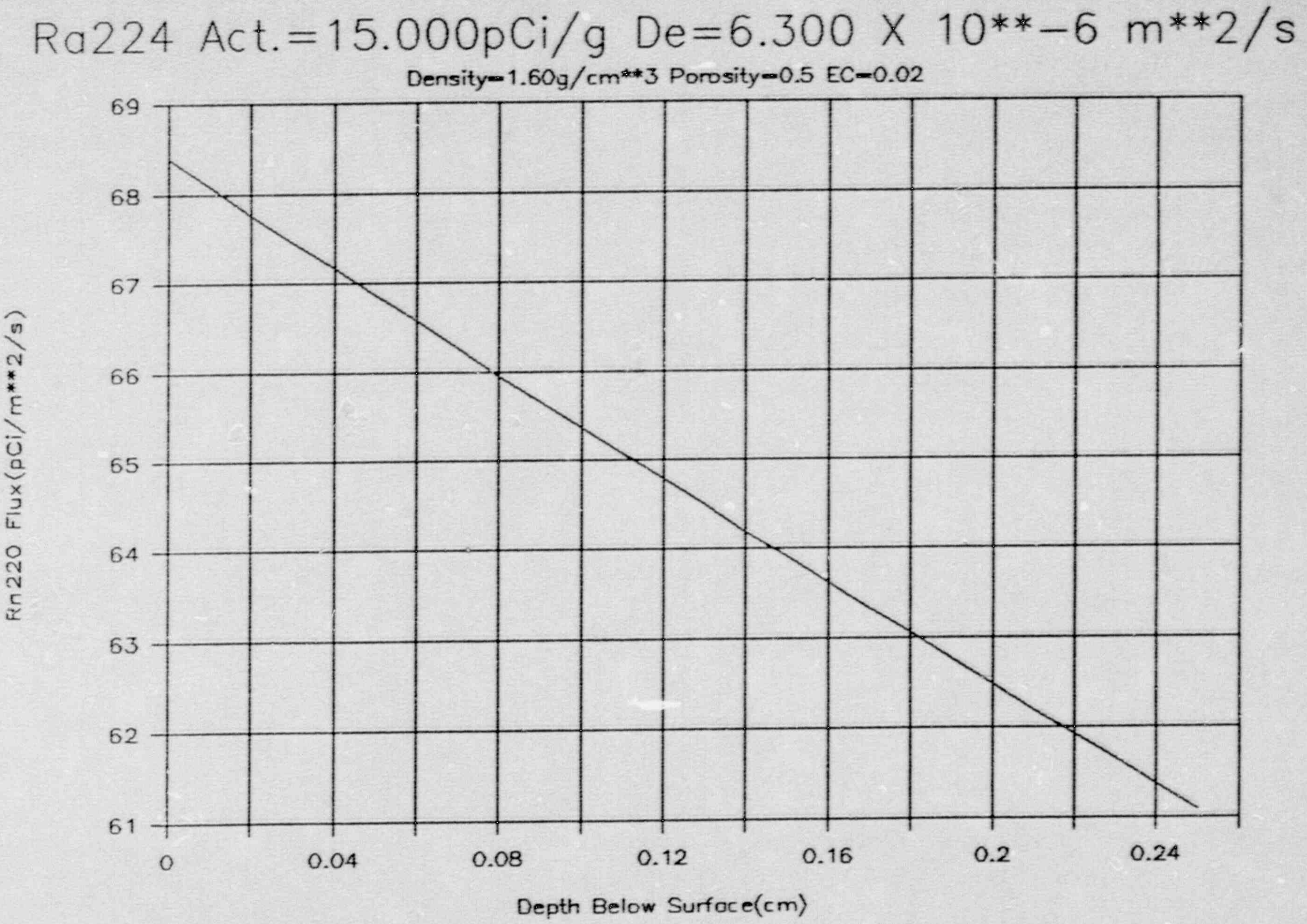


Figure 2. Calculated Radon 220 Flux for the West Pile Slag as a Function of Distance Below the Surface of the Slag

Radon Flux Measurement Data
Shield Alloy Corp
November 8, 1988

System Efficiency (cpm/pCi)	0.2765
Critical Level Flux ($pCi/m^2 sec$)	0.09
Cannister Area (m^2)	0.0076

Sample ID	Radon Flux $pCi/m^2 sec$	R max radon flux $pCi/m^2 sec$	Sigma * 2, radon flux	Collection time (hr)
SAC/11	0.23		0.13	24.83
SAC/29	0.80		0.15	24.48
SAC/6	0.23		0.13	24.88
SAC/5	0.34		0.13	25.03
SAC/14	0.11		0.10	24.83
SAC/4	1.23		0.17	25.06
SAC/12		< 0.17	0.12	24.82
SAC/19	18.17		0.60	24.40
SAC/23	1.88		0.18	24.40
SAC/10	1.06		0.19	24.93
SAC/24		< 0.17	0.12	24.42
SAC/25		< 0.18	0.12	24.82
SAC/20	0.77		0.15	24.42
SAC/16	15.84		0.47	[illegible]
SAC/15	1.42		0.18	[illegible]
SAC/33	0.44		0.14	25.43
SAC/32	0.49		0.14	25.25
SAC/31	0.42		0.14	25.28
SAC/21	0.15		0.12	24.43
SAC/27	0.45		0.14	[illegible]
SAC/9	0.20		0.13	24.88
SAC/17	0.34		0.13	25.72
SAC/2	0.71		0.15	25.13
SAC/26	2.81		0.22	24.47
SAC/22	0.53		0.14	24.43
SAC/13	0.86		0.16	24.83
SAC/8	0.64		0.16	24.73
SAC/3	0.75		0.15	25.06
SAC/30	0.22		0.13	24.82
SAC/34	0.14		0.12	25.37
SAC/28	0.27		0.13	24.37
SAC/35	0.71		0.15	25.23
SAC/18	8.70		0.32	24.47
SAC/7		< 0.18	0.12	25.73

