R-008-209 .2

5528

DRAFT FINAL REPORT FOR THE SILOS 1 & 2 (K-65) REMOVAL ACTION
MAY 1994

05/17/94

DOE-FN EPA
146
REPORT

DRAFT

FINAL REPORT

FOR THE

SILOS 1 & 2 (K-65) REMOVAL ACTION

MAY 1994

Submitted by:

Fernald Environmental Restoration Management Corporation
Fernald Environmental Management Project
7400 Willey Road
Fernald, Ohio 45030

5528

TABLE OF CONTENTS

List of Tables ii

List of Figures ii

Acronym List iii

List of Weights and Measures iv

Executive Summary ES-1

1.0 Overview 1

2.0 Silos 1 & 2 Removal Action Implementation 6

3.0 Sampling and Analysis 26

4.0 Health and Safety Plan 27

5.0 Quality Assurance Plan 28

6.0 Regulatory Concerns 29

7.0 Future Activities 31

8.0 Conclusion 32

9.0 References 34

Appendix A - Radon Grab Sampling and Continuous Monitoring Results

Appendix B - Radiation Levels Before and After Bentonite Placement

Appendix C - Statistical Evaluation of Pre-Bentonite and Post-Bentonite Placement Data

Appendix D - Silos 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan (April 1992)

Appendix E - Silos 1 and 2 Headspace Concentration Calculations

Appendix F - K-65 Silo 2 Closed Circuit Camera Installation and Bentonite Inspection Work Plan, Revision 1

Appendix G - FEMP Administrative Record References

Appendix H - Operable Unit 4 Potential ARARs

000002

5528

LIST OF TABLES

2-1 Waste, Bentonite, and Headspace Volumes in Silos 1 and 2 Calculated by Using the Structured Light Surface Data 16

LIST OF FIGURES

2-1 Cross Sectional Schematic of the K-65 Silos at Fernald 8

2-2 Illustration of a Surface Mapping Measurement Unit 10

2-3 Contour Plot of Silo 1 Baseline Waste-Surface Data (6 Inch Contours) 11

2-4 Contour Plot of Silo 2 Baseline Waste-Surface Data (6 Inch Contours) 12

2-5 Silo 1 Baseline Waste-Surface Map, 256-Color Vertical Dimension 13

2-6 Silo 2 Baseline Waste-Surface Map, 256-Color Vertical Dimension 14

2-7 Contour Plot of Silo 1 Bentonite-Surface Data (6 Inch Contours) 18

2-8 Contour Plot of Silo 2 Bentonite-Surface Data (6 Inch Contours) 19

2-9 Silo 1 Bentonite Surface, 256-Color Vertical Dimension 20

2-10 Silo 2 Bentonite Surface, 256-Color Vertical Dimension 21

000003

5528

ACRONYM LIST

AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
ARARs	Applicable or Relevant and Appropriate Requirements
ASME	American Society of Mechanical Engineers
CAA	Clean Air Act
CWA	Clean Water Act
CATEX	Categorical Exclusion
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DLS	Data Logging System
DOE	U.S. Department of Energy
DOE-FN	U.S. Department of Energy-Fernald Field Office
DOE-HQ	U.S. Department of Energy-Headquarters
EE/CA	Engineering Evaluation/Cost Analysis
FEMP	Fernald Environmental Management Project
FFCA	Federal Facilities Compliance Agreement
FERMCO	Fernald Environmental Restoration Management Corporation
FMPC	Feed Materials Production Center
FS	Feasibility Study
GRF	Global Reference Frame
HEPA	High Efficiency Particulate Air
MCL	Maximum Concentration Levels
MCLG	Maximum Concentration Levels Goals
MU	Measurement Unit
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
OSHA	Occupational Safety and Health Administration
ORNL	Oak Ridge National Laboratories
OTD	Office of Technology Development
PACD	Proposed Amended Consent Decree
RWP	Radiation Work Permit
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RSE	Removal Site Evaluation
RTS	Radon Treatment System
RWP	Radiation Work Permit
SDWA	Safe Drinking Water Act
SLN	Sandia National Laboratories
TBC	to be considered
WEMCO	Westinghouse Environmental Management Company of Ohio
WMCO	Westinghouse Management Company of Ohio
USC	United States Code
USEPA	United States Environmental Protection Agency

000004

5528

LIST OF WEIGHTS AND MEASURES

ha	hectare
kg	kilograms
km	kilometers
lbs	pounds
m^3	cubic meters
mCi/ml	microCuries per milliliter
mg/g	microgram per gram
mg/kg	microgram per kilogram
mi	miles
ml	milliliters
ml/min	milliliters per minute
mrem/hr	milliroentgen equivalent man per hour
mrem/yr	milliroentgen equivalent man per year
pCi/g	picocuries per gram
pCi/l	picocuries per liter
$pCi/m^2/sec$	picocuries per square meters per second
ppm	parts per million
yd^3	cubic yard

000005

EXECUTIVE SUMMARY

From 1952 until 1958, the K-65 Silos received approximately 6117 cubic meters (m^3) [8000 cubic yards (yd^3)] of radium-bearing residues, which are by-products of uranium ore processing. Radon grab sampling of the K-65 silo headspace indicated concentrations in excess of 3×10^7 picoCuries/liter (pCi/l), resulting from the radium decay within the residues. Calculations projected that a bentonite covering over the K-65 silo residues would lower silo headspace radon equilibrium concentrations to within a range of 190,000 pCi/l to 226,000 pCi/l.

On May 21, 1990 the Removal Site Evaluation of the Silos 1 & 2 Removal Action was submitted by the U.S. Department of Energy (DOE). Based on review by DOE as the Lead Agency and based on Consent Agreement Negotiations between DOE and the U.S. Environmental Protection Agency (USEPA), this removal action was determined to be non-time critical. Since more than six months time was available for planning the Silos 1 & 2 Removal Action, an Engineering Evaluation/Cost Analysis (EE/CA) was performed to analyze removal action alternatives and to support DOE selection of a preferred alternative.

On November 30, 1990, the USEPA conditionally approved the Silos 1 & 2 Removal Action Work Plan. On December 5, 1990 the Ohio Environmental Protection Agency (OEPA) conditionally approved the Silos 1 & 2 Removal Action Work Plan. The required modifications to the work plan were made to meet the conditions and all OEPA and USEPA comments were addressed.

On June 4, 1991, Radon Treatment System (RTS) modifications were proposed in support of the Silos 1 & 2 Removal Action. On September 20, 1991, work began on the K-65 Silo Mapping Project, an Integrated Technology Demonstration. On October 10, 1991, surface mapping work on the K-65 Silos was completed.

On November 20, 1991, placement of bentonite into Silos 1 & 2 was initiated. Approximately 670 m^3 [23,700 cubic feet (ft^3)] of slurried bentonite was successfully placed over the K-65 silo residues by remote access pumping. On November 28, 1991, placement of bentonite into Silos 1 & 2 was completed. The success of the application of the bentonite clay layer was measured by its ability to absorb water and hold it in place so that radon emissions were subsequently reduced. Radiological technicians measured radiation levels before and after the process to document the impact of the bentonite layer on radon concentrations around the silos, on the domes, in the headspace, and at various FEMP fenceline locations.

The objective and performance goal for the removal action was established by the receipt of the USEPA's conditional approval of the Engineering Evaluation/Cost Analysis - Environmental Assessment (EE/CA-EA) for the K-65 Silos Removal Action No. 4. The objective of the removal action was to reduce radon emissions from the silos to a level as low as reasonably achievable and the goal was an ambient radon concentration of no greater than 0.015 picoCuries/liter (pCi/l) above background, at the location of the maximally exposed individual, at a non-FEMP location.

Due to the limits of best available technology, an incremental increase of radon concentrations of 0.015 pCi/l above background cannot be directly measured. Instead, the attainment of the removal action goal was determined by a combination of monitoring and standard computations/methods which were approved by the USEPA (see Appendix D). The off-site contribution to background radon levels was modeled using an Industrial Source Complex Long-Term Model, by inputting measured headspace concentrations to establish the exposure point concentrations for critical receptors in the FEMP area (see Appendix E).

In accordance with the Silos 1 and 2 Removal Action Work Plan, the effectiveness of the bentonite to mitigate the release of radon has been assessed on a continuous and monthly basis since January 1992. From January 1992 to September 1992, the data logging system used to record radon headspace concentrations experienced equipment failures which resulted in inconsistent data output from a quality control perspective. From September 1992 through March 1993, a number of minor modifications and unscheduled maintenance activities to the data logging system were required to improve system operations and data reliability. From April 1993 to the present, the data logging system has functioned quite well.

The monthly fenceline radon concentration at the K-65 exclusion zone has ranged over the past year (April 1993 - March 1994) from a minimum of 0.2 pCi/l to a maximum of 135.6 pCi/l (see Appendix A, Figures A-3 through A-6). The radon concentration in the silos headspace has ranged from 315 pCi/l to a maximum of 7.4×10^6 pCi/l (see Appendix A, Figures A-1 and A-2). This was a significant reduction in radon concentration within the silos headspace since pre-removal action levels were measured at 2.5×10^7 pCi/l in Silo 1 and 3×10^7 pCi/l in Silo 2. Therefore, the monitoring results indicate that the K-65 Silos 1 and 2 Removal Action has been successful in reducing radon emission from the K-65 Silos.

In December 1993, two video cameras were installed in Silo 2 to view the bentonite cap in an effort to explain a recent upward trend in headspace radon concentration in that silo. It was observed that bentonite remains essentially intact with localized areas of subsidence and shrinkage cracks. The presence of shrinkage cracks in the bentonite clay provides for more direct pathways for the radon (gas) to migrate to the silo headspace, bypassing the bentonite clay's attenuation effect. Although the silos headspace concentrations have gradually increased, they remain well below levels which would exceed the removal action's goal and necessitate further action.

1.0 OVERVIEW

The Fernald Environmental Management Project (FEMP) is located on 425 hectares (1050 acres) in a rural area approximately 27 kilometers (km) [17 miles (mi)] northwest of Cincinnati, Ohio. The site was formerly a contractor-managed federal facility used to produce purified uranium metal for DOE from 1951 until 1989. On July 18, 1986, a Federal Facilities Compliance Agreement (FFCA) was jointly signed by the DOE and the USEPA. This agreement ensures that environmental impacts are thoroughly investigated so that appropriate remedial actions can be assessed and implemented. A schedule for the investigation and remediation was established in a Consent Agreement between the USEPA and DOE, which was signed in 1990 and later amended in 1991.

A Remedial Investigation/Feasibility Study (RI/FS) has been initiated to develop these remedial actions. To make this process more efficient, the site has been segregated into five Operable Units. Operable Unit boundaries are determined through two criteria: physical location of the waste materials and similar types of waste. Operable Unit 4 is located at the western periphery of the site, south of the waste pit area. Operable Unit 4 consists of four waste storage silos, their ancillary structures and the surrounding soils. Silos 1 and 2, known as the K-65 Silos, contain radium-bearing, low-level radioactive waste. Silo 3 contains dry, low-level radioactive metal oxide powder. Silo 4 was never used and remains empty.

The Remedial Investigation (RI) for Operable Unit 4 was conducted to determine the nature and extent of contamination in Operable Unit 4 and establish remedial action objectives. The Feasibility Study (FS) evaluated alternative remedial actions for the silo structures, for materials stored in the silos and for contaminants in the surrounding soils, perched water and other structures within the Operable Unit 4 boundary. The evaluation considered several criteria, including long-term effectiveness, reduction in toxicity mobility and volume of waste, cost, and time required for implementation.

From 1952 until 1958, the K-65 Silos received approximately 6117 m^3 (8000 yd^3) of radium-bearing residues, which are by-products of uranium ore processing. Raffinates (residues resulting from uranium solvent extraction) were pumped into the silos as a slurry, where the solids would settle. The free liquid was decanted through a series of evenly spaced valves and piping along the height of the silo wall. This procedure continued until the waste material was approximately 1.2 meters (4 feet) below the top of the vertical wall. Historic analyses of the K-65 Silo residues indicate that they contain approximately 11,200 kilograms (kg) [24,500 pounds (lbs)] of uranium (0.71 percent U-235). Analytical results of K-65 residue samples taken in July 1988 indicated uranium concentrations were 1400 parts per million (ppm) in Silo 1 and 1800 ppm in Silo 2. In addition, the estimated concentration of radium was between 0.13 to 0.21 ppm in the K-65 residues.

In 1963, it became obvious that the K-65 silos were deteriorating on their exterior. Site workers repaired the concrete around each silo and constructed an earthen embankment around them to counterbalance the

000003

load from the silo contents. The embankment also protected the silo walls from weathering and served as a radiation shield. This embankment was expanded in 1983 to reduce erosion.

Radon and the elements resulting from its decay (referred to as daughter products, or progeny) are the nuclides of concern from a health and environmental perspective. Radon was known to be emanating from the K-65 Silos via cracks and at structural joints. Radon and its daughter products are relatively mobile and capable of migrating through air and water. Through the RI/FS characterization efforts, it was found that the berms and surrounding subsoils contain elevated levels of lead-210 (Pb-210) and polonium-210 (Po-210), which are daughter products of radon decay.

In late 1985, Camargo Associates Limited performed a structural analysis of the silos that showed evidence of structural instability and recommended that some protective action be taken (Camargo 1986). In January 1986, 9-meter (30-foot) diameter protective plywood covers for the domes of the silos were constructed and installed on Silos 1 and 2. In late 1987, a foam coating was applied to the domes of the silos to further reduce weathering and to reduce radon gas emissions. A Radon Treatment System (RTS) was installed to remove radon from the silos prior to installation of the plywood covers and foam coating.

In 1988, the first videotapes of the Silos 1 and 2 interiors were made in an effort to verify the 1985 Camargo report's assertions that both of the silos' domes integrity had been reduced by either the spalling of the interior concrete surface of the domes or the physical separation of the single concrete dome into multiple layers. These initial videotapes provided visual confirmation that both the interior silo dome surfaces were not spalling nor was there any other direct evidence of dome deterioration. This "lack" of physical evidence supported the other Camargo assertion that the concrete silo domes have undergone a physical separation, resulting in at least two distinct concrete layers within the dome structures themselves.

In January 1990, Bechtel National Inc., completed an additional structural analysis of Silos 1 and 2. Included in this analysis were predicted life expectancies of the silos and an evaluation of their structural integrity. The findings showed that the silo concrete had lost at least 60 percent of its design strength, and confirmed the Camargo finding that silo dome failure would result in an immediate release to the environment of radon gas from the head space of the silos. There would also be the potential for K-65 residues to become airborne under certain tornado loading conditions, presented in the University of Cincinnati K-65 Probabilistic Risk Assessment. Based on these impacts and the removal action criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a removal action was deemed appropriate.

In March 1990, radon grab sampling of the K-65 silo headspace indicated concentrations in excess of 3×10^7 pCi/l, resulting from the radium decay within the residues. Given the known volumes for the silo voids, radon activity was estimated at an equilibrium value of 33 Curies (Ci) per silo void. This corresponded to a radon generation rate of 11 Ci/day. Flux measurements made at various locations on

the silo dome surface to the fenceline of the K-65 Exclusion Zone. Flux values ranged from 13 pCi/m^2/sec to 3 x 10^7 pCi/m^2/sec. Calculations projected that a bentonite covering over the K-65 silo residue would lower silo headspace radon equilibrium concentrations to within a range of 190,000 pCi/l to 226,000 pCi/l.