Radon Flux Data

Shieldalloy Metallurgical Corp

November 6, 1989

Sample Identification	Location	Collection Time (hr)	Radon Flux ± 2 sigma (pCi/m^2 sec)	Canister No.
SAC-1	SUBSURFACE - 1.0'	25.15	SAMPLE DAMAGED	1646
SAC-2	SUBSURFACE - 2.0'	25.13	0.71 ± 0.15	1849
SAC-3	SUBSURFACE - 1.0'	25.08	0.75 ± 0.15	1869
SAC-4	SUBSURFACE - 2.0'	25.05	1.23 ± 0.17	620
SAC-5	SURFACE	25.03	0.39 ± 0.13	601
SAC-6	SUBSURFACE - 1.0'	24.98	0.25 ± 0.13	1928
SAC-7	SUBSURFACE - 1.0'	25.73	<0.16 ± 0.12	1303
SAC-8	SUBSURFACE - 2.0'	24.73	0.84 ± 0.16	1365
SAC-9	SUBSURFACE - 2.0'	24.68	0.29 ± 0.13	1394
SAC-10	SUBSURFACE - 2.0'	24.83	1.66 ± 0.19	580
SAC-11	SUBSURFACE - 1.0'	24.63	0.23 ± 0.13	815
SAC-12	SURFACE	24.62	<0.17 ± 0.12	1240
SAC-13	SUBSURFACE - 1.0'	24.83	0.86 ± 0.16	1331
SAC-14	SURFACE	24.63	0.11 ± 0.10	700
SAC-15	SUBSURFACE - 2.0'	24.60	1.42 ± 0.18	627
SAC-16	SUBSURFACE - 1.0'	24.55	15.94 ± 0.47	993
SAC-17	SURFACE	25.72	0.34 ± 0.13	1174
SAC-18	SUBSURFACE - 1.0'	24.47	6.70 ± 0.32	1287
SAC-19	SUBSURFACE - 1.0'	24.40	18.17 ± 0.50	1284
SAC-20	SURFACE	24.42	0.77 ± 0.15	1502
SAC-21	SUBSURFACE - 1.0'	24.43	0.15 ± 0.12	1188
SAC-22	SURFACE	24.43	0.53 ± 0.14	747
SAC-23	SUBSURFACE 1.0'	24.40	1.59 ± 0.19	920
SAC-24	SURFACE	24.42	<0.17 ± 0.12	1198
SAC-25	SUBSURFACE 1.0'	24.42	<0.18 ± 0.12	1207
SAC-26	SURFACE	24.47	2.61 ± 0.22	1323
SAC-27	SURFACE	24.45	0.95 ± 0.14	1312
SAC-28	SURFACE	24.37	0.27 ± 0.13	1291
SAC-29	SURFACE	24.48	0.80 ± 0.16	411

SAMPLE IDENTIFICATION	LOCATION	COLLECTION TIME (HR)	RADON FLUX ± 2 SIGMA	CANISTER NO.
SAC - 30	SURFACE	24.52	0.22 ± 0.13	680
SAC - 31 *	SURFACE	25.25	0.42 ± 0.14	1280
SAC - 32 *	SURFACE	25.25	0.49 ± 0.14	1674
SAC - 33 *	SURFACE	25.43	0.44 ± 0.14	290
SAC - 34 *	SUBSURFACE - 1.0'	25.37	0.14 ± 0.12	1202
SAC - 35 *	SUBSURFACE - 2.0'	25.23	0.71 ± 0.15	1242
SAC - 36 *	SUBSURFACE - 3.0'	N/A	SAMPLE TOO WET	1312

* BACKGROUND

APPENDIX K

ENSR STANDARD OPERATING PROCEDURE

Number: 7120 Date of Issue: 1st Quarter, 1984

Title: Surface Water Sampling

Organizational Acceptance	Authorization	Date
Originator	[illegible]	3/2/84
Department Manager	[illegible]	3/2/84
Divisional Manager	[illegible]	3-2-84
Group Quality Assurance Officer	[illegible]	3/2/84
Other		

Revisions	Changes	Authorization	Date
1	Update	SMW	3/2/84
		LB	3/2/84
		AGL	3/2/84
		EM	3-2-84

ENSR Consulting & Engineering

STANDARD OPERATING PROCEDURE

Title: Surface-Water Sampling Techniques

Date: 1st Qtr. 198
Number: 7120
Revision: 1

1.0 Applicability

Tnis Standard Operating Procedure (SOP) defines the basic techniques and general considerations to be followed for the collection of water-quality samples from rivers, lakes and ponds. The specific details of actual sample collection are highly dependent upon local conditions as well as upon the purpose of the water-quality study. Nevertheless, certain aspects of sample collection procedures are independent of project-specific variations.

2.0 Responsibilities

The project manager is responsible for ensuring that a properly designed sampling program is prepared prior to any sample collection. The sampling program will identify the general sampling location(s), frequency, sample type (grab or composite), water-quality parameters and analytical procedures. The field team is responsible for familiarizing themselves with the sampling program, and ensuring that all field equipment is in proper operating condition and that the appropriate sample containers and preservatives are available. The field team is also responsible for proper sample handling as specified in SOP 7510, Handling and Storage of Samples.

3.0 Materials

- Project specific sampling program
- Site area maps (e.g., USGS 7-1/2 minute or 15 minute quadrangle topographic maps)
- Sample containers and preservatives
- Insulated containers (e.g., coolers) for sample storage and an ample supply of ice
- Field equipment as specified in the sampling program and the corresponding manufacturer's manuals.
- Calibration standards for field equipment
- Alpha horizontal type sample collector (for deep rivers, lakes and ponds)
- Boat or raft (for deep rivers, lakes and ponds)
- Weighted tape measure or rigid gage
- Field-data sheets and/or log book
- First aid kit

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4.0 Procedures

4.1 Sample Location Selection

The selection of the precise sampling location requires professional judgment and an understanding of the purpose of the study. Sampling locations where mixing is incomplete should be avoided if an average composition is required. Often, areas of poor lateral or vertical mixing can be visually identified. For example, color or turbidity differences may be apparent immediately below the confluence of a tributary and the main river or at a wastewater discharge point. Use of a field conductivity meter is recommended for determining the uniformity of the water composition across the width and depth of the water body. Once the sampling point has been selected, it must be fixed by detailed description, maps, or with the aid of stakes, buoys, or other landmarks so that others can identify the sampling location.

4.2 Stream Sampling

4.2.1 In shallow streams (those which can be safely traversed on foot) the sample container can be filled directly with the flowing water. Unless otherwise specified in the project sampling program, samples should be collected at mid-depth in the mid-section or deepest flow channel of the stream.

4.2.2 In deep rivers, use of a boat or raft will usually be required to obtain a representative sample. As with shallow streams, samples should be obtained at mid-depth in the mid-channel unless otherwise specified in the sampling program. Stream depth can be determined using a depth sounder or by physical measurement with a heavily weighted flexible measuring tape or a rigid gage.

4.2.3 An Alpha horizontal type sampler should be used for collecting samples at a specific depth in the water column. Figure 1 illustrates the operation of one of these samplers.

4.3 Lake and Pond Sampling

4.3.1 Water in lakes and ponds is generally poorly mixed and thermal stratification is frequently observed. Single samples can only represent the specific spot from which they were obtained. For many studies, samples taken at the inlet(s) and/or outlet of the lake or pond are of the most interest. In other studies, a grid is established over the lake or pond and samples are collected at grid-line intersections.

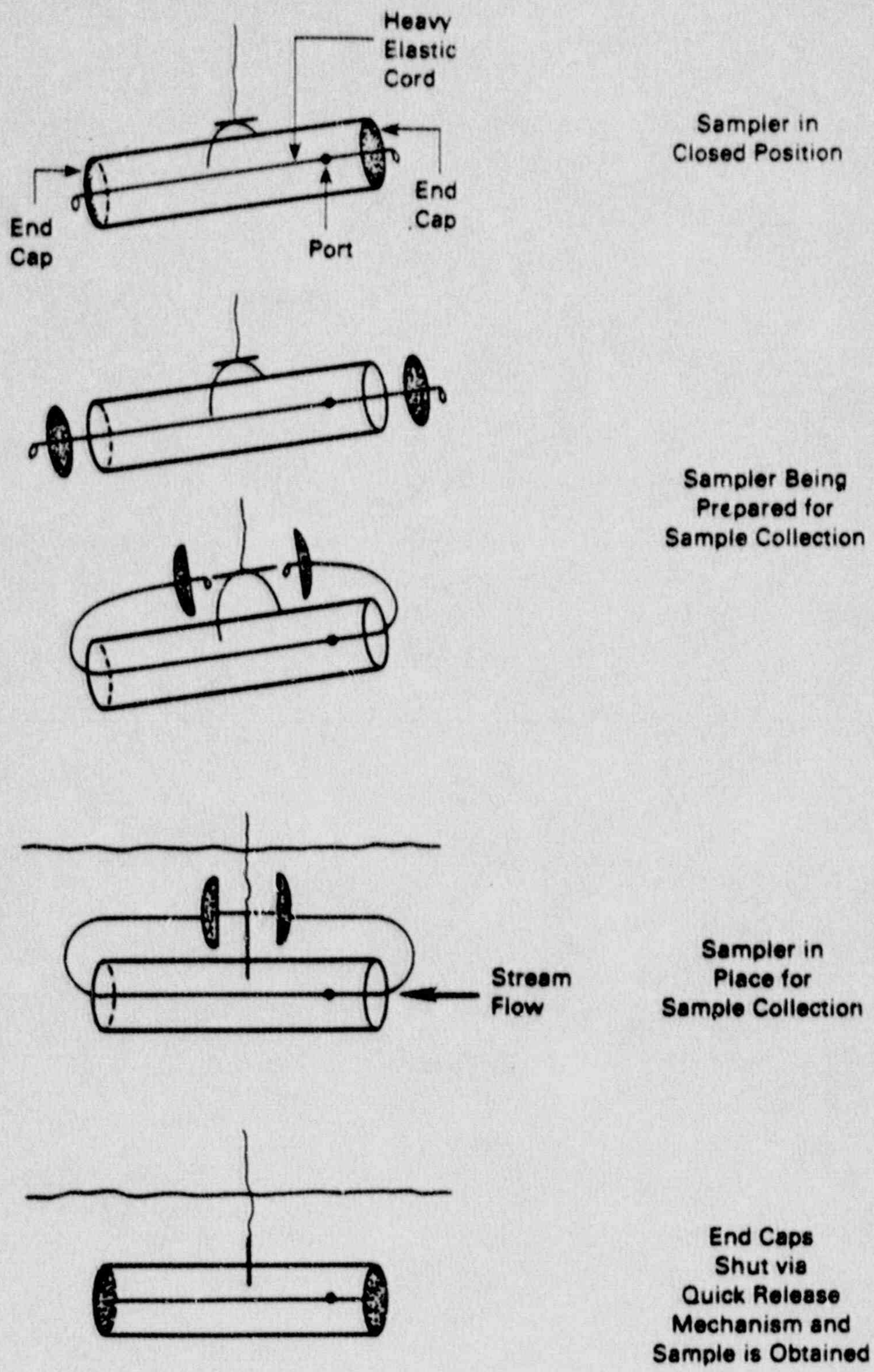

Figure 1 Alpha Horizontal Type Sampler

4.3.2 As with deep rivers, an Alpha horizontal type sampler should be used for sample collection.

4.4 Sample Handling and Preservation

4.4.1 In general, the shorter the time lapse between sample collection and analysis, the more reliable the results will be. Certain water-quality parameters, especially pH, temperature and dissolved oxygen, are so closely related to the environment of the water that meaningful results can only be obtained by in-situ field measurements.

4.4.2 EPA has developed a list of recommended sample containers, preservatives and maximum holding times for water quality measurements (see Federal Register 44:69464). Unless otherwise specified in the sampling program, this list should be followed. Preservatives may be added to the sample containers in the field after filling, or the containers can be pre-spiked with the preservative. All samples should be placed on ice immediately after collection and should remain iced until delivery to the analytical laboratory.

5.0 Documentation

A record must be kept of every sample collected and every bottle must be clearly marked, preferably with a waterproof label. An example field-data sheet is provided in Figure 2. Project-specific data sheets or log books may be used. The field record must provide positive sample identification as well as the name of the sample collector, the date, time and exact location of the sample collection point, and results of all field water quality measurements. Other information such as weather and stream-flow conditions should also be noted. All documentation will be retained in the appropriate project files.

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WATER QUALITY FIELD DATA SHEET

Title	Date	Time	Project No.	Proposal No.

Location ____________________

Station No. ____________________ Station Name ____________________

Observers ____________________

Comments ____________________

____

____

Location Within Transect* ____________________

Total Depth ____________________ Secchi Disc Depth ____________________

FIELD MEASUREMENTS

Depth (meters)	Temp (°C)	DO (mg/1)	DO Sat. (%)	Conductivity (umhos/cm)	pH (units)	Depth (meters)	Velocity (ft/sec)

*Left bank and right bank are determined facing downstream.

8403001

Figure 2 Example Field Data Sheet

STANDARD OPERATING PROCEDURE

Number: 7130 Date of Issue: March 12, 1984

Title: Ground-Water Sample Collection from Monitoring Wells

Organizational Acceptance	Authorization	Date
Originator	Christopher Carlo	3-13-84
Department Manager	[signature]	3/13/84
Divisional Manager	[signature]	3-13-84
Group Quality Assurance Officer	[signature]	3-13-84
Other		

Revisions	Changes	Authorization	Date
1	• Sect. 3.0 - Equipment checklists have been added.	JMW	9-5-86
	• Sect. 4.4 - The use of electronic sounding devices has been removed from procedures for obtaining water-level measurements.	CEM	9-11-86
	• Sect. 4.5 - Some unneccessary steps have been deleted from procedures for decontamination.		
	• Sect. 5.0 - The volume of ground water for purging wells has been changed from 4 to 10 volumes to 3 to 10 volumes.		
	• Sect. 6.2 - A more detailed description of bailing was added.		
	• Additional figures have been added.	EM	9-10-86
	• Miscellaneous rewording and renumbering for clarification.		

Title: Ground-Water Sample Collection from Monitoring Wells

1.0 Applicability

This Standard Operating Procedure (SOP) is concerned with the collection of valid and representative samples from ground-water monitoring wells. The scope of this document is limited to field operations and protocols applicable during ground-water sample collection.

2.0 Responsibilities

The site coordinator or his delegate will have the responsibility to oversee and ensure that all ground-water sampling is performed in accordance with the project-specific sampling program and this SOP. In addition, the site coordinator must ensure that all field workers are fully apprised of this SOP. The field team is responsible for proper sample handling as specified in SOP 7510, Handling and Storage of Samples.

3.0 Supporting Materials

The list below identifies the types of equipment which may be used for a range of ground water-sampling applications. From this list, a project-specific equipment list will be selected based upon project objectives, the depth to ground-water, purge volumes, analytical parameters and well construction. The types of sampling equipment are as follows:

- Purging/Sample Collection

  Bailers
  Centrifugal Pump
  Submersible Pump
  Peristaltic Pump

- Sample Preparation/Field Measurement

  pH Meter
  Specific Conductance Meter
  Filtration Apparatus
  Water-Level Measurement Equipment

Additional equipment to support sample collection and provide baseline worker safety will be required to some extent for each sampling task. The additional materials are separated into two primary groups: general equipment which is reusable for several samplings, and materials which are expendable.