As outlined in the Amended Consent Agreement, removal actions can be initiated to prevent the potential for contaminant release (e.g. chronic release of radon gas from the K-65 Silos) into the environment until a final remedial alternative can be implemented. On May 21, 1990, the Removal Site Evaluation (RSE) of the Silos 1 & 2 Removal Action was submitted by the DOE. Based on review by DOE as the lead agency and based on Consent Agreement Negotiations between DOE and the USEPA this removal action was determined to be non-time critical. Since more than six months time was available for planning the Silos 1 & 2 Removal Action, an Engineering Evaluation/Cost Analysis (EE/CA) was performed to analyze removal action alternatives and to support DOE selection of a preferred alternative. The Silos 1 & 2 Removal Action EE/CA, submitted August 1, 1990, was to be used as the basis for remedy selection and implementation. The USEPA conditionally approved the Silos 1 & 2 Removal Action EE/CA on September 4, 1990.

On October 29, 1990, a Silos 1 & 2 Removal Action Memorandum was sent from DOE to Westinghouse Management Company of Ohio (WMCO). The remedy selected by DOE for the Silos 1 and 2 (K-65) Removal Action (RA Number 4 per the Amended Consent Agreement) would consist of placing a layer of bentonite clay (e.g. BentoGrout) over the K-65 residues in Silos 1 and 2 to attenuate release of radon gas to the environment and to reduce the potential risk of airborne contaminants in the case of dome failure.

The Silos 1 & 2 Removal Action Work Plan was submitted by WMCO to DOE on November 1, 1990. The Silos 1 & 2 Removal Action Work Plan identified the removal action objectives. On completion of the Safety and Risk Assessments, a task-specific Health and Safety Plan was prepared to protect personnel during the implementation of the removal action. The activities associated with the removal action work plan were evaluated to be consistent with the various alternatives to be selected at the conclusion of the RI/FS on the safe and final disposition of the K-65 silo materials. While addition of the BentoGrout would increase the total volume of waste in the silos, the benefit of elimination of chronic radon releases to the environment outweighed waste minimization concerns. Furthermore, the bentonite clay would also minimize potential releases as a consequence of accidents during final remediation.

On November 5, 1990, DOE submitted Removal Action Number 4 - K-65 Silos Work Plan to the USEPA and OEPA. On November 9, 1990, WMCO initiated an Operational Readiness Review for the Silos 1 & 2 Removal Action. On November 14, 1990, U.S. Department of Energy-Headquarters (DOE-HQ) National Environmental Policy Act (NEPA) Coordinator reviewed the EE/CA-EA and provided a finding of no significant impact on the Silos 1 & 2 Removal Action. On November 30, 1990, the USEPA conditionally approved the work plan. On December 5, 1990, the OEPA conditionally approved

the Silos 1 & 2 Removal Action Work Plan. The required modifications to the work plan were made to meet the conditions and all Ohio and USEPA comments were addressed.

On June 4, 1991, RTS modifications were proposed in support of the Silos 1 & 2 Removal Action. The RTS was modified to allow better access through the manway for equipment, remote valve actuation control, to provide by-pass piping and a new fan. On September 18, 1991, a Construction Excavation/Penetration Permit was issued to RUST Engineering to prepare for supporting the Silos 1 & 2 Removal Action Work Plan construction activities.

On September 20, 1991, work began on the K-65 Silo Mapping Project, an Integrated Technology Demonstration. Surface mapping technology was developed to define the exact height of the K-65 residue material in the silos, including contours and anomalies on the surface of the residues. The initial portion of the K-65 Silo Mapping Project was to demonstrate the application of structured light technology in the empty Silo 4 structure. The success of the Silo 4 surface mapping project provided management with encouraging information that the waste surface topography could be accurately mapped thus satisfying the need to measure the change in surface height after the bentonite was placed. Hands-on training for operators of the robotic mapping equipment, and optimal health and safety procedural data was also deemed necessary to safely complete the BentoGrout placement and logistics outlined in the Silo 1 & 2 Removal Action Work Plan. On October 10, 1991, surface mapping work on the K-65 Silos was completed.

On November 20, 1991, installation of bentonite into the Silos 1 & 2 was initiated. Approximately 670 m^3 (23,700 ft^3) tons of slurried bentonite was successfully placed over the K-65 silo residues by remote access pumping. On November 28, 1991, installation of bentonite into Silos 1 & 2 was completed. The success of the application of the bentonite clay process was measured by its ability to absorb water and hold it in place so that radon emissions are subsequently reduced, which was supplemented by the mapping technology to ensure proper coverage across the entire 5000 ft^2 waste surface for long-term placement. Radiological technicians measured radiation levels before and after the process to document the impact of the bentonite on radon emissions around the silos, on the domes, in the headspace, and at various FEMP fenceline locations. The application of the BentoGrout resulted in a significant reduction of the radon concentration in the silos headspace. The added BentoGrout also achieved reduced radiation measurements at the silo dome surface, at K-65 exclusion zone fenceline, as well as at the perimeter of the FEMP site near the K-65 Silo.

The effectiveness of the bentonite to mitigate the release of radon has been assessed on a monthly basis since January 1992. The effectiveness was performed in accordance with the approved Silos 1 and 2 Removal Action Work Plan and the results are reported monthly to the USEPA and OEPA. On December 17, 1992, the Draft Bentonite Effectiveness Evaluation Report was prepared to determine the effectiveness of the bentonite layer in reducing the radon levels in the headspace as well as to the nearest resident. The Draft Bentonite Effectiveness Report was reviewed and disapproved by the USEPA. Since

that report was issued, it was discovered that the headspace data collected and analyzed in that report was inaccurate due to hardware failures in the data collection system. In addition, the report did not evaluate the current conditions of the bentonite layers and silo headspace concentrations. The Draft Bentonite Effectiveness Report will not be reissued, in lieu the submittal of this Final Report for the Silos 1 and 2 Removal Action.

Radon concentrations have remained relatively steady in both silos through April 1993. Since that time, Silo 1 readings have remained relatively steady while Silo 2 is showing an upward trend. The Silo 2 Camera Installation Work Plan was prepared on October 4, 1993 to cover the installation of remote controlled television cameras in Silo 2 to view the interior of the silo (See Appendix F). In December 1993, two cameras were installed in Silo 2 to view the bentonite cap in an effort to explain a recent upward trend in headspace radon concentration in that silo.

2.0 SILOS 1 & 2 REMOVAL ACTION IMPLEMENTATION

2.1 Introduction

This Removal Action was conducted pursuant to the Amended Consent Agreement under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120 and 106(a) between the DOE and the USEPA. Initially, after reviewing the K-65 Silos 1 & 2 Removal Action EE/CA, Department of Energy-Fernald Field Office (DOE-FN) as the lead agency, issued an Action Memorandum on October 3, 1991, requesting implementation of the removal action:

- modification and upgrade of the existing RTS;
- precision surface mapping of the interior contents of the K-65 silos;
- development and installation of a Data Logging System (DLS);
- installation of video monitors;
- installation of silo manway glove bags;
- modification of silo manways to accept remotely operated pump equipment;
- placement of slurried bentonite clay over K-65 silo residue;
- surface mapping as verification of proper bentonite emplacement;
- sealing of silo penetrations; and,
- continuous monitoring of radon concentrations utilizing the DLS.

Radon grab sampling prior to the removal action indicated radon K-65 silo headspace concentrations in excess of 3 x 10^7 pCi/l. The origin of the radon in the headspace results from the natural decay of the radium within the residues. Given the known volumes for the silo voids, radon activity was estimated at an equilibrium value of 33 Ci per silo void. This corresponded to a radon generation rate of 11 Ci/day. Flux measurements made at various locations on the silo dome surface ranged from 13 pCi/m^2/sec to 3 x 10^7 pCi/m^2/sec. Modeling projected that the bentonite covering would lower radon equilibrium concentrations to less than 190,000 pCi/l to 226,000 pCi/l. This value, in part, established the criteria for measuring the success of the bentonite covering.

000013

It was calculated that an application of a one (1) foot layer of bentonite to the surface of the residues contained in Silos 1 and 2 would sufficiently retard radon gas emanation from the residues, and thereby reduce radon gas emissions to the environment. Bentonite was selected because of several properties:

- controlled plasticity for easy placement;
- durability and resistance to effects of falling debris;
- flowability, flexibility, and self-healing ability to seal cracks;
- not absorbed by the K-65 residue;
- retains moisture and will not solidify;
- absorbs water and reduces radon emissions;

2.2 Physical Constraints

The silos at Fernald are ~24.4 m (80 ft) in diameter, with 7.9-m-high (26-ft-high) vertical walls and a domed top rising to 11.0 m (37 ft) at the center (see Figure 2-1). The walls are ~20-cm-thick (8-in.-thick) concrete, and the dome tapers from 20 cm (8 in.) thick at the edges to 10 cm (4 in.) thick at the center. Five 0.5-m-diameter (1.6-ft-diam.) access portals are available on the dome tops, one near the center and four at 90° spacings, 7.6 m (25 ft) from the center of the dome. An array of 5-cm (2-in.) sounding ports, typically spaced 4.6 m (15 ft) apart, are also located on the dome tops. Various other penetrations exist on some, but not all, of the silos. Operating constraints included the use of existing penetrations only, load limits of not more than 311 kg (700 lb) on the outer part of the dome, and no net loading on the center of the dome. Operation from a suspended platform was necessary to access the center access portal without loading the dome center.

Because the waste surfaces were not flat but were known to have several mounds and other surface features, the thickness of bentonite needed to be measured at points throughout the waste surfaces to ensure adequate coverage. The silos had a limited number of access portals and moderately high levels of radioactivity; therefore, remote measurements were required utilizing techniques that would be applicable at distances up to 15.2 m (50 ft) from an access portal.

2.3 Surface Mapping Baseline

The following describes the application of a structured light source (laser mapping) to obtain waste-surface contour data before bentonite deposition and to obtain bentonite-surface contour data after deposition. The thickness of bentonite at any point along the waste surface can be determined by the change in surface height between the two surface maps. Development of this technology and testing in Silo 4 was sponsored by the DOE Office of Technology Development (OTD) Robotics Technology

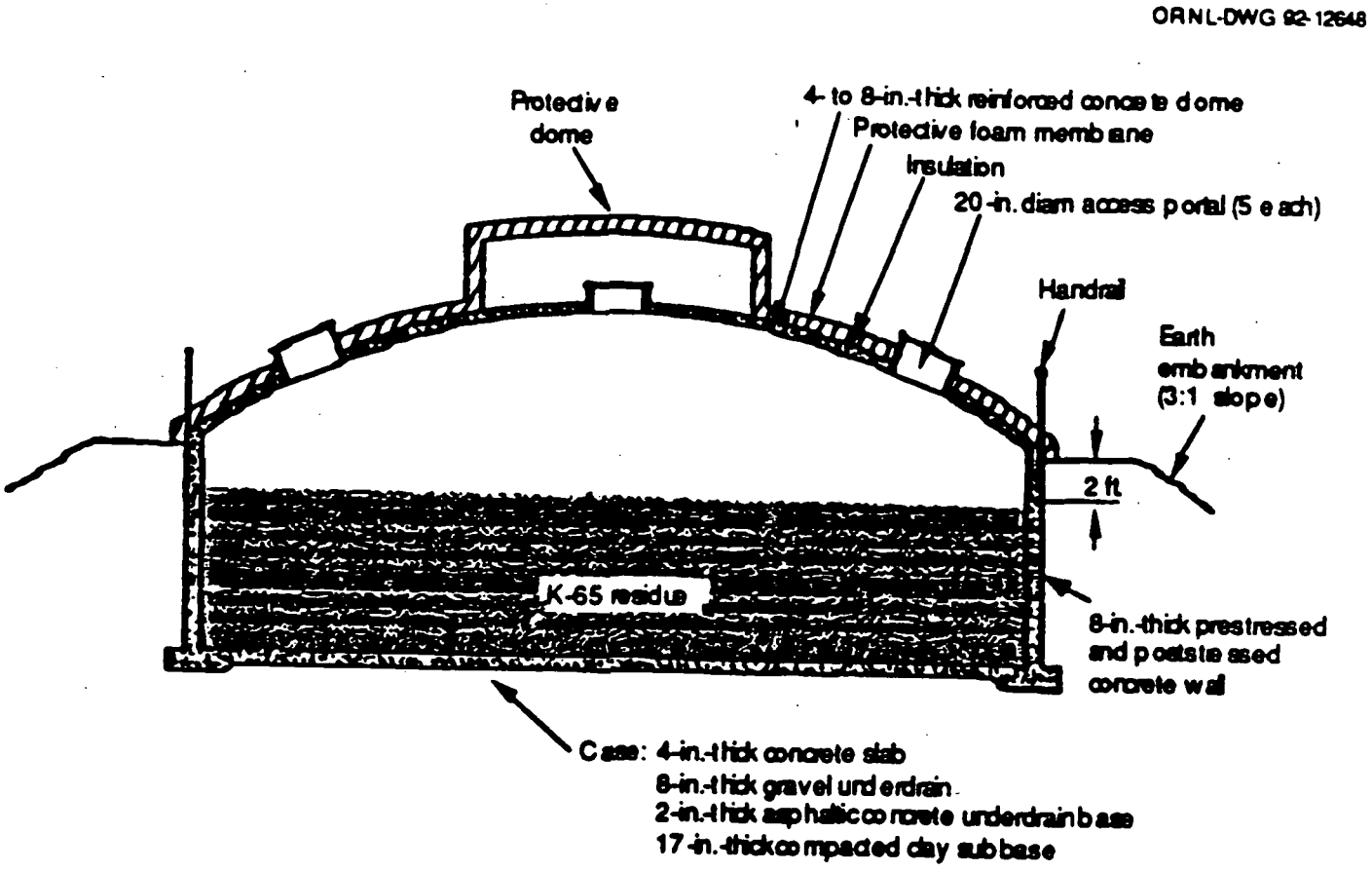


FIGURE 2-1 Cross-sectional schematic of the K-65 silos at Fernald.

Development Program. Participants included personnel from Oak Ridge National Laboratory (ORNL), WEMCO, and Rust Engineering. During the early stages of the development phase, ORNL was assisted by Sandia National Laboratories (SNL).

The in-silo hardware consisted mainly, but not exclusively, of three structured light measurement units (MUs). Each of these units consisted of a mounting base, light, camera, line laser, and spot laser. This assembly was fastened to a pan-and-tilt mechanism for azimuth and pitch alignment and adjustment. The pan-and-tilt encoders had resolution of 0.0035° or ~0.2 min. of arc. To obtain that accuracy, the mechanism was custom designed with precision rotary components.

The pan-and-tilt mechanism of each MU was fastened to an aluminum pipe extending down from a flange plate mounted in one of the access portals of the silo dome. The length of pipe was chosen to provide pan-and-tilt clearance inside the dome, while also maximizing MU height above the waste surface. Electrical connectors and wiring were provided to power the pan-and-tilt motors and the electronic apparatus as well as receive and transmit data and control signals with the lasers, cameras, and rotary stage encoders. This assembly is shown in Figure 2-2.

In addition to the MUs, three global reference light assemblies were used to define a reference plane called the global reference frame (GRF). These GRF assemblies were inserted through 5-cm (2-in.) sounding ports near the periphery of the silo. During installation of the GRF, a water balance was used to ensure that the lights were mounted in a plane, level with respect to gravity. In this way, a level reference plane was established regardless of any local nonuniformity in the shape of the dome.