- General

Project-specific sampling program
Deionized-water dispenser bottle
Methanol-dispenser bottle
Site-specific Health & Safety equipment (gloves, respirators, goggles)
Field data sheets and/or log book
Preservation solutions
Sample containers
Buckets and intermediate containers
Coolers
First-Aid kit

- Expendable Materials

Bailer Cord
Respirator Cartridges
Gloves
Water Filters
Chemical-free paper towels
Plastic sheets

Equipment checklists have been developed to aid in field trip organization and should be used in preparation for each trip.

4.0 Water-Level Measurement

4.1 Introduction

Prior to obtaining a water-level measurement, cut a slit in one side of the plastic sheet and slip it over and around the well, creating a clean surface onto which the sampling equipment can be positioned. This clean working area should be a minimum of eight feet square. Care will be taken not to kick, transfer, drop, or in any way let soil or other materials fall onto this sheet unless it comes from inside the well. Do not place meters, tools, equipment, etc. on the sheet unless they have been cleaned first with a clean rag.

After unlocking and/or opening a monitoring well, the first task will be to obtain a water-level measurement. Water-level measurements will be made using an electronic or mechanical device. Electronic measurement devices will be used in all wells wherein a clearly audible sound cannot be produced with a mechanical device.

4.2 Well Security

Unlock and/or open the monitoring well. Enter a description of condition of the security system and protective casing on the Ground-Water Sample Collection Record shown in Figure 1.

4.3 Measuring Point

Check for the measuring point for the well. The measuring point location should be clearly marked on the outermost casing or identified in previous sample collection records. If no measuring point can be determined, a measuring point should be established. Typically the top (highest point) of the protective or outermost well casing will be used as the measuring point. The measuring point location should be described on the Ground-Water Sample Collection Record and should be the same point used for all subsequent sampling efforts.

4.4. Measurement

To obtain a water-level measurement lower a clean steel, fiberglass tape into the monitoring well. Care must be taken to assure that the water-level measurement device hangs freely in the monitoring well and is not adhering to the wall of the well casing. The water-level measuring tape will be lowered into the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. At this time the precise measurement should be determined (to hundredth of a foot) by repeatedly raising and lowering the tape to converge on the exact measurement. The water-level measurement should be entered on the Ground-Water Sample Collection Record. As well point of measurement should be indicated; i.e., top of protective casing, top of pueriser, ground level.

4.5 Decontamination

The measurement device shall be decontaminated immediately after use with a methanol soaked towel. Generally only that portion of the tape which enters the water table should be cleaned. It is important that the measuring tape is never placed directly on the ground surface.

5.0 Purge-Volume Computation

All monitoring wells to be purged prior to sample collection. Depending upon the ease of purging, 3 to 10 volumes of ground water to be determined by hydrogeologing prior to sampling present in a well shall be withdrawn prior to sample collection or one volume if well can be purged dry. The volume of water present in each well shall be computed based on the length of water column and well casing diameter. The water volume shall be computed using Figure 2.

6.0 Well-Purging Methods

6.1 Introduction

Purging must be performed for all ground-water monitoring wells prior to sample collection in order to remove stagnant water from within the well casing and ensure that a representative sample is obtained. The following sections explain the proper procedures for purging and collecting water samples from monitoring wells.

Three general types of equipment are used for well purging: bailers, surface pumps, or down-well submersible pumps.

In all cases pH and/or specific conductance will be monitored during purging. Field parameter values will be entered on the Ground-Water Sample Collection Record along with the corresponding purge volume.

6.2 Bailing

In many cases bailing is the most convenient method for well purging. Bailers are constructed using a variety of materials; generally, PVC stainless steel, and Teflon®. Care must be taken to select a specific type of bailer that suits a study's particular needs. Teflon® bailers are generally most "inert" and are used most frequently. Keep in mind the diameter of each monitoring well so that the correct size bailers are taken to the site. It is preferable to use one bailer per well; however, field decontamination is a relatively simple task if required.

Bailing presents two potential problems with well purging. First, increased suspended solids may be present in samples as a result of the turbulence caused by raising and lowering the bailer through the water column. High solids concentrations may require that total suspended solids (TDS) and the chemical character of solids be evaluated during sample analyses. Second, bailing may not be feasible for wells which require that greater than twenty (20) gallons be removed during purging. Such bailing conditions mandate that long periods be spent during purging and sample collection or that centrifugal pumps be used. All ground-water collected from monitoring wells for subsequent volatile organic compound analyses shall be collected using bailers, regardless of the purge method.

6.3 Surface Pumping

Ground-water withdrawal using pumps located at the ground surface is commonly performed with centrifugal or peristaltic pumps.

All applications of surface pumping will be governed by the depth to the ground-water surface. Peristaltic and centrifugal pumps are limited to conditions where ground water need only be raised through approximately 20 feet of vertical distance. The lift potential of a surface pumping system will depend upon the net positive suction head of the pump and the friction losses associated with the particular suction line, as well as the relative percentage of suspended particulates.

Surface pumping can be used for many applications of well purging and ground-water sample collection. In all cases, pumping cannot be used for the collection of samples to be analyzed for volatile organic compounds (VOCs).

6.3.1 Peristaltic Pump

Peristaltic pumps provide a low rate of flow typically in the range of 0.02-0.2 gallons/min (75-750 ml/min). For this reason, peristaltic pumps are not particularly effective for well purging. Peristaltic pumps are suitable for purging situations where disturbance of the water column must be kept minimal for particularly sensitive analyses. Peristaltic pumps are most often used in conjunction with field filtering of samples and therefore can be used to obtain water samples for direct filtration at the wellhead.

6.3.2 Centrifugal Pump

Centrifugal pumps are designed to provide a high rate of pumping, in the range of 10-40 gallons per minute (gpm), depending on pump capacity. Discharge rates can also be regulated somewhat provided the pump has an adjustable throttle.

When centrifugal pumps are used, samples should be obtained from the suction (influent) line during pumping by an entrapment scheme as shown in Figure 3. Construction of this sampling scheme is relatively simple and will not be explained as part of this SOP. It is suggested that if samples cannot be obtained before going through the pump, that samples be obtained by using a bailer once pumping has ceased. Collecting samples from the pump discharge is not recommended.

6.3.3 Submersible Pump

Submersible pumps provide an effective means for well purging and in some cases sample collection. Submersible pumps are particularly useful for situations where the depth to water table is greater than twenty (20-30) feet and the depth or diameter of the well requires that a large purge volume be removed during purging.

ERT uses the Johnson-Keck pump model SP-81 which has a 1.75 inch diameter pump unit. The pump diameter restricts use to monitoring wells which have inside diameters equal to or greater than two (2) inches. As with other pump-type purge/sample collection methods, submersible pumps will not be used for the collection of samples for analyses of volatile organic compounds. Submersible pumps should never be used for well development as this <u>will</u> seriously damage the pump.

7.0 Sample Collection Procedures

7.1 Bailing

Obtain a clean/decontaminated bailer and a spool of polypropylene rope or equivalent bailer cord. Using the rope at the end of the spool tie a bowline knot or equivalent through the bailer loop. Test the knot for security and the bailer itself to ensure that all parts are intact prior to inserting the bailer into the well.

Remove the protective foil wrapping from the bailer, and lower the bailer to the bottom of the monitoring well and cut the cord at a proper length. Boiler rope should never touch the ground surface at any time during the purge routine.

Raise the bailer by grasping a section of cord using each hand alternately in a "rocking" action. This method requires that the samplers' hands be kept approximately 2-3 feet apart and that the bailer rope is alternately looped onto or off each hand as the bailer is raised and lowered.

Bailed ground water is poured from the bailer into a graduated bucket to measure the purged water volume.

For slowly recharging wells, the bailer is generally lowered to the bottom of the monitoring well and withdrawn slowly through the entire water column. Rapidly recharging wells should be purged by varying the level of bailer insertion to ensure that all stagnant water is removed. The water column should be allowed to recover

to 70-90% of its static volume prior to collecting a sample. Water samples should be obtained from midpoint or lower within the water column.

Samples collected by bailing will be poured directly into sample containers from bailers which are full of fresh ground water. During sample collection, bailers will not be allowed to contact the sample containers.

7.2 Peristaltic Pump

Place a new suction and discharge line to the peristaltic pump. Silicon tubing must be used through the pump head. A second type of tubing may be attached to the silicon tubing to create the suction and discharge lines. Such connection is advantageous for the purpose of reducing tubing costs, but can only be done if airtight connections can be made. Tygon tubing will not be used when performing well purging or collecting samples for organic analysis. The suction line must be long enough to extend to the static ground-water surface and reach further should drawdown occur during pumping.

Measure the length of the suction line and lower it down the monitoring well until the end is in the upper 2-5 inches of the water column present in the well. Start the pump and direct the discharge into a graduated bucket.

Measure the pumping rate in gallons per minute by recording the time required to fill a selected volume of a bucket. Flow measurement shall be performed three times to obtain an average rate.

The pumping shall be monitored to assure continuous discharge. If drawdown causes the discharge to stop, the suction line will be lowered very slowly further down into the well until pumping restarts.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record.

Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and Specific Conductance) have stabilized.

When the sample bottles are prepared, each shall be filled directly from the discharge line of the peristaltic pump. Care will be taken to keep the pump discharge line from contacting the sample bottles. Ground-water samples requiring filtration prior to placement in sample containers, will be placed in intermediate containers for subsequent filtration or filtered directly using the peristatic pump.

At each monitoring point when use of the peristaltic pump is complete, all tubing including the suction line, pump head and discharge line must be disposed of. In some cases where sampling will be performed frequently at the same point, the peristaltic pump tubing may be retained between each use in a clean zip-lock plastic bag.

7.3 Centrifugal Pump

7.3.1 Direct Connection Method (Note: This method requires that the well casing be threaded at the top.)

Establish direct connection to the top of the monitoring well if possible using pipe connections, extensions, and elbows, with Teflon® tape wrapping on all threaded connections. If the centrifugal pump will subsequently be used for sample collection, a sample isolation chamber will be placed in the suction line configuration as shown in Figure 3.

Prime the pump by adding tap water to the pump housing until the housing begins to overflow.

Start the pump and direct the discharge into a graduated bucket or a bucket of known capacity (>2.5 gallons).

Start the pump and measure the pumping rate in gallons per minute by recording the time required to fill the graduated bucket. Flow measurement should be checked periodically to determine if pumping rates are continuous, fluctuating, or diminishing. If discharge stops, the pump will be throttled back to determine if pumping will restart at a lower rate. If pumping does not restart, the pump should be shut off to allow the well to recharge.

Measurements of pH and specific conductance will be made periodically during well purging. All readings will be entered on the Ground-Water Sample Collection Record. Samples will be collected after the required purge volume has been withdrawn and the field parameters (pH and Specific Conductance) have stabilized. Samples should be collected from an in-line discharge valve or with a bailer. The pump should be properly decontaminated between wells.

7.3.2 Down-Well Suction-Line Method

Lower a new suction line into the well. The suction line will have a total length great enough to extend to the water table and account for a minimum of five (5) feet of drawdown. Note should be made that drawdown may exceed the depth where pumping will terminate as a result of a limitation derived from suction-line conditions and the lift potential of the pump. All connections should be made using Teflon® ferrules and Teflon® thread wrapping tape. Run the pump as per Section 7.3.1.

At each monitoring well when use of a centrifugal pump is complete, all suction line tubing should be disposed of properly.

7.4 Submersible Pump

Prior to using a submersible pump, a check will be made of well diameter and alignment. A 1.75 inch diameter decontaminated cylindrical tube should be lowered to the bottom of each monitoring well to determine if the alignment or plumbness of a well is adequate to accommodate the submersible pump. All observations will be entered in the Ground-Water Sample Collection Record.

Slowly lower the submersible pump into the monitoring well taking notice of any roughness or restrictions within the riser.

Count the graduations on the pump discharge line and stop lowering when the stainless steel portion is below the uppermost section of the static water column within monitoring well. Secure the discharge line and power cord to the well casing.

Connect the power cord to the power source (i.e., rechargeable battery pack or auto battery monitor) and turn the pump on (forward mode). When running, the pump can usually be heard by listening near the well head.

Voltage and amperage meter readings on the pump discharge must be checked continuously. The voltage reading will decline slowly during the course of a field day representing the use of power from the battery. Amperage readings will vary depending upon the depth to water table. Amperage readings greater than 10 amps usually indicate a high solids content in the ground water which may cause pump clogging and serious damage. If a steady increase in amperage is observed, the pump should be shut off, allowed to stop, switched to the reverse mode, stopped again and then placed in forward mode. If high amperage readings persist, the pump should be withdrawn and checked using the large upright cylinder and tap water. Ground-water conditions such as high solids may require that an alternate purge/sample method be used.

Drawdown must also be monitored continuously by remaining near the well at all times and listening to the pump. When drawdown occurs, a metallic rotary sound will be heard as the pump intake becomes exposed and ceases to discharge water, but continues to run. The pump should be lowered immediately to continue pumping water within the uppermost section of the static water column. NOTE: The submersible pump cannot be allowed to run while not pumping for more than five seconds or the pump motor will burn out.

If drawdown continues to the extent that the well is pumped dry, the pump should be shut off and the well allowed to recharge. This on/off cycle may need to be repeated several times in order to purge the well properly.

Measurements of the pumping rate, pH, and specific conductance should be made periodically during well purging. All readings and respective purge volumes should be entered on the Ground-Water Sample Collection Record.

While pumping is on-going and when sample bottles are prepared, bottles will be filled directly from the discharge line of the pump taking care not to touch sample bottles to the discharge line.

At each monitoring well when use of the submersible pump is complete, the pump, discharge line and power cord shall be decontaminated according to the procedures contained in the SOP for Decontamination.

8.0 Sample Preparation

8.1 Introduction

Prior to sample transport or shipment, ground-water samples may require filtration and/or preservation dependent on the specific type of analysis required.

Specific preservation techniques are described in the EPA document, Handbook for Sampling and Sample Preservation of Water and Wastewater (EPA-600/4-82-029). The EPA manual and laboratory manager should be consulted during the planning stage of the project. Project-specific sampling plans shall be assembled using the approved procedures obtained from the EPA manual.

8.2 Filtration

Ground-water samples collected for dissolved metals analyses will be filtered prior to being placed in sample containers. Ground-water filtration will be performed using a peristaltic pump and a 0.45 micron, water filter. Typically the water filters are 142 mm in diameter and are usually placed in 142 mm polycarbonate housings.