2.3.1 Surface Mapping Baseline

The baseline mapping completion deadline given the team was October 12, 1991. This date was chosen to allow sufficient time to install and test the bentonite-emplacement equipment. Waste surface mapping of both silos was completed in the early morning of October 11, 1991. As a result of the learning process on Silo 1, mapping of Silo 2 required only 47 hours from the start of mapping to completion even though this surface was much more irregular. In addition to the surface maps, videotapes were made of the silo interior. To assist with data verification before and after bentonite emplacement, a series of digitized images were acquired at 10° to 15° intervals using the center MU.

Results of the waste-surface mapping included some surprises (see Figures 2-3 through 2-6). The surfaces were not as smooth and flat as the 1988 videotapes had indicated. The waste surfaces were littered with deep cracks and crevices and were very craggy, with hundreds of small puffy areas surrounded by cracks. The surfaces strongly resembled dried mud flats. The surfaces were nominally crown shaped with dropoffs of 0.6 to 1 m (2 to 3 ft) from the center to the walls. Large mounds were located near all five access portals of Silo 2 and near the southeast access portal of Silo 1. The mound in Silo 1 was about 6.5 m (21.5 ft) wide and about 0.8 m (2.5 ft) high and peaked at about 2 cm (0.8 in.) below the GRF. The largest mound in Silo 2 was about 7.5 m (24 ft) wide but reached a height of

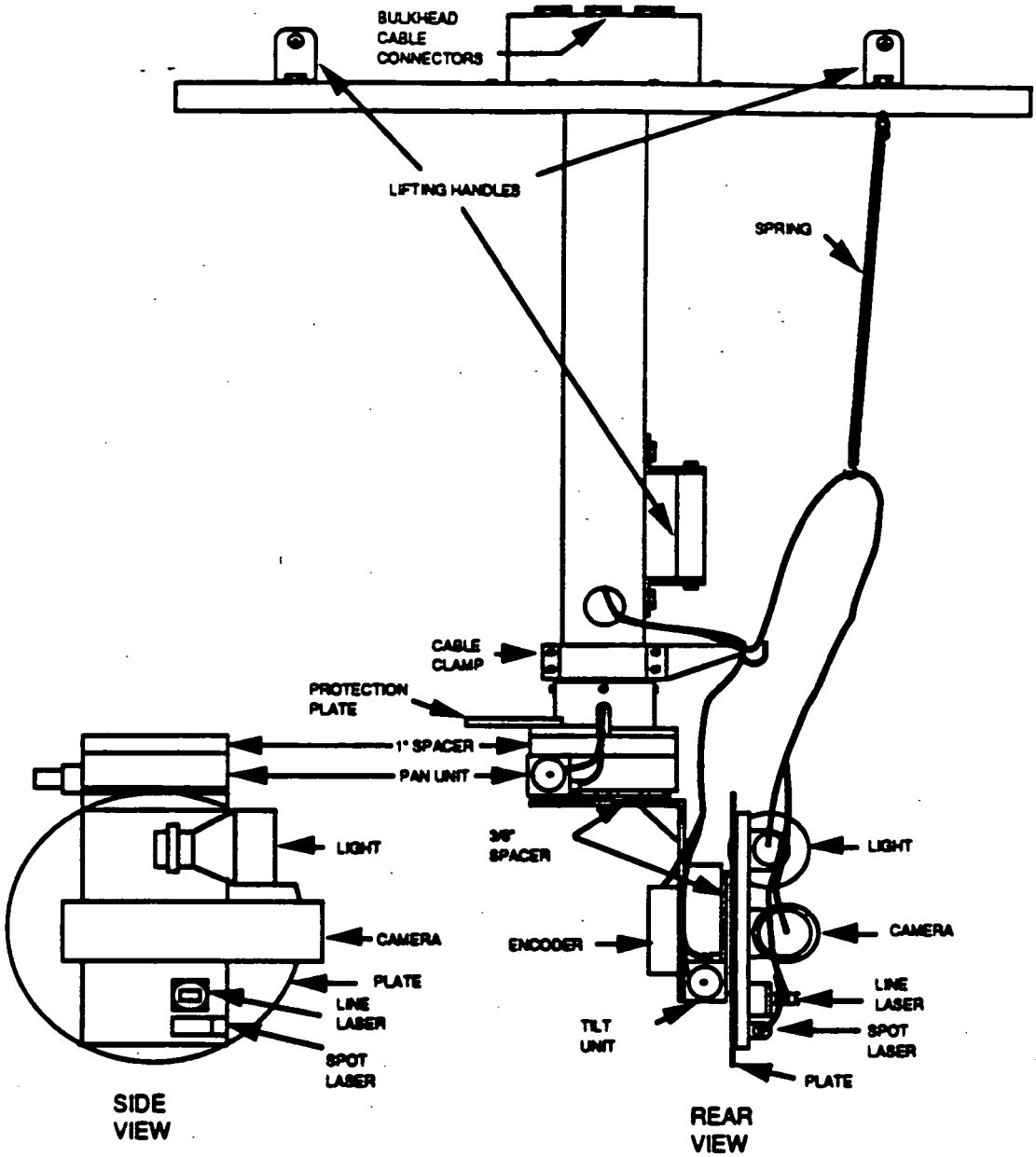


FIGURE 2-2 Illustration of a surface mapping measurement unit.

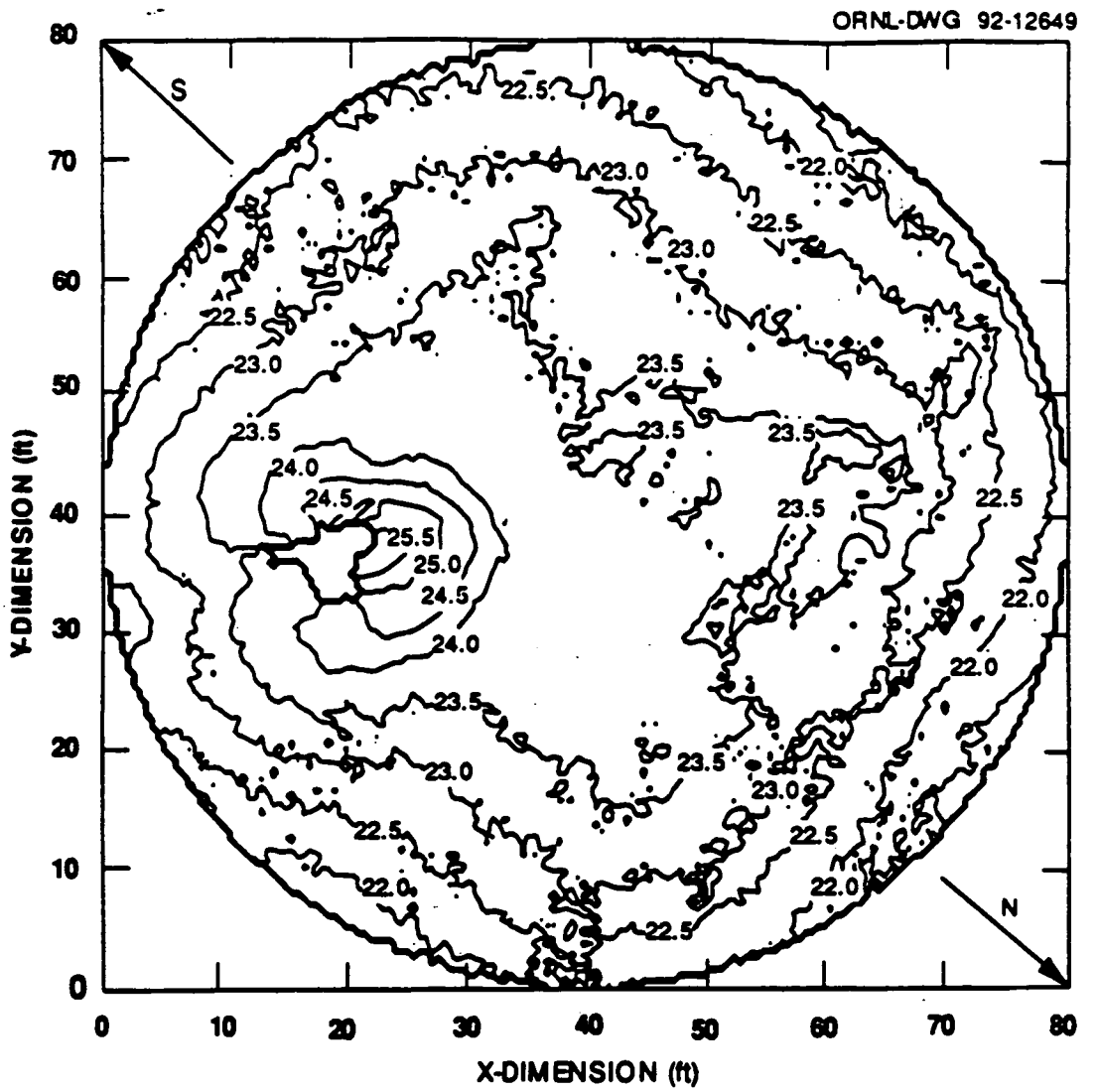


FIGURE 2-3 Contour plot of Silo 1 baseline waste-surface data (6 inch contours).

5528

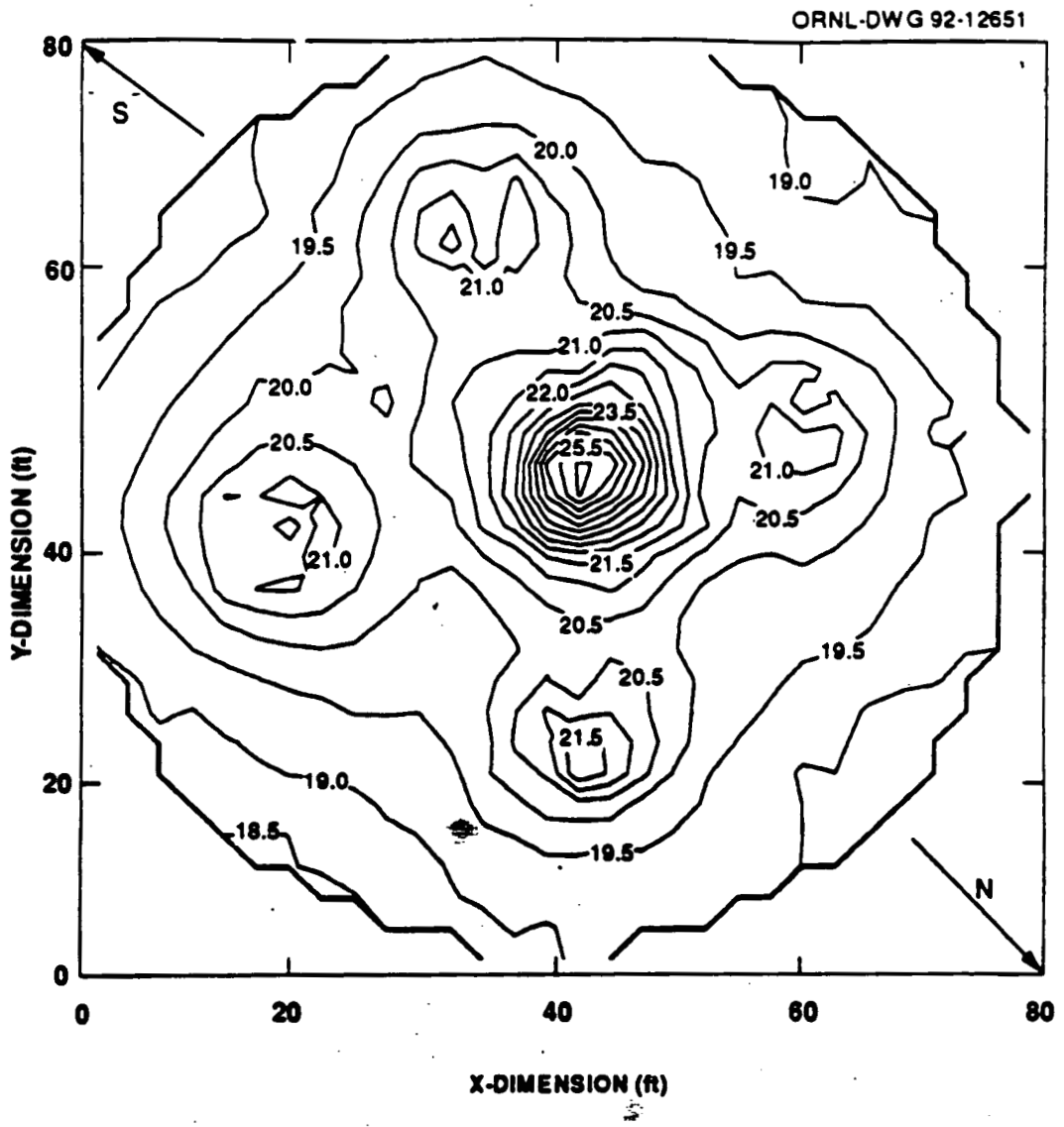
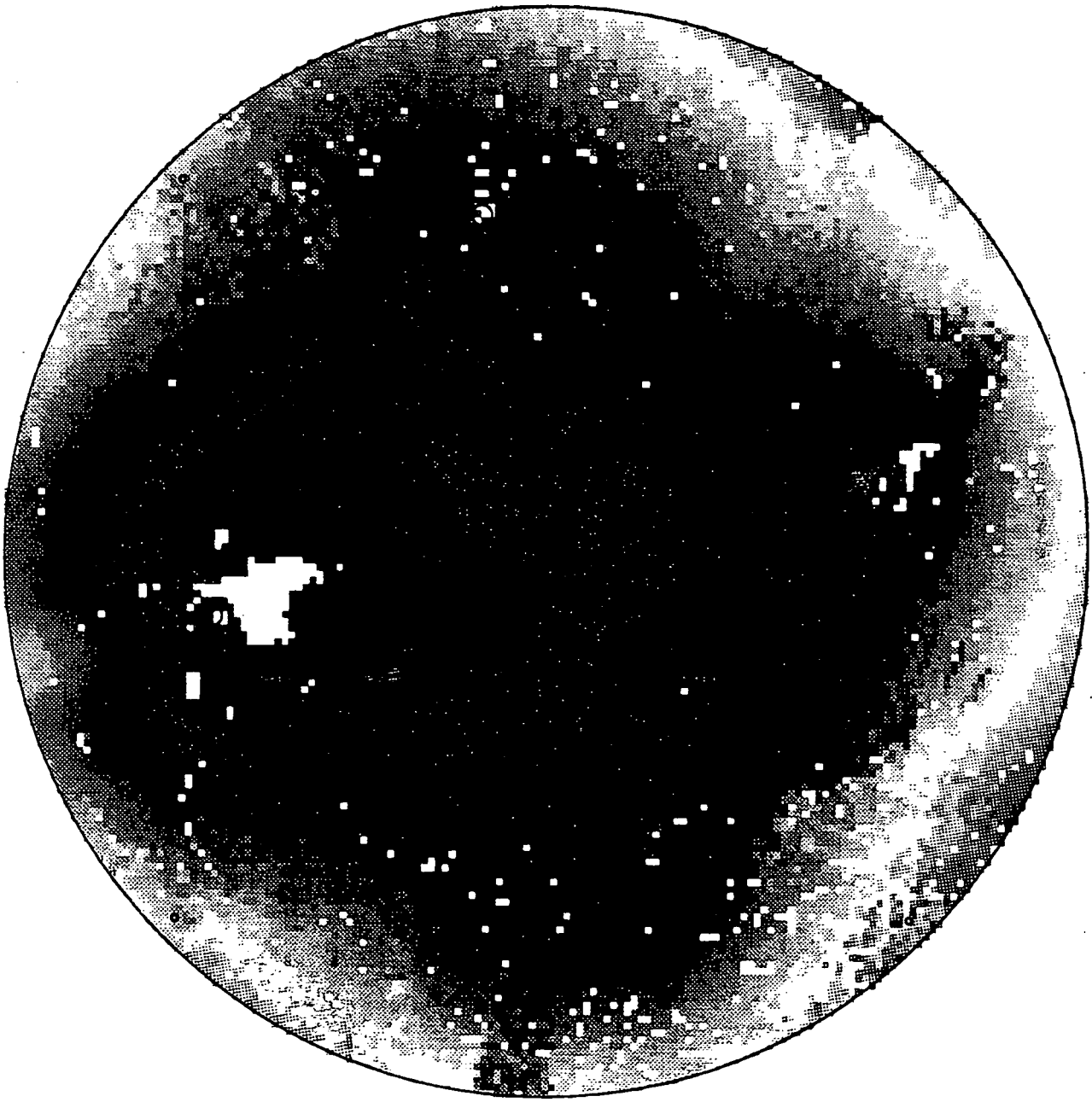


FIGURE 2-4 Contour plot of Silo 2 baseline waste-surface data (6 inch contours).