The filtration of ground-water samples shall be performed either directly from the monitoring well or from intermediate sample containers such as decontaminated buckets. In either case, well purging shall be performed first. Fresh ground water shall then be filtered and discharged from the filtration apparatus directly into sample containers. For most dissolved metal analyses, pH adjustment of the sample is also required and shall be performed after filling the sample bottles. This is generally accomplished using laboratory supplied compounds such as sulfuric or nitric acid and sodium hydroxide.

9.0 Documentation

A number of different documents must be completed and maintained as a part of ground-water sampling effort. The documents provide a summary of the sample-collection procedures and conditions, shipment method, the analyses requested and the custody history. The list of documents is:

- Ground-water sample collection record
- Sample labels
- Chain of custody forms and tape
- Shipping receipts

Sample labels shall be completed at the time each sample is collected and will include the information listed below. A sample label is shown in Figure 4.

- Client or project name
- Sample number
- Designation (i.e., identification of sample point no.)
- Analysis
- Preservative (e.g., filtration, acidified pH<2 HNO_3)
- Sample-collection date
- Sampler's name

Figure 5 displays the chain of custody record used by ERT. The chain of custody form is the record sample collection and transfer of custody. Information such as the sample collection date and time of collection, sample identification and origination, client or project name shall be entered on each chain of custody record. In accordance with 40 CFR 261.4(d) the following information must accompany all ground water samples which are known to be non-hazardous and to which U.S. Department of Transportation and U.S. Post Office regulations do not apply. Such information is:

- sample collector's name, mailing address and telephone number,
- analytical laboratory's name, mailing address and telephone number,
- quantity of each sample,
- date of shipment, and
- description of sample.

The chain of custody forms provide a location for entry of the above-listed information.

10.0 References

EPA, Handbook for Sampling and Sample Preservation of Water and Wastewater EPA-600/4-82-029, September 1982.

Geotrans, Inc. RCRA Permit Writer's Manual, Ground-Water Protection prepared for U.S. EPA. Contract No. 68-01-6464, October 1983.

Code of Federal Regulations, Chapter 40 (Section 261.4(d).

Figure 1

ENSR

Well No ______

GROUND WATER SAMPLE COLLECTION RECORD

Job No __________ Date __________

Location ______________________________ Time S ______

Weather Conds ______________________________ F ______

1. WATER LEVEL DATA (from ToC) ToC Elevation (from LS) ______________

a. Total Well Length (+ TC) ______________ (known, meas.) Tape Corr. (TC) ______________

b. Water Table Elev. (+ TC) ______________ Well Dia ______________

c. Length of Water Column ______________ (a-b)

2. WELL PURGING DATA

a. Purge Method ______________________________

b. Required Purge Volume (@ ____ well volumes) ______________________________

c. Field Testing: Equipment Used ______________________________

Volume Removed	T°	PH	Spec. Cond.	Color

3. Sample Collection: Method ______________________________

Container Type	Preservation	Analysis Req.

Comments: ______________________________

____

____

____

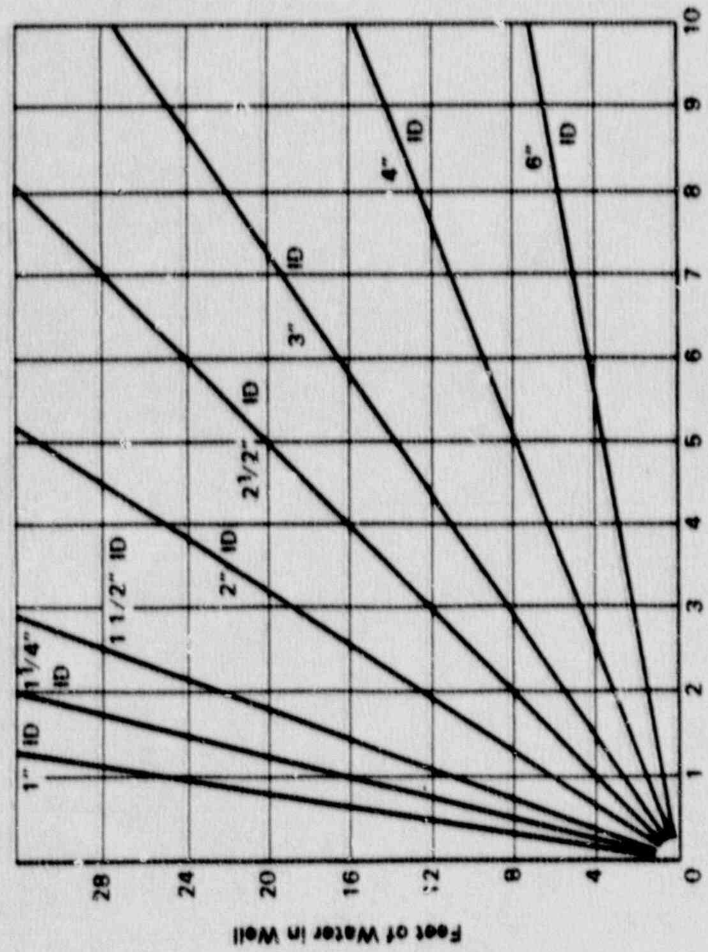
____

____

1995 12-84

Volume/Linear Ft. of Pipe		
ID(in)	Gal	Liter
1/4	0.003	0.010
3/8	0.006	0.022
1/2	0.010	0.039
3/4	0.023	0.087
1	0.041	0.154
2	0.163	0.618
3	0.367	1.39
4	0.653	2.47
6	1.47	5.56

(b) Volume Factors



(a) Graphical Explanation

Figure 2 Purge Volume Computation

Title: Ground-Water Sample Collection from Monitoring Wells

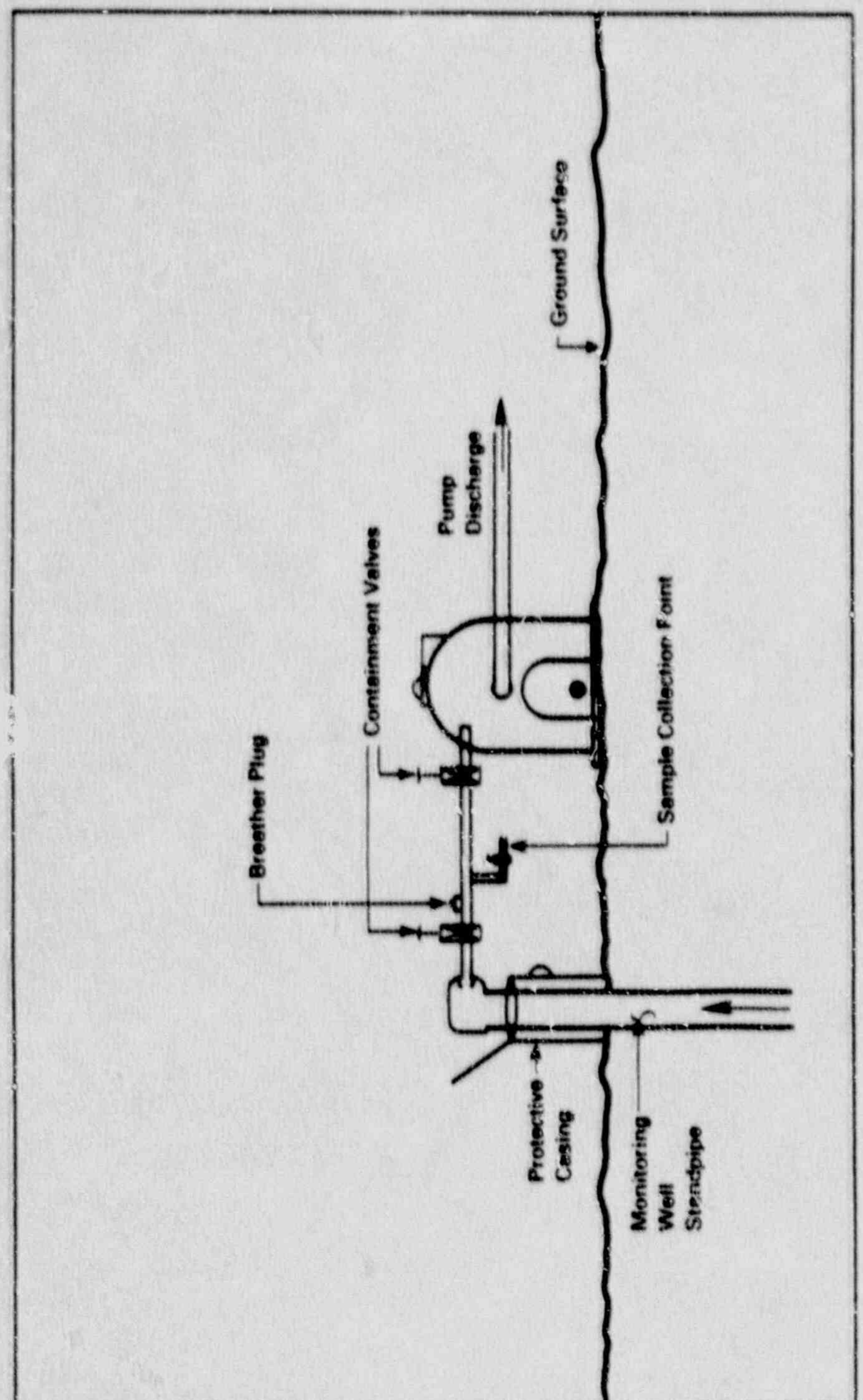


Figure 3 Point Well Suction Line Configuration

CLIENT ______________________

SAMPLE NO. ______________________

DESIGNATION ______________________

ANALYSIS ______________________

PRESERVATIVE ______________________

DATE ____________ BY ____________

Figure 4 Sample Container Label

CHAIN OF CUSTODY RECORD

Client/Project Name	Project Location	ANALYSES
Project No.	Field Logbook No.	
Sampler: (*Signature*)	Chain of Custody Tape No.	

Sample No./ Identification	Date	Time	Lab Sample Number	Type of Sample							REMARKS

Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
Relinquished by: (*Signature*)	Date	Time	Received for Laboratory: (*Signature*)	Date	Time
Sample Disposal Method:			Disposed of by: (*Signature*)	Date	Time
SAMPLE COLLECTOR			ANALYTICAL LABORATORY	No	

1974 3-84

Figure 5 Sample Chain-of-Custody Record

ENSR STANDARD OPERATING PROCEDURE

Number: 7131 Date of Issue: 2nd Qtr. 1986

Title: FIELD FILTRATION OF WATER SAMPLES FOR INORGANICS

Organizational Acceptance	Authorization	Date
Originator	[signature]	9/9/86
Department Manager	[signature]	9-9-86
Divisional Manager	[signature]	9/10/86
Group Quality Assurance Officer	[signature]	8-12-86
Other		

Revisions	Changes	Authorization	Date

ENSR Consulting & Engineering

1283a (12/78)

1.0 GENERAL APPLICABILITY

This Standard Operating Procedure (SOP) is concerned with the field filtration of water samples for inorganic analyses. The specific analysnes that require filtration will be determined each project work plan. The most common parameters requiring filtration however are dissolved metals and orthophosphate.

2.0 EQUIPMENT DESCRIPTIONS

2.1 Peristaltic Pump - This type of pump is a low volume pump which operates by progressively squeezing the water sample through a silicon tube by means of 3 rollers which revolve within a housing. The advantage of this type of pump is that the sample never contacts any mechanical parts of the pump. The tubing to be used with the pump is of a typical size which is dictated by the manufacturer. Be sure to check the pump head number against the tubing number. These numbers should be the same and are located on the pump roller housing and on the tubing package respectively. Use of the wrong tubing will either diminish the effectiveness of the pump or will cause it to stop operating entirely.

2.2 Pump tubing - The pump tubing is made of silicon and is of a specific inside and outside diameter determined by the pump head design. Due to the fact that this tubing is relatively expensive and is difficult to obtain in the field it is an acceptable option to clamp a less expensive and more common tubing to it to use down a well. However, to maintain the pump's lift capability use only tube with the same or smaller inside diameter as the pump tubing. The length required to use through the pump head is only about two feet.

2.3 Filters

2.3.1 The filters to be used in all cases are the EPA specified .45 micron filters. These filters are round 127 mm diameter teflon membranes that are used in conjunction with a pre-filter which removes the coarser particles. The filter and pre-filter are clamped inside of a polycarbonate filter frame, this frame consists of 2 nearly identical halves. The bottom half contains fittings for the frame legs, a channel for an "O" Ring, and 6 hinged bolts with wing nuts & washers. The top half has none of these features. Within the frame are two plastic fine mesh screens with solid borders and a lip on one side, the filter and prefilter go between these screens with the lipped side of each screen facing the other. To place a filter in the frame first press the "O" ring into the groove in the bottom half of the frame. On top of this place one of the plastic screens with the lip side up. Take particular care to ensure that the screen is aligned properly on the "O" ring. On top of this bottom screen is placed the filter. When placing the filter it is important that the filter remains in the same orientation that it was in it's package (i.e. the side that faced the bottom of the box now faces the bottom half of the filter frame). The outside edge of the filter should exactly coincide with the outside edge of the bottom screen. Once the filter is in place gently saturate it with deionized water from a squeeze bottle, this will help it pass filtrate. Having completed this now place the prefilter with the rough textured side facing up on top of the filter and soak it with deionized water. The prefilter is smaller than the filter so judge its alignment by the center of the frame. On top of the prefilter place the top screen with the lip side down. With the filter "sandwich" in place the upper half of the frame is placed on the lower half and the six bolts are swung into position. These bolts are then tightened little by little by first tightening one bolt then the one opposite it, and the one opposite that one etc., until all of the bolts are as tight as they can be. For a visual description of the frame and its tightening pattern . See the Figure 1.

2.3.2 Filter Cartridges - for some applications it may be desirable to use sealed filter cartridges. These cartridges are also .45 micron filters and they are disposable. The cost per unit is higher for cartridges.

3.0 RESPONSIBILITIES

The project manager will be responsible for determining the application of field filtration and the field coordinator will be responsible for proper use of the field filtration equipment. The field coordinator will also be responsible for the proper maintenance of the filtration equipment and will be responsible for proper labeling, preservation and shipment of the filtered samples.