K-65 Silo # 1

ORNL-DWG 92-8155

Waste Surface Map - Oct. 91



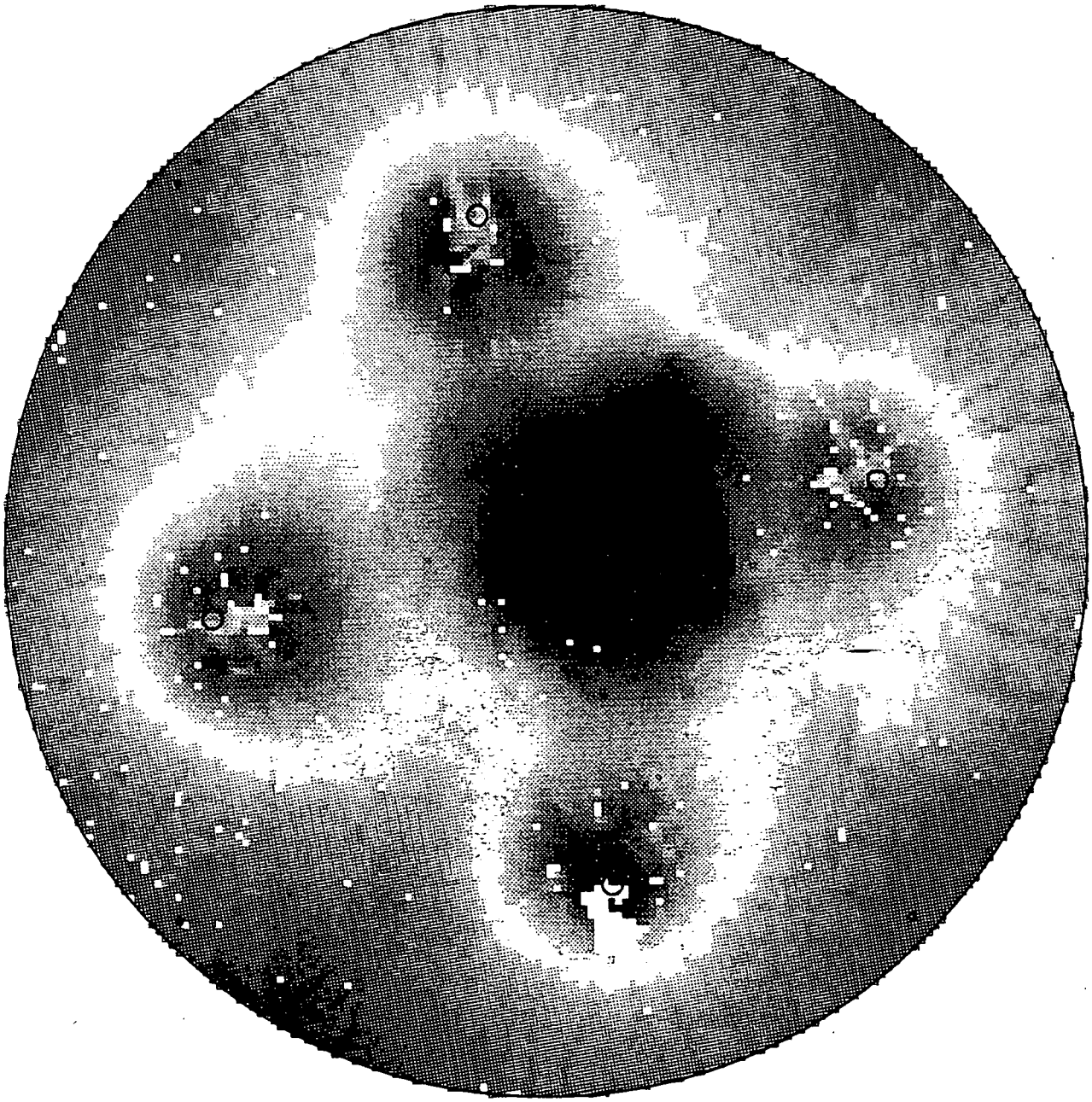
Distance below ORNL Global Reference Frame
Minimum (red) = -67" Maximum (indigo) = -1"

FIGURE 2-5 Silo 1 baseline waste-surface map, 256-color vertical dimension.

K-65 Silo # 2

ORNL-DWG 92-8163

Waste Surface Map - Oct. 91



Distance below ORNL Global Reference Frame
Minimum (red) = -100" Maximum (indigo) = +2"

FIGURE 2-6 Silo 2 baseline waste-surface map, 256-color vertical dimension.

nearly 2 m (6.5 ft). The top of this mound was about 5 cm (2 in.) above the GRF. Because the GRF was located about 15 cm (6 in.) above the top of the vertical walls. The waste-surface data were used to plan for the bentonite emplacement and also as a baseline for bentonite-thickness measurements. Volumetric analyses were also performed to determine the volume of waste in each silo (see Table 2-1).

A number of methods can be used to display the three-dimensional data that were gathered in Silo 1 and 2. Presented here are surface-contour maps generated by using Spyglass software (see Figures 2-3 and 2-4). The operator interface color plots use 256 colors in a continuous blend from purple to red to indicate the vertical dimension or surface height (see Figures 2-5 and 2-6). As a result of this color resolution, features like the crevices are retained in the surface data in spite of the coarse binning (15 by 15 cm). Maximum and minimum surface heights are indicated in the figures.

2.4 Bentonite Installation

The process involved the mixture of bentonite with water to form a slurry of controlled consistency. The bentonite slurry was then remotely applied by spraying onto the residue in each silo. Since the surfaces of the waste residues contained in Silos 1 & 2 varied considerably from a level interior placement of the bentonite without accurately determining the surface contours would have resulted in the bentonite layer ranging from a minimum of one (1) foot up to six (6) feet in thickness. Topographical mapping of each silo's residue surface area before and after the bentonite placement ensured that the one (1) foot minimum required thickness was achieved across the entire surface area both minimizing the cost of material placed; but more importantly, minimizing the amount of bentonite requiring treatment and disposal in the future.

The dry bentonite bulk material was delivered by pneumatic tanker to a receiving area near the silo and then pumped with water into the bentonite hopper, which was used to produce the desired viscosity and specific gravity of the bentonite slurry. A bin vent filter, located on top of the hopper, kept bentonite dust material from blowing into the air during the process. The tele-operated distributor sprayhead delivered the bentonite slurry in a circular fashion using two (2) opposing sprayheads. The RTS was operated prior to opening the manways in order to reduce the potential radiation exposures to workers at the silo domes.

The bentonite distribution sprayheads were lowered into the silos through the manways by remote operations. A crane was utilized to position the sprayheads assembly above the silo dome to avoid additional structural loads on the silo domes. Silo manway glove bags were installed to minimize radon emissions during the placement of the bentonite. Two closed circuit television cameras were installed into separate peripheral manways to view the operations of the distributor sprayheads.

A control trailer, housing two (2) operators, was used to direct the operations. Two (2) other operators, located on the bentonite skid, controlled the rate of flow, mix design, mix time, distributor sprayhead rotations, and conducted quality assurance inspections on random bentonite samples.

5528

TABLE 2-1
Waste, Bentonite, and Headspace Volumes in Silos 1 and 2
Calculated by Using the Structured Light Surface Data

Volume	Silo 1	Silo 2
Waste	3280 ± 35 m^3 115,900 ± 1,250 ft^3	2840 ± 35 m^3 100,400 ± 1,2500 ft^3
Headspace before bentonite	1150 ± 35 m^3 40,500 ± 1,250 ft^3	1580 ± 35 m^3 55,900 ± 1,250 ft^3
Bentonite	360 ± 14 m^3 12,600 ± 500 ft^3	310 ± 14 m^3 11,100 ± 500 ft^3
Headspace after bentonite	790 ± 35 m^3 27,900 ± 1,250 ft^3	1270 ± 35 m^3 44,800 ± 1,250 ft^3
Total waste and bentonite	3160 ± 35 m^3 128,400 ± 1,250 ft^3	3640 ± 35 m_3 111,500 ± 1,250 ft^3

SOURCE: Burks, B.L. and others, October 1992, "Waste Surface Mapping of the Fernald K-65 Silos Using a Structured Light Measurement System," ORNL/TM-12185, U.S. Department of Energy, Office of Technology Development, Table 5.5, p. 74.

000023

Silo 1 received the bentonite layer first. Continual placement (around the clock), required forty (40) hours to achieve the required minimal thickness. Silo 2 bentonite mixture had an increased viscosity to obtain a greater angle of repose while being applied to surface mounds as a waste minimization effort since the interior residue surface had a unique topography. Placement of the bentonite in Silos 1 and 2 was completed in eight (8) days. A total of 670 m^3 (23,700 ft^3) of bentonite clay slurry was applied to the K-65 silos [approximately 360 m^3 (12,600 ft^3) of bentonite were placed in Silo 1 and 310 m^3 (11,100 ft^3) of bentonite were placed in Silo 2].

2.5 Surface Mapping - Verification

Final surface mapping results were obtained in December 1991, after the bentonite deposition, in a mapping campaign lasting from December 2-21, 1991. After bentonite emplacement, the surfaces were much higher, resulting in even more challenging data acquisition geometries.

The surface data displayed in Figures 2-7 through 2-10 were generated by using the same approach shown in Figures 2-3 to 2-6 and discussed previously. Together with Figures 2-7 through 2-10 and video footage taken during the bentonite placement, there was verification that the K-65 waste surfaces in both Silos 1 and 2 were covered with a one-foot minimum layer of bentonite clay.

The resulting surface maps have been used for five purposes. First, the baseline waste surface maps provided the site with data needed to plan the deposition of the bentonite clay cap over the waste including amount of bentonite required to procure. Second, the bentonite-surface maps were compared to the baseline data to determine bentonite thickness over the entire waste surface. Third, these two sets of data provided planning information for the eventual removal of the cap and the waste. Fourth, the baseline data provided verification of waste volumes and historical data (see Table 2-1). Fifth, the headspace volume calculations were needed to support subsequent radon data logging.

Using the change in surface height to verify bentonite thickness is dependent on the assumptions that the bentonite addition does not significantly compress the waste and that the underlying surface was not significantly altered during the bentonite application. The first assumption is supported by the resulting measurements, that is, no evidence of significant compression was observed. During the application of the bentonite, video cameras visually confirmed that the underlying surface area was affected where sharp features (i.e., crevice edges and mounded areas) were concerned. The crevice edges and mounds were definitely eroded by the bentonite application.

Direct evidence of this phenomena is provided by the bentonite contours in Figures 2-7 and 2-8 which suggest that several of the underlying mounded areas may not be actually covered by a 1-foot thickness of bentonite. The erosion of these mounds during the bentonite placement caused a decrease in the measured baseline surface elevations (pre-bentonite) by which the post-bentonite surface elevations would be compared. The alterations (i.e., erosion) to the baseline surface elevations of the mounded areas cannot be compensated for using this measurement technique, thus causing the measured bentonite

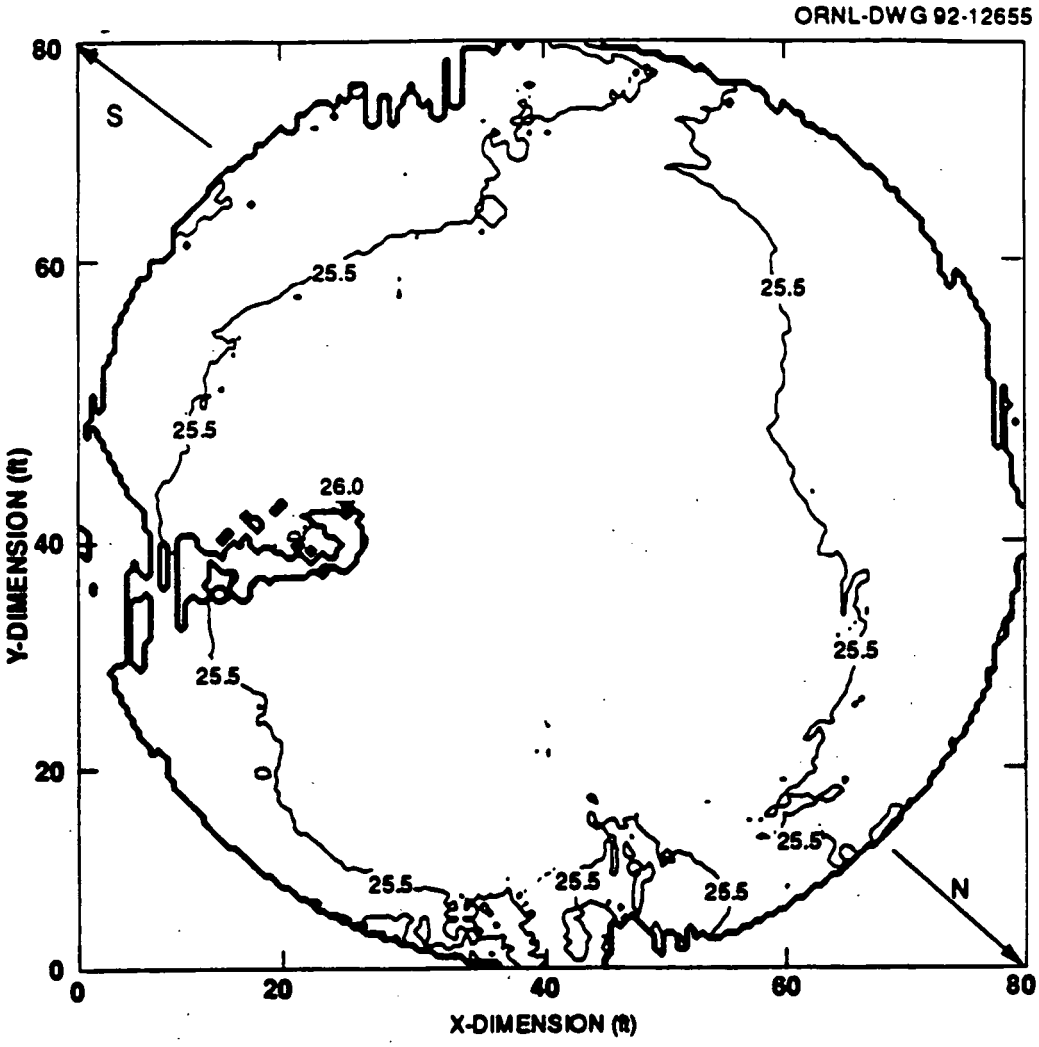


FIGURE 2-7 Contour plot of Silo 1 bentonite-surface data. (6 inch contours).

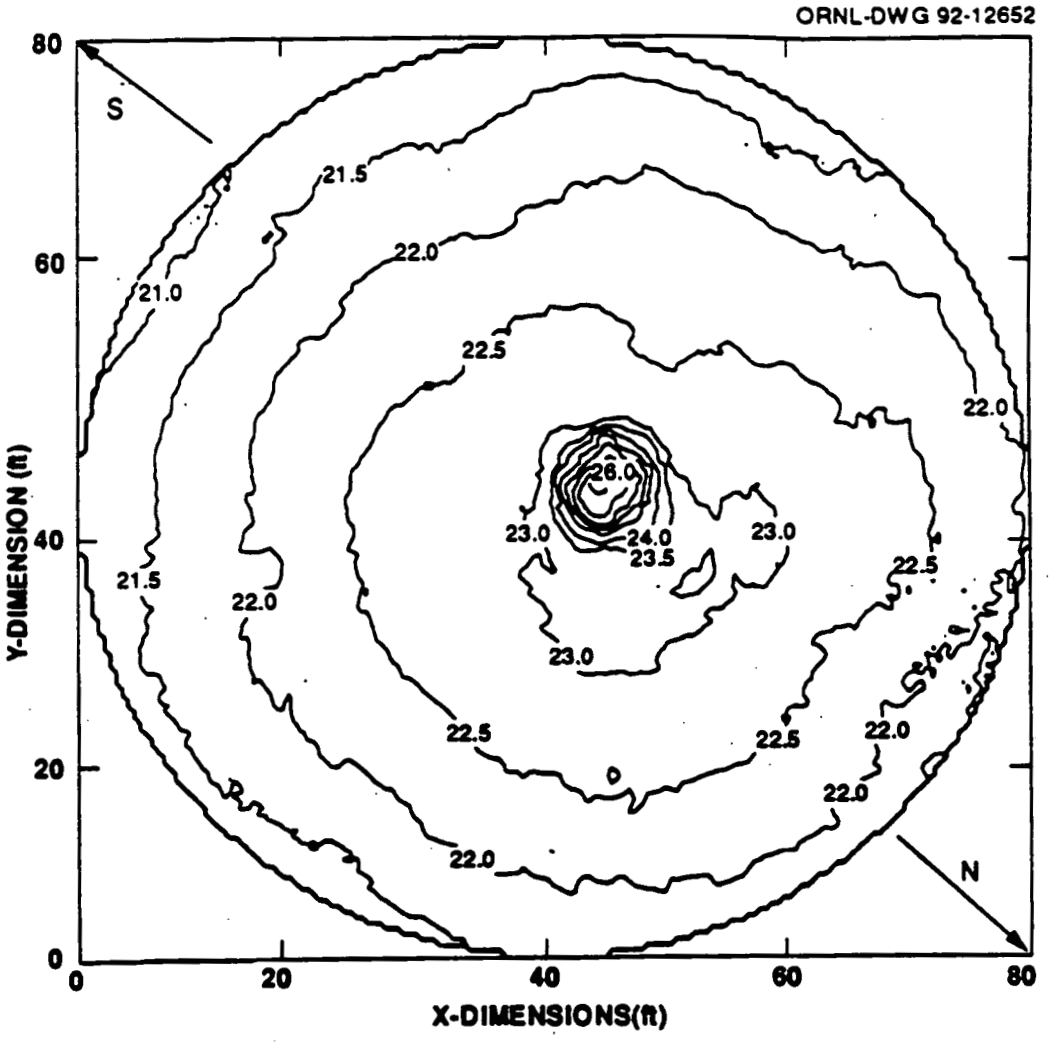
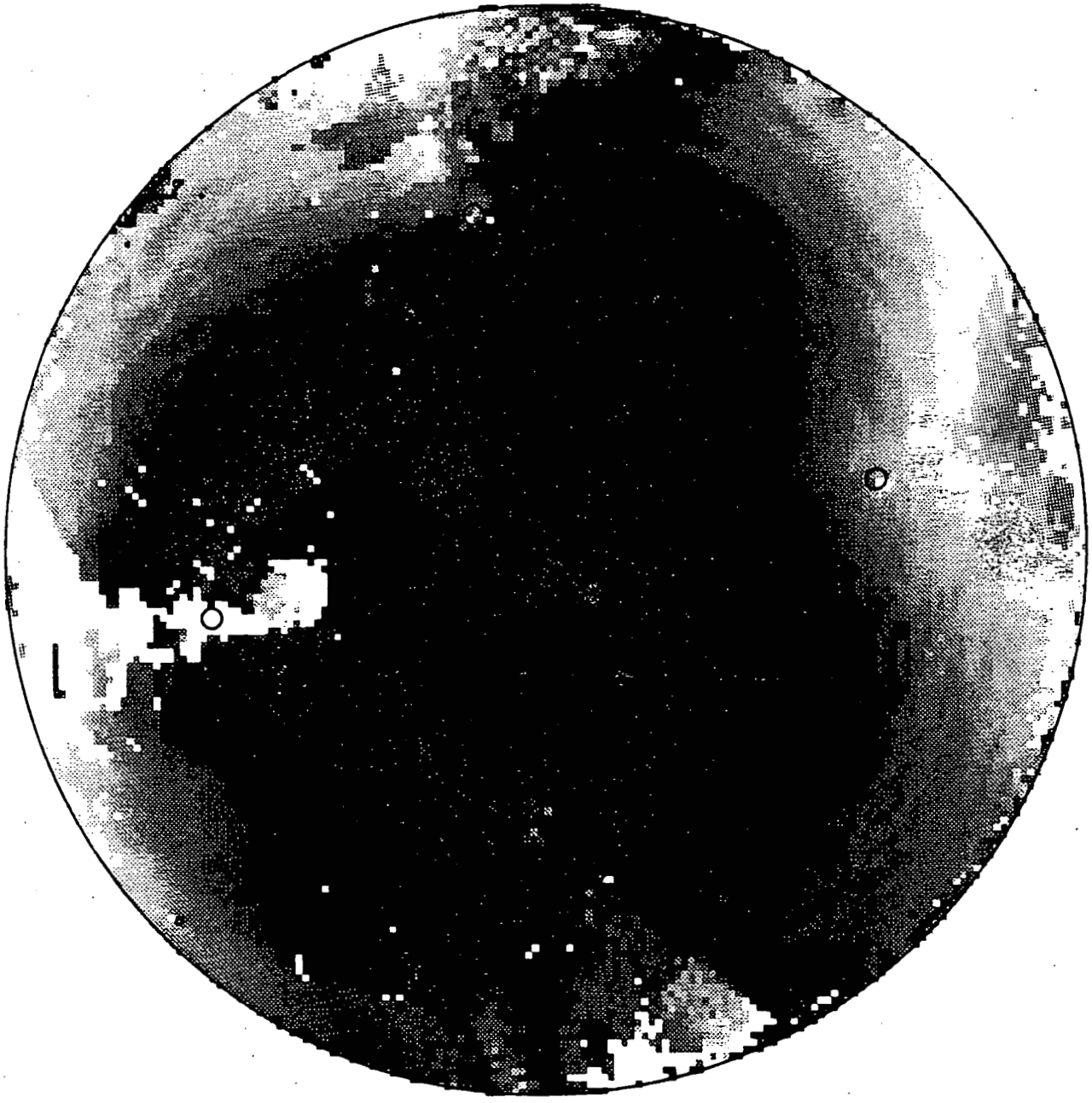


FIGURE 2-8 Contour plot of Silo 2 bentonite-surface data. (6 inch contours).

K-65 Silo # 1

ORNL-DWG 92-8162

Waste Surface Map - Dec. 91



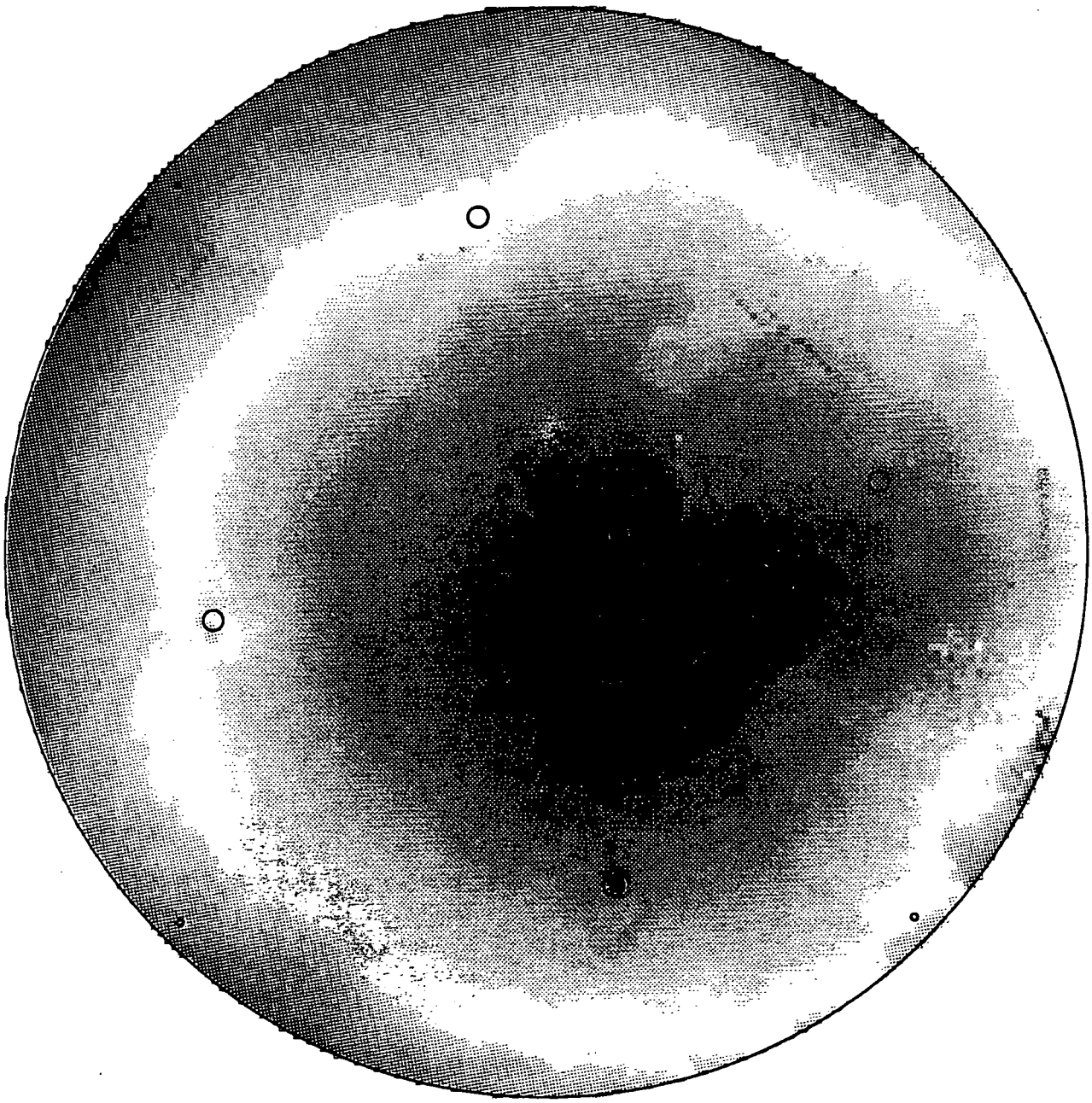
Distance below ORNL Global Reference Frame
Minimum (red) = -18" Maximum (indigo) = +0"

FIGURE 2-9 Silo 1 bentonite surface, 256-color vertical dimension.

K-65 Silo # 2

ORNL-DWG 92-8154

Waste Surface Map - Dec. 91



Distance below ORNL Global Reference Frame
Minimum (red) = -70" Maximum (indigo) = +2"

FIGURE 2-10 Silo 2 bentonite surface, 256-color vertical dimension.

thickness to be less than 1-foot (as shown) over these areas. Nonetheless, the change in surface height measured by the structured light mapping system is still a far superior approach to simpler single-point dipstick techniques.

Prior to development of this mapping system, the Fernald site did not have an adequate means of measuring the waste surface shape or the bentonite cap thickness. As a result of this technology development project and the rapid and successful field deployment, a bentonite deposition scheme was determined that satisfied EPA requirements and minimized the excess bentonite placed in the silos. Because all material placed in the silos is thereafter considered as waste, this surface-mapping system directly resulted in a significant reduction of waste to be retrieved and treated from the K-65 silos during final remediation.

2.6 Radon Monitoring

Continuous radon monitoring of the silo void space, in lieu of periodic gas or progeny sampling, was considered the best means of assessing the bentonite effectiveness. The need for continuous monitoring led to the development of the DLS. The DLS was designed to monitor and provide output for the physical and radiological conditions which affected radon emissions and the integrity of the bentonite layer including: radon concentration, temperature, pressure, and humidity. The continuous radon measurement portion of the DLS is based on a standard Pylon AB-5 scintillation monitor coupled to a 151 ml flow-through scintillation monitor cell (Lucas Cell). Silo air is drawn through the cell by an external pump at a nominal flow rate of 300 ml/min. The air sample is pumped nearly 27.4 m (90 ft) before entering a desiccant column, a pre-filter for progeny removal, and the scintillation cell.

The AB-5 monitor is set for continuous counting at 5 minute intervals to provide local qualitative data output via installed printer. The pulsed output is accumulated and sent to a PC-based micro processor for data accumulators. AB-5 and cell assemblies for each silo sampling system are located within a weather enclosure to allow for static sample acquisition in parallel with the continuous system. This configuration allowed for comparisons of differing sampling methods from the same stream. The main computer system is located outside the silo exclusion area, and a fully functional terminal is stationed near the site boundary.

Following placement of the bentonite layer over Silos 1 and 2 residues, continuous radon monitoring had been performed. From January 1992 to September 1992, DLS equipment failures resulted in inconsistent data output from a quality control perspective. A number of minor modifications and unscheduled maintenance activities to the DLS were required to reduce the equipment failure occurrences.

Data output of continuous radon monitoring from the period of September 1992 through March 1994 is presented in Appendix A - Tables and Figures A-1 through A-6. It was determined that the silo headspace radon concentrations being reported in September 1992 through March 1993 were consistent, however, the concentrations appeared to be unrealistically low since pre-removal action levels were

measured at 2.5 x 10^7 pCi/l in Silo 1 and 3 x 10^7 pCi/l in Silo 2, and there was a lack of consistency between continuous monitoring and grab samples.

A multifaceted technical team consisting of instrumentation technicians, radiological technicians, engineering, and quality assurance personnel was assembled to thoroughly investigate and identify the source(s) of the erroneous data, implement corrective actions and test their effectiveness. The team's focus eventually centered upon the Lucas Cells performance with a two-fold problem:

- The physical loss of integrity (developing a leak) of the cell itself; and
- The normally sensitive cell was saturated and unable to accurately record counts due to the high radon concentration activity.

The latter problem was resolved by the cell manufacturer physically modifying the Lucas Cell to lower its sensitivity. At this lower level of sensitivity, the Lucas Cell (110-20) and Pylon AB-5 monitor could note and record each count. This lower count was then multiplied by a correction factor to get an actual count rate. After resolving this particular Lucas Cell problem, it was decided that the DLS should be upgraded in an effort to resolve quality assurance concerns over the unrealistically low radon concentrations reported.

The special low sensitivity 110-20 Lucas Cells were installed in March 1993 to measure radon concentrations. Grab samples were performed for comparison with the original Lucas Cells. It was determined that special Lucas Cells, installed in March 1993, produced data output which resulted in radon concentrations calculations of approximately ten (10) times greater than the original Lucas Cell data. This increase was determined to be the loss of counting capability observed in the original Lucas Cells. Periodic change out of Lucas Cells was required to maintain and ensure counting effectiveness.

The monthly fenceline radon concentration at the K-65 exclusion zone has ranged over the past year (April 1993 - March 1994) from a minimum of 0.2 pCi/l to a maximum of 135.6 pCi/l (see Appendix A, Figures A-3 through A-6). The radon concentration in the silos headspace has ranged from 315 pCi/l to a maximum of 7.4 x 10^6 pCi/l (see Appendix A, Figures A-1 and A-2). This was a significant reduction in radon concentration within the silos headspace since pre-removal action levels were measured at 2.5 x 10^7 pCi/l in Silo 1 and 3 x 10^7 pCi/l in Silo 2. Therefore, the monitoring results indicate that the K-65 Silos 1 and 2 Removal Action has been successful in reducing radon emission from the K-65 Silos.

Although the Silos 1 and 2 radon headspace concentrations have risen above the levels measured immediately following the bentonite placement, the increase can be attributed to the following factors:

- Abnormally low (incorrect) radon measurements prior to April 1993, thereby creating a false perception of increase; and

- An actual increase over the latter half of 1993 due to the development of localized shrinkage cracks over the bentonite layer (supported by video footage).

- The bentonite cap in Silo 2 is not as good as the cap in Silo 1.

The recent videocamera footage (November 1993) of Silo 2's interior provided visible proof of the anticipated presence of shrinkage cracks in the bentonite cap of Silo 2. The increased presence of shrinkage cracks in the bentonite clay provides for more direct pathways for the radon (gas) to migrate to the silo headspace, by-passing the bentonite clay's attenuation effect. This physical phenomena explains why the Silos 1 and 2 radon headspace concentration has gradually increased. The reason why the Silo 2 radon headspace concentration has risen slightly higher than Silo 1 is that given its original surface topography, the Silo 2 bentonite clay layer has experienced a greater degree of cracking than Silo 1.

2.7 Waste Characterization

The Operable Unit 4 applicable or relevant and appropriate requirements are included in the Draft Applicable or Relevant and Appropriate Requirement (ARARs) (Appendix H), initially developed for the Conceptual Design Report, and were utilized during the removal action as a guideline for waste management practices.

Prior to initiation of this removal action a Material Evaluation Form was generated to support the characterization of the waste. Actual field activities of the Silos 1 & 2 Removal Action included modification and sealing of silo penetrations to prevent radon release during implementation of the removal action, mapping of the waste surface topography to support bentonite emplacement strategy and approved storage of the incidental waste generated (i.e., personnel protective equipment) until final disposition was determined.

2.8 Waste Management

This removal action was conducted pursuant to the Amended Consent Agreement under CERCLA 120 and 106(a) between the DOE and the USEPA. Management and control of the incidental waste generated (i.e., personnel protective equipment and liquid waste from BentoGrout operations) during the project was in accordance with the FEMP radiological and Resource Conservation and Recovery Act (RCRA) waste management practices.

Silos 1 and 2 materials are excluded from regulation under RCRA (see Section 6.0). However, since Silos 1 and 2 materials have the potential to exhibit a RCRA characteristic, RCRA waste management practices were followed as relevant and appropriate requirements for this removal action. The RCRA

waste management practices adopted by this removal action included the following: waste handling and collection, containerization, labeling, and temporary storage in a controlled holding area until a hazardous waste determination was made.

Other regulatory based or FEMP procedures followed during the removal action included the following: use of personnel protective equipment; adherence to As Low As Reasonably Achievable (ALARA) practices; High Efficiency Particulate Air (HEPA) filtration of dust and residue containing radionuclides; spill protection around the containers used for disposal; use of DOT approved containers (e.g. white metal boxes and ISO containers); waste identification as non-hazardous prior to off-site disposal; and off-site disposal of waste according to site disposal procedures, as well as, compliance with other identified federal and state regulations.

2.9 Project Management

Project management procedures included the adherence to the Silos 1 & 2 Removal Action Work objectives, project scheduling and planning, verification and site safety requirements. Regulatory concerns were considered by following or implementing the following: RCRA waste management procedures, the Safety Assessment, the ARARs list for Silos 1 & 2 Removal Action, the Risk Assessment, the Operational Readiness Review, the NEPA analysis document, a task-specific Health and Safety Plan, the Hoisting and Rigging Plan, and the Health and Safety training requirements that were required to perform the activities outlined in the work plan of the Silos 1 & 2 Removal Action.

5528

3.0 SAMPLING AND ANALYSIS

As determined by historical sampling analysis [i.e. RI Report for Operable Unit 4 (November 1993)], the radionuclide and heavy metal constituents in the K-65 residue contain the following maximum constituent concentrations of concern: U-238 (26,000 pCi/l), U-234 (139 pCi/l), Ra-226 (1,200 pCi/l), Th-230 (< 1 pCi), and Pb-210 (8,000 pCi/l). Due to their origin and being consistent with the State of Ohio Proposed Amended Consent Decree (PACD), the process residues stored in the K-65 silos are by definition "by-product" material and therefore are excluded from RCRA regulations under 40 CFR 261.4(a)(4). They are however, regulated as solid waste under Ohio regulations. As discussed in Section 2.8, both the liquid (i.e., BentoGrout operations wastewater) and incidental waste (i.e., personnel protective equipment) generated by this removal action were managed in accordance with RCRA management practices until a complete characterization of the waste was completed.

000033

4.0 HEALTH AND SAFETY PLAN

The task-specific Health and Safety Plan, which was prepared for implementation of this removal action, was designed to protect personnel working under the Radiation Work Permit (RWP) from excessive exposure to both the penetrating radiation and the airborne particulate radiation found in the vicinity of the K-65 Silos. The penetrating radiation dose was determined to be in the range of 50-60 millirem per hour (mrem/hr) on the K-65 berm to about 0.6 mrem/hr at the inside of the exclusion zone fence to the west of Silo 1. The highest radiation readings in the area were 150 mrem/hr on contact with the silo domes. Furthermore, Radon from the K-65 Silos was identified as the constituent that exhibited the highest potential for personnel exposure.

An Exclusion Zone was established to demark the area of high potential hazard from radiological or chemical dangers. Access to the Exclusion Zone was restricted to trained and certified employees as required by Occupational Safety and Health Administration (OSHA) 29 CFR§ 1910.120. Personnel stay-times in the K-65 Area were controlled by radiological safety procedures to ensure that personnel did not exceed the site administrative exposure control level of 150 mrem/week.

Air monitoring, targeted in the breathing zone, assured that contaminant concentrations did not exceed the concentrations specified by allowable exposure levels. The air monitoring program was designed to detect radon and radon progeny. Continuous radon gas monitoring was provided at the K-65 Area fenceline using alpha scintillation devices. Working level grab samples, designed to detect radon progeny, were collected by a portable air pump and filter unit (breathing zone monitor). Working level concentrations are exposure concentration estimates for personnel working in the immediate area.

Radiation surveys were conducted at the beginning of the work. Personnel were required to wear direct reading dosimeters and to monitor radiation exposure periodically. Particulate radionuclides from the waste water were prevented from becoming airborne by use of HEPA-filtered vents on the receiving tanks. Monitoring was performed to ensure that personnel were not excessively exposed above the allowable weekly dose and was as low as reasonable achievable.

All site personnel were trained in accordance with OSHA 29 CFR § 1910.120, as well as, project specific Fernald Environmental Restoration Management Corporation (FERMCO) and DOE-FN site requirements.

5.0 QUALITY ASSURANCE PLAN

The Silos 1 & 2 Removal Action was conducted in accordance with quality program requirements of the FEMP Quality Assurance Plan, Feed Materials Production Center (FMPC) 2139. The Quality Assurance Plan is based on the criteria specified in American Society of Mechanical Engineers (ASME) NQA-1, Federal EPA Guideline QAMS-005/80, and DOE Orders 5700.6 and 5400.1. Specific quality assurance requirements were incorporated into written and approved procedures and into personnel training. Periodic surveillance reports, performed by the FEMP operating contractor, verified that implementation of the K-65 Silos 1 & 2 Removal Action complied with the K-65 Silos 1 & 2 Work Plan and FMPC - 2139 Quality Assurance Plan.

6.0 REGULATORY CONCERNS

The contents of Silos 1 and 2 are exempt from RCRA regulation by the USEPA in 40 CFR§ 261.4(a)(4), which excludes "by-product" material as defined by the Atomic Energy Act (AEA) of 1954, as amended, 42 USC 2011 et seq. (AEA). The material stored in the K-65 Silos are tailings and/or residues produced by the extraction of uranium (10 CFR§ 962, 52 FR§ 15937) and therefore meet the exclusion by definition.

The exclusion, according to 40 CFR§ 261.4 (a)(4), applies to "...source, special nuclear or "by-product" material as defined in the ...[AEA]...". The AEA defines "by-product" as:

> "...(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and (2) the tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content" [AEA Section 11(e)].

The material stored in the K-65 Silos is residue resulting from the processing of uranium ore. Under 40 CFR§ 261.1(a)(4), as applied here, the residues in the K-65 Silos are excluded from regulation under RCRA as the residues resulting from the processing of uranium ores, and are not "... "by-products" from utilizing special nuclear material...". In addition, "by-product" material is expressly excluded from the definition of solid waste under federal law [40 USC 6903(27)]. However, the residue is still considered solid waste under Ohio regulations.

To support waste management activities, a list of potential ARARs (Appendix H) for the removal action was developed because the material exhibited the potential for heavy metals in quantities in excess of RCRA levels. The solid "contact" wastes generated during this removal action were handled, collected, containerized, labeled, and temporarily stored in a controlled holding area until a hazardous waste determination was made. Meeting the FEMP wastewater pre-treatment standards (e.g. volatile organic or semi-volatile organic constituents below levels of regulatory concern), the liquid waste generated from the BentoGrout operations, was treated in the existing FEMP wastewater treatment facilities using approved treatment procedures for heavy metals and radionuclides. The National Pollutant Discharge Elimination System (NPDES) regulatory requirements for FEMP wastewater discharge were met by the proper storage, treatment, and disposal activities performed in accordance with the requirements of CERCLA and DOE orders and procedures.

To fulfill the requirements of the National Environmental Protection Action of 1969 (NEPA), the DOE prepared an EE/CA-EA for the proposed K-65 Silos Removal Action No. 4 at the Fernald Environmental Management Project. Based on the analysis of the EE/CA-EA, DOE determined that K-65 Removal Action No. 4 was not a major federal action significantly affecting the quality of the human environment, within the meaning and the intent of the NEPA. Consequently, the preparation of an Environmental

Impact Statement (EIS) was not required and the DOE issued an approved finding of no significant impact on November 26, 1991. The contents of the documents prepared for this removal action are not intended to represent a statement on the legal applicability of NEPA to remedial actions under the CERCLA.

7.0 FUTURE ACTIVITIES

With the historical DLS hardware problems having been resolved, the data recorded and evaluated over the past year (April 1993 through March 1994) provides a good basis for determining that the Silos 1 and 2 removal action objectives and goals were achieved after the placement of the bentonite and continue to be maintained to the present time. However, because of the sensitivities associated with the K-65 Silos and the gradual upward trend of both silos' radon headspace concentrations, both Silos 1 and 2 warrant continued monitoring. The following discussion provides the basis for this determination.

Since the upward trend of the measured radon headspace concentrations, when projected, would eventually exceed the removal action goal of an ambient radon concentration of no greater than 0.015 pCi/l above background, at the location of the maximally exposed individual, at a non-FEMP location, continuous DLS radon gas monitoring will continue to be performed and the data evaluated. Should the combined radon headspace concentrations for Silos 1 and 2 reach a value of 9×10^6 pCi/l, further actions will be implemented by DOE.

In accordance with the plot of Figure E-2, the ambient radon concentration of 0.015 pCi/l above background , at the location of the maximally exposed individual, at a non-FEMP location could theoretically be exceeded if a specific combination of headspace concentrations for Silos 1 and 2 reach 1.2×10^7 pCi/l. The 9×10^6 pCi/l action level has been established by the DOE in an effort to initiate mitigative measures (i.e., the placement of additional bentonite) to reduce radon headspace concentrations before the combined Silos 1 and 2 radon headspace concentrations would result in 0.015 pCi/l above background at the critical receptor (see Appendices D and E for more discussion on the monitoring plan and methodology used).

Because of the uncertainties associated with the long-term performance of the bentonite layers for Silos 1 and 2, the DOE recommends that continuous DLS radon gas emission monitoring continue to be performed and the data evaluated until remedial actions have effectively removed both silos' contents. The approved Operable Unit 4 Remedial Action Workplan will identify and specify all monitoring requirements and actions necessary to ensure protectiveness of human health and the environment during remediation of the silo contents. In the meantime, data will continue to be reported and provided to the USEPA in the Consolidated Consent Agreement/Federal Facility Compliance Agreement/Federal Facility Agreement for Control and Abatement of Radon-222 Emissions Monthly Progress Report.

5528

8.0 CONCLUSION

Approximately 670 m^3 (23,700 ft^3) of slurried bentonite were successfully placed over the K-65 silo residues by remote access pumping in a period of eight (8) days. On November 28, 1991, Silos 1 & 2 Removal Action was completed. The success of the application of the bentonite clay process was measured by its ability to retain water so that radon emissions were subsequently reduced. Radiation technicians measured radiation levels before and after the process to document the impact of the bentonite on radon emissions around the silos, on the domes, in the headspace, and at various FEMP fenceline locations near the Silos (see Tables and Figures B-1 through B-4 in Appendix B).

The application of the BentoGrout resulted in a significant reduction of the radon concentrations at the 95 percent confidence level (α = 0.05) based upon the statistical evaluations performed on the pre-bentonite and post-bentonite data sets (see Appendix C). Thus, the overall objectives of this removal action were achieved.

The overall objective of the removal action was to significantly attenuate radon emissions as low as reasonably achievable from the K-65 silos, in order to reduce their contribution to off-site radon concentrations and their subsequent risk to human health and the environment. More specifically, the USEPA established a remedial action goal of reducing the silos' contribution to off-site radon emissions to a level no greater than 0.015 pCi/l above background levels, at the location of the maximally exposed individual, at a non-FEMP location. Although the incremental level of 0.015 pCi/l above background is not discernable using best available technology, the overall effectiveness of the bentonite could be modelled using measured radon headspace concentrations (post-bentonite placement) as direct data input for USEPA approved air modelling techniques. Based on the modelled data, the removal action goal of reducing radon emissions to a level no greater than 0.015 pCi/l above background levels, at the location of the maximally exposed individual at a non-FEMP location has been achieved. Appendices D and E provides a detailed description of the monitoring plan, modelling techniques, assumptions and graphical representation of the results.

The plot of Silos 1 and 2 radon headspace concentrations, which when modelled result in a radon concentration of 0.015 pCi/l above background levels for the critical receptor is shown in Figure E-3 of Appendix E. By locating the measured concentration of radon in the headspace for each silo on the appropriate axis of Figure E-3, one can quickly determine if the expected concentration at the critical receptor is above or below the 0.015 pCi/l target concentration. The actual Silos 1 and 2 headspace concentrations data, shown in Tables A-1 and A-2 in Appendix A, when plotted together in Figure E-3, all lie below the 0.015 pCi/l target level, clearly showing that the removal action goal was achieved and has been maintained to the present time.

Project management procedures and checklists were developed to aid the implementation of the removal action. These procedures included planning and design requirements, health and safety requirements, and

quality assurance objectives. The waste generated from the removal action was containerized and managed in a manner consistent with RCRA regulations as relevant and appropriate. The waste was stored in a RCRA approved controlled holding area prior to waste characterization.

Two remotely operated cameras were installed in Silo 2 in December 1993 to view the bentonite cap. The videotape of the Silo 2 's headspace provided valuable confirmation of the speculative condition of the bentonite cap. It was observed that the bentonite cap is still effectively performing its job by physically covering the Silo 2 residues. There is no evidence of subsidence of the bentonite cap from the mounded portion of the silo's residues. However, there does appear to be some minor subsidence with characteristic shrinkage cracks near the areas where the vertical samples of the residues were previously taken. These areas appear to be localized directly underneath the sampled manways and collectively affect about 25 percent of the bentonite cap surface area.

Adjacent to these areas, the bentonite cap appears to be in a sound, moist condition, relatively unaffected. Areas of ponded water appear intermittently across the surface area of the bentonite cap suggesting the silo's headspace atmospheric conditions are not causing the bentonite cap to dry out. This remote visual inspection coupled with the headspace and perimeter monitoring data suggests that the bentonite cap is still achieving its performance objectives. Therefore, with the exception of continued monitoring and data evaluation as discussed in Section 7, it is the conclusion and recommendation of the DOE that no further action should be taken at this time.

The results of the video camera installation support the explanation of the measured upward trend of radon headspace concentrations in both silos. The shrinkage cracks in the bentonite layer provide a pathway by which the radon (gas) can by-pass the attenuation effect of the bentonite layer. The reason why the Silo 2 radon headspace concentration has risen slightly higher than Silo 1 is that given its original surface topography, the Silo 2 bentonite layer has experienced a greater degree of cracking than Silo 1. The presence of additional cracks provides for more pathways by which the radon (gas) can by-pass the attenuation effect of the bentonite cap.

Since the upward trend of the measured radon headspace concentrations would eventually exceed the removal action goal of an ambient radon concentration of no greater than 0.015 pCi/l above background, at the location of the maximally exposed individual, at a non-FEMP location, continuous DLS radon gas monitoring will continue to be performed and the data evaluated. Should the combined radon headspace concentrations for Silos 1 and 2 reach a value of 9×10^6 pCi/l, further actions will be implemented by DOE.

The 9×10^6 pCi/l action level has been established in an effort to initiate mitigative measures to reduce radon headspace concentrations before the combined Silos 1 and 2 radon headspace concentrations would result in 0.015 pCi/l above background at the critical receptor (see Appendices D and E for more discussion on the monitoring plan and methodology used).

5528

9.0 REFERENCES

A copy of each document associated with the Silos 1 & 2 Removal Action has been compiled and placed in the FEMP Administrative Record, under the title, "Removal Action #4 -K-65 Removal Action". A copy of the Removal Action #4 index for the Administrative Record is included as Appendix G.

APPENDIX A

RADON GRAB SAMPLING AND CONTINUOUS MONITORING RESULTS

APPENDIX A
TABLE OF CONTENTS

List of Tables . . . . . a-i
List of Figures . . . . . a-i
A.1 Introduction A-1

LIST OF TABLES

A-1 Silo 1 Radon Headspace Concentration Summary A-2
A-2 Silo 2 Radon Headspace Concentration Summary A-2
A-3 Radon Concentrations at K-65 NE Exclusion Zone A-4
A-4 Radon Concentrations at K-65 SE Exclusion Zone A-4
A-5 Radon Concentrations at K-65 NW Exclusion Zone A-6
A-6 Radon Concentrations at K-65 SW Exclusion Zone A-6

LIST OF FIGURES

A-1 Radon Headspace Concentrations for Silo 1 . . . . . A-3
A-2 Radon Headspace Concentrations for Silo 2 . . . . . A-3
A-3 Radon Concentrations at K-65 NE Exclusion Zone A-5
A-4 Radon Concentrations at K-65 SE Exclusion Zone A-5
A-5 Radon Concentrations at K-65 NW Exclusion Zone A-7
A-6 Radon Concentrations at K-65 SW Exclusion Zone A-7

5528

A.1 INTRODUCTION

This Appendix presents the post-bentonite placement, radon monitoring data for the Silos 1 and 2 headspace and at the K-65 exclusion zone fenceline. The statistical evaluation of the data presented in Appendix A is presented in Appendix C in an effort to demonstrate that the bentonite layer was effective in reducing the radon headspace concentrations for both Silos 1 and 2 and the radon concentrations measured at the K-65 exclusion zone fenceline.

It should be noted that from September 1992 through March 1993, a number of minor modifications and unscheduled maintenance activities to the data logging system were required to improve the system operations and data reliability. Upon completion of these system improvements, more reliable data for the Silos 1 and 2 radon headspace concentrations has been generated effective April 1993 to the present. The data presented in this Appendix recognizes this fact by annotating (shading) the data presentation accordingly.

It should also be noted that the February 1994 data reflects elevated levels of radon recorded at the K-65 Silos exclusion zone fenceline (see Tables A-3 through A-6 and Figures A-3 through A-6). The elevated levels of radon are directly attributed to a radon release which occurred during the performance of radon adsorption tests in the K-65 area in support of future Operable Unit 4 Pilot Plant operations. During the performance of these tests, severe meteorological inversion conditions persisted at the site which exacerbated the problem. It should also be noted that at no time during this event did the boundary fence levels exceed regulatory or DOE Order limits. The K-65 Silos were and remain in compliance with all DOE orders and regulatory requirements as specified under mandatory legal agreements, specifically, the Federal Facilities Agreement and the Consent Agreement as amended under CERCLA Sections 120 and 106(a).

000044

TABLE A–1

Silo 1 Radon Headspace Concentration Summary (pCi/l)

MONTH	AVG	log (AVG)	MAX	log (MAX)	MIN	log (MIN)	GRAB	log (GRAB)
Sep. 92	42,042	4.62	79,180	4.90	2,630	3.42	141,309	5.15
Oct. 92	43,330	4.64	408,470	5.61	2,550	3.41	116,046	5.06
Nov. 92	38,012	4.58	286,460	5.46	1,920	3.28	55,157	4.74
Dec. 92	38,570	4.59	226,240	5.35	1,920	3.28	51,757	4.71
Jan. 93	35,409	4.55	243,810	5.39	80	1.90	168,471	5.23
Feb 93	28,037	4.45	279,600	5.45	80	1.90	216,439	5.34
Mar. 93	34,863	4.54	220,050	5.34	2,090	3.32	11,363	4.06
Apr. 93	220,763	5.34	1,290,730	6.11	1,650	3.22	198,063	5.30
May 93	369,276	5.57	1,212,560	6.08	60,175	4.78	235,500	5.37
Jun. 93	402,499	5.60	1,212,560	6.08	8,040	3.91	781,714	5.89
July 93	295,998	5.47	700,205	5.85	4,150	3.62	277,167	5.44
Aug. 93	292,549	5.47	749,593	5.87	8,040	3.91	289,375	5.46
Sep. 93	208,925	5.32	969,788	5.99	315	2.50	162,500	5.21
Oct. 93	233,688	5.37	886,641	5.95	2,888	3.46	342,875	5.54
Nov. 93	234,973	5.37	1,046,225	6.02	2,258	3.35	536,286	5.73
Dec. 93	241,728	5.38	1,200,000	6.08	2,000	3.30	296,222	5.47
Jan. 94	286,833	5.46	1,234,000	6.09	3,000	3.48	611,800	5.79
Feb. 94	153,034	5.18	1,224,000	6.09	6,000	3.78	265,429	5.42
Mar. 94	363,273	5.56	1,176,000	6.07	5,000	3.70	413,889	5.62

TABLE A–2

Silo 2 Radon Headspace Concentration Summary (pCi/l)

MONTH	AVG	log (AVG)	MAX	log (MAX)	MIN	log (MIN)	GRAB	log (GRAB)
Sep. 92	236,642	5.37	297,810	5.47	125,720	5.10	323,629	5.51
Oct. 92	215,670	5.33	309,680	5.49	69,365	4.84	200,154	5.30
Nov. 92	186,672	5.27	393,870	5.60	3,050	3.48	673,364	5.83
Dec. 92	126,922	5.10	411,680	5.61	2,550	3.41	496,904	5.70
Jan. 93	101,277	5.01	504,810	5.70	2,550	3.41	375,730	5.57
Feb 93	81,244	4.91	467,720	5.67	2,390	3.38	461,035	5.66
Mar. 93	69,826	4.84	414,150	5.62	2,550	3.41	457,294	5.66
Apr. 93	1,304,163	6.12	2,296,331	6.36	2,550	3.41	1,179,356	6.07
May 93	1,975,921	6.30	3,565,830	6.55	10,070	4.00	2,334,500	6.37
Jun. 93	2,496,051	6.40	4,005,830	6.60	1,219,170	6.09	2,978,571	6.47
July 93	2,886,893	6.46	3,292,280	6.52	1,424,660	6.15	3,852,167	6.59
Aug. 93	2,909,393	6.46	7,410,620	6.87	1,640,150	6.21	3,141,375	6.50
Sep. 93	2,542,503	6.41	3,268,330	6.51	586,620	5.77	3,082,750	6.49
Oct. 93	2,371,735	6.38	2,933,120	6.47	754,230	5.88	2,558,889	6.41
Nov. 93	2,578,251	6.41	3,364,110	6.53	371,130	5.57	2,911,429	6.46
Dec. 93	2,742,546	6.44	3,651,000	6.56	1,137,000	6.06	3,473,111	6.54
Jan. 94	3,173,491	6.50	4,920,000	6.69	98,000	4.99	4,080,571	6.61
Feb. 94	2,963,381	6.47	4,250,000	6.63	802,000	5.90	3,334,571	6.52
Mar. 94	3,390,744	6.53	4,346,000	6.64	180,000	5.26	3,549,000	6.55

Note: Shaded area denotes reported data in error.

Figure A–1 Radon Headspace Concentration for Silo 1

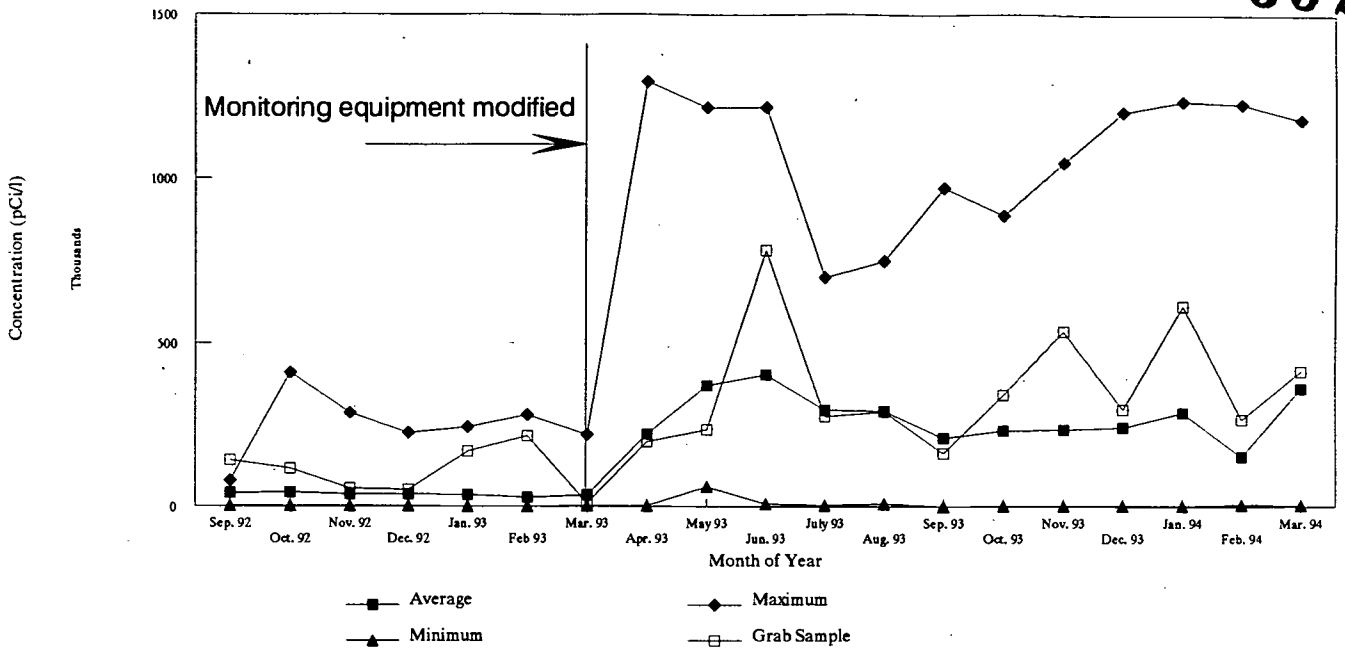


Figure A–2 Radon Headspace Concentration for Silo 2

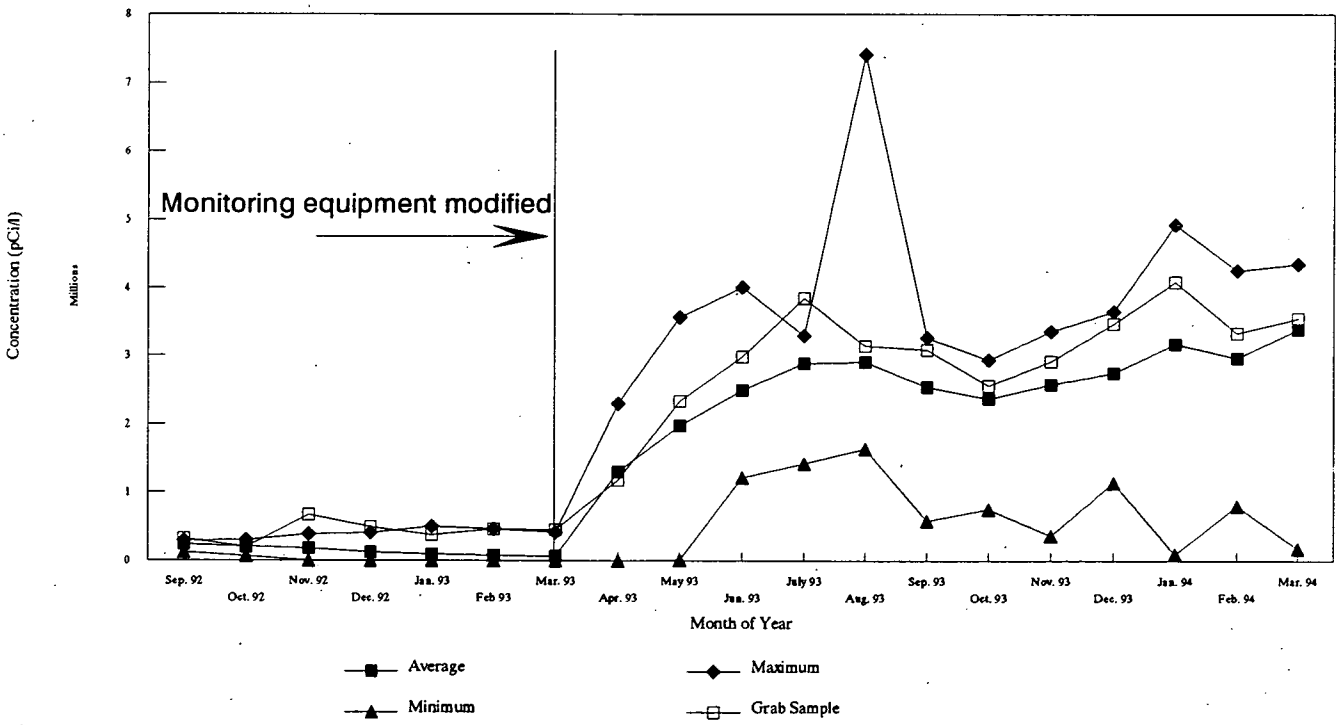


TABLE A-3
Radon Concentration at K-65 NE Exclusion Zone (pCi/l)

MONTH	AVERAGE CONC	MAXIMUM CONC	MINIMUM CONC
Sep. 92	2.8	6.5	0.5
Oct. 92	3.0	8.0	0.6
Nov. 92	1.2	3.1	0.5
Dec. 92	1.6	5.5	0.5
Jan. 93	2.0	7.9	0.5
Feb 93	2.9	8.8	0.4
Mar. 93	2.7	8.8	0.5
Apr. 93	1.2	4.9	0.2
May 93	1.7	3.4	0.3
Jun. 93	2.5	6.3	0.8
July 93	2.6	6.3	1.1
Aug. 93	3.3	7.8	1.2
Sep. 93	2.6	5.2	0.6
Oct. 93	4.0	12.0	0.6
Nov. 93	3.6	14.6	0.6
Dec. 93	2.7	12.0	0.4
Jan. 94	2.2	11.5	0.5
Feb. 94	13.9	135.6	0.6
Mar. 94	2.3	5.3	0.6

TABLE A-4
Radon Concentration at K-65 SE Exclusion Zone (pCi/l)

MONTH	AVERAGE CONC	MAXIMUM CONC	MINIMUM CONC
Sep. 92	1.6	4.0	0.4
Oct. 92	1.5	6.0	0.5
Nov. 92	0.7	2.5	0.2
Dec. 92	1.5	4.3	0.2
Jan. 93	1.6	5.6	0.2
Feb 93	2.3	6.1	0.6
Mar. 93	2.0	5.5	0.2
Apr. 93	1.6	5.1	0.6
May 93	1.4	2.3	0.6
Jun. 93	2.0	12.3	0.7
July 93	1.5	2.5	0.7
Aug. 93	2.0	2.9	0.9
Sep. 93	1.8	3.0	0.7
Oct. 93	2.4	5.6	0.9
Nov. 93	2.1	5.4	0.7
Dec. 93	1.9	6.0	0.7
Jan. 94	1.9	5.0	0.7
Feb. 94	5.2	39.5	0.2
Mar. 94	1.6	4.2	0.3

Figure A–3 Radon Concentration at K–65 NE Exclusion Zone

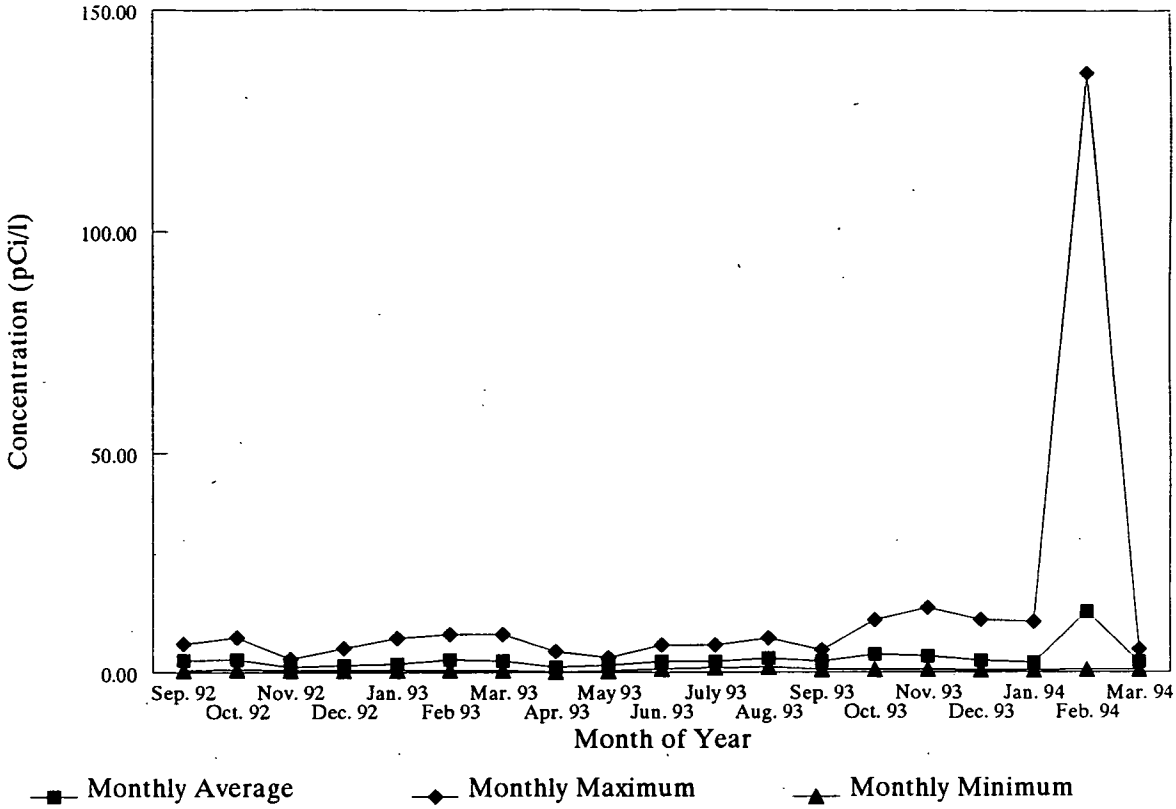


Figure A–4 Radon Concentration at K–65 SE Exclusion Zone

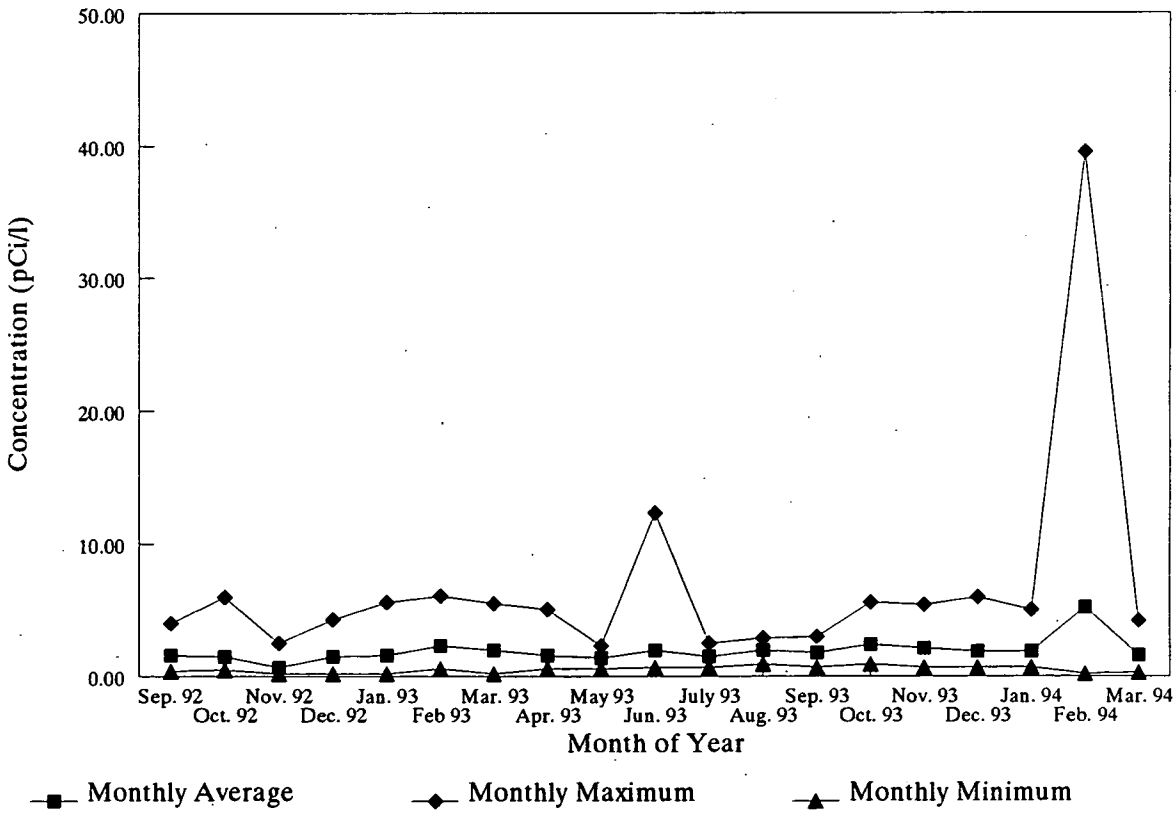


TABLE A-5
Radon Concentrations at K-65 NW Exclusion Zone (pCi/l)

MONTH	AVERAGE CONC	MAXIMUM CONC	MINIMUM CONC
Sep. 92	1.5	2.2	0.6
Oct. 92	1.6	2.7	0.7
Nov. 92	1.1	2.3	0.6
Dec. 92	1.4	3.7	0.6
Jan. 93	1.3	4.0	0.6
Feb 93	2.0	6.8	0.7
Mar. 93	1.9	6.8	0.6
Apr. 93	1.1	2.6	0.6
May 93	1.3	2.0	0.6
Jun. 93	1.3	1.9	0.7
July 93	1.6	4.9	0.8
Aug. 93	1.8	2.7	1.1
Sep. 93	1.7	2.9	0.7
Oct. 93	1.8	3.5	0.8
Nov. 93	1.8	9.0	0.6
Dec. 93	1.6	4.1	0.7
Jan. 94	2.3	12.9	0.8
Feb. 94	2.8	21	0.4
Mar. 94	1.2	2.8	0.3

TABLE A-6
Radon Concentrations at K-65 SW Exclusion Zone (pCi/l)

MONTH	AVERAGE CONC	MAXIMUM CONC	MINIMUM CONC
Sep. 92	1.8	3.4	0.8
Oct. 92	1.4	2.9	0.2
Nov. 92	1.3	2.7	0.7
Dec. 92	1.3	3.2	0.7
Jan. 93	1.5	3.4	0.7
Feb 93	2.0	4.5	0.6
Mar. 93	2.0	4.5	0.7
Apr. 93	1.2	2.3	0.6
May 93	1.3	2.3	0.6
Jun. 93	1.3	2.2	0.6
July 93	1.5	2.2	0.6
Aug. 93	1.9	2.6	0.9
Sep. 93	1.7	2.9	0.6
Oct. 93	1.7	3.6	0.4
Nov. 93	1.3	2.8	0.4
Dec. 93	1.3	4.3	0.3
Jan. 94	1.6	6.2	0.4
Feb. 94	2.3	12.6	0.3
Mar.94	1.2	3.8	0.3

Figure A–5 Radon Concentrations at K–65 NW Exclusion Zone

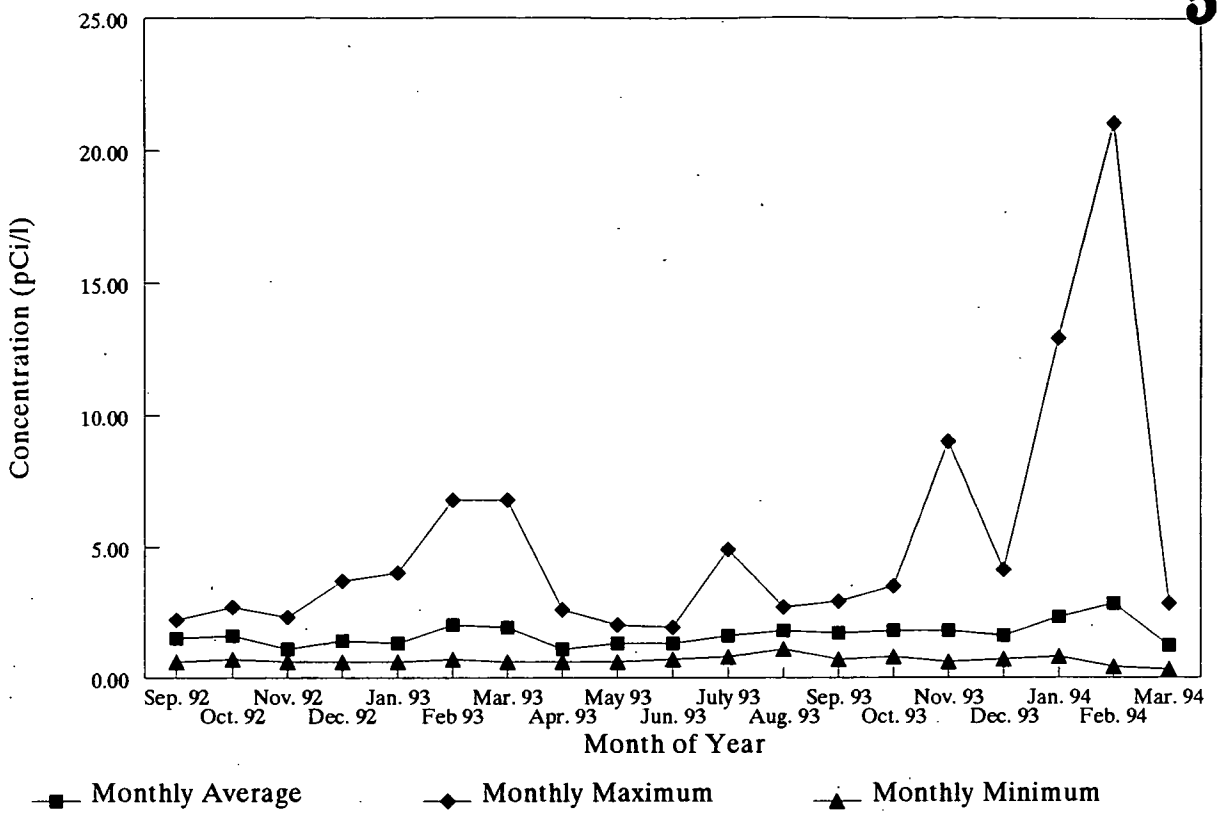