4.0 SUPPORTING MATERIALS

- 12V marine battery
- Methanol - with squirt bottle

- Deionized water - with squirt bottle
- Chemical free paper towels
- Sample containers
- Laboratory decontaminated intermediate containers (SOP #7600)
- Preservatives
- Indelible marker

5.0 METHOD OR PROTOCOL

5.1 General

Ideally the laboratory decontaminated filter apparatus (SOP #7600) should be set up next to the well that the filtered sample is to be obtained from. The well should have been purged previously by another means (see SOP #7130 Ground Water Sample Collection from Monitoring Wells). Thread silicon tubing through the pump head and attach one end to the upper nozzle of the filter frame which is assembled as in Section 2.3.1. To the opposite end of the pump tubing attach an intake line (Teflon, polyethylene or other excluding tygon). The intake line should extend about one foot below the water level. Draw down should be negligible due to the low flow rate of this pump. Attach the pump to an auto or marine battery or if it has an internal battery switch to the appropriate setting, turn the speed control to the slowest speed and turn the pump on. The rollers should begin to rotate. Check the rotation direction to be sure that the rollers are moving sample towards the filter frame, if they are not reverse the pump. Sample water should be visible moving through the pump. When the sample reaches the filter apparatus and begins to discharge through the bottom nozzle slowly increase the pump speed. When filtered sample passes through the apparatus discard the first 5-10 ml then collect the sample. If the sample does not pass through the filter turn off the pump and then reverse it to relieve the back pressure. Having done this remove the pump output line and attach it to the opposite side of the filter frame. Turn the pump on again, filtrate should start to pass through the filter in the opposite direction. When this happens again relieve the back pressure and return the filter system to its original configuration. This backwashing operation seems to help saturate the filter enabling it to pass sample water more easily. After doing this it is necessary to discard the first 10-20 ml of sample after returning the system to its original configuration to avoid cross contamination of filtered sample with non filtered. Once the sample has been collected from the filter it may be preserved if necessary. Remember to always reverse the pump flow direction before disconnecting any hoses. This will keep the sampler's face free of sample.

5.2.1 Standard Procedure

5.2.1 Surface Water Sample Filtration

The apparatus and procedures for surface water sample collection and filtration with the peristaltic pump are the same as for ground water. The only significant difference is that when collecting a surface water sample in this manner the sampler must be sure that the pump intake line is positioned at the desired location and depth. This information should be recorded on the surface water sample collection record.

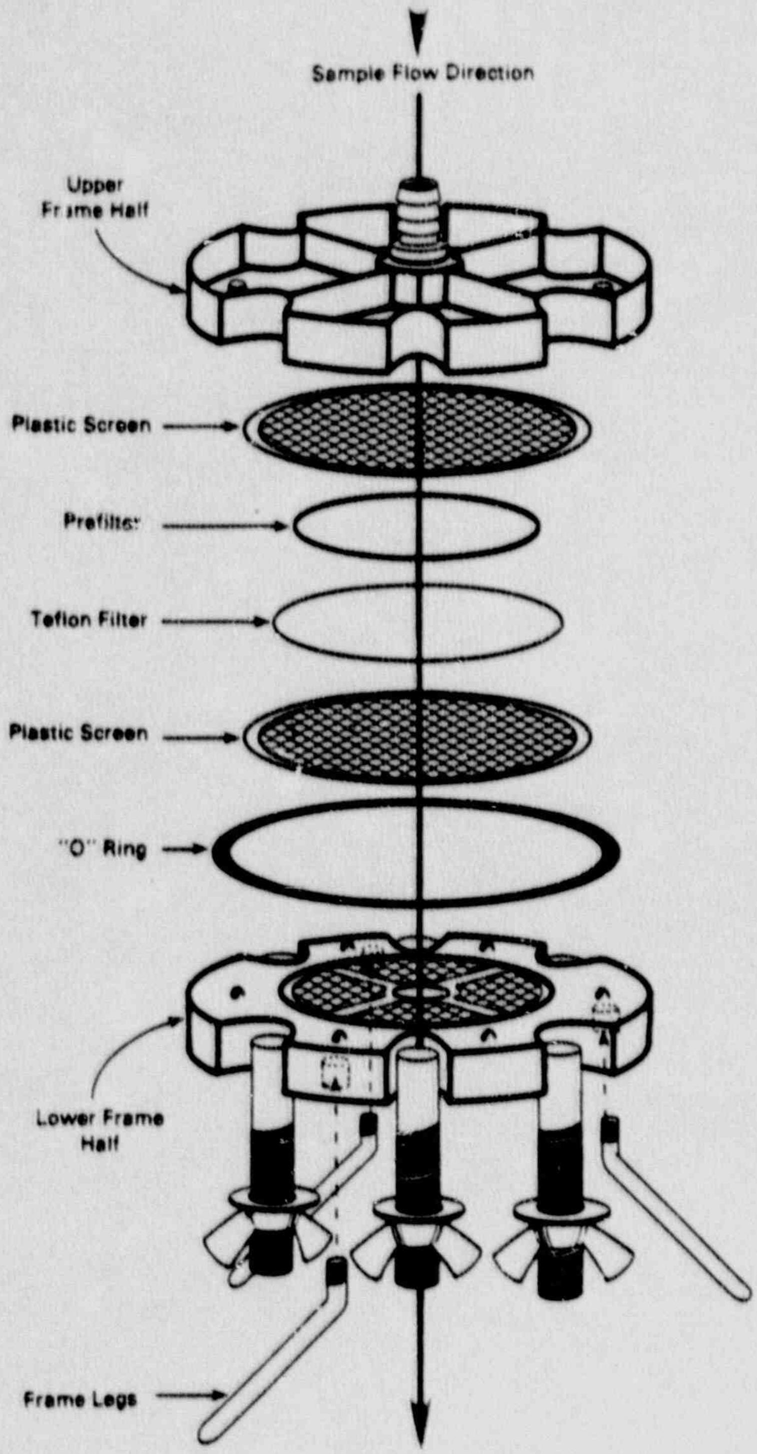
5.2.2 Filtration of samples below pumping limit.

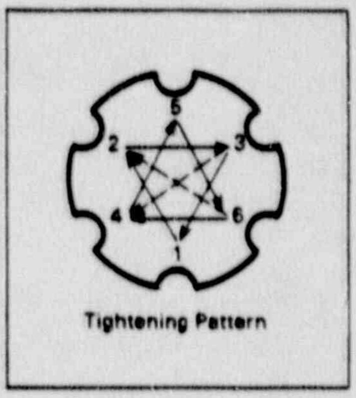
The Peristaltic pump has a suction limit of 20-25 feet. If the water level is below that limit it is necessary to use an alternative method. This method involves the use of intermediate containers.

The intermediate containers should have a volume 2 to 4 times greater than that of a single sample to allow additional volume for filling the frame and for filter backwashing. If a larger container which is of the same type as the sample collection container is not available then an alternative is to use two to four of the same size containers.

When it is necessary to use the intermediate container option it is most convenient to filter the samples at the end of the sample day just prior to shipment. A filter station is set up at the field vehicle. If more than one filter frame is available then while one sample is filtering the other frame can be decontaminated and assembled with a clean filter and pre-filter. Any residual unfiltered sample should be disposed of in its container in an appropriate manner. This method may also be used when time and personnel restrictions make it inefficient to set up the filtering apparatus at each sample location.

Figure 1


Sample Flow Direction
Upper Frame Half
Plastic Screen
Prefilter
Teflon Filter
Plastic Screen
"O" Ring
Lower Frame Half
Frame Legs


5
2
3
4
6
1
Tightening Pattern

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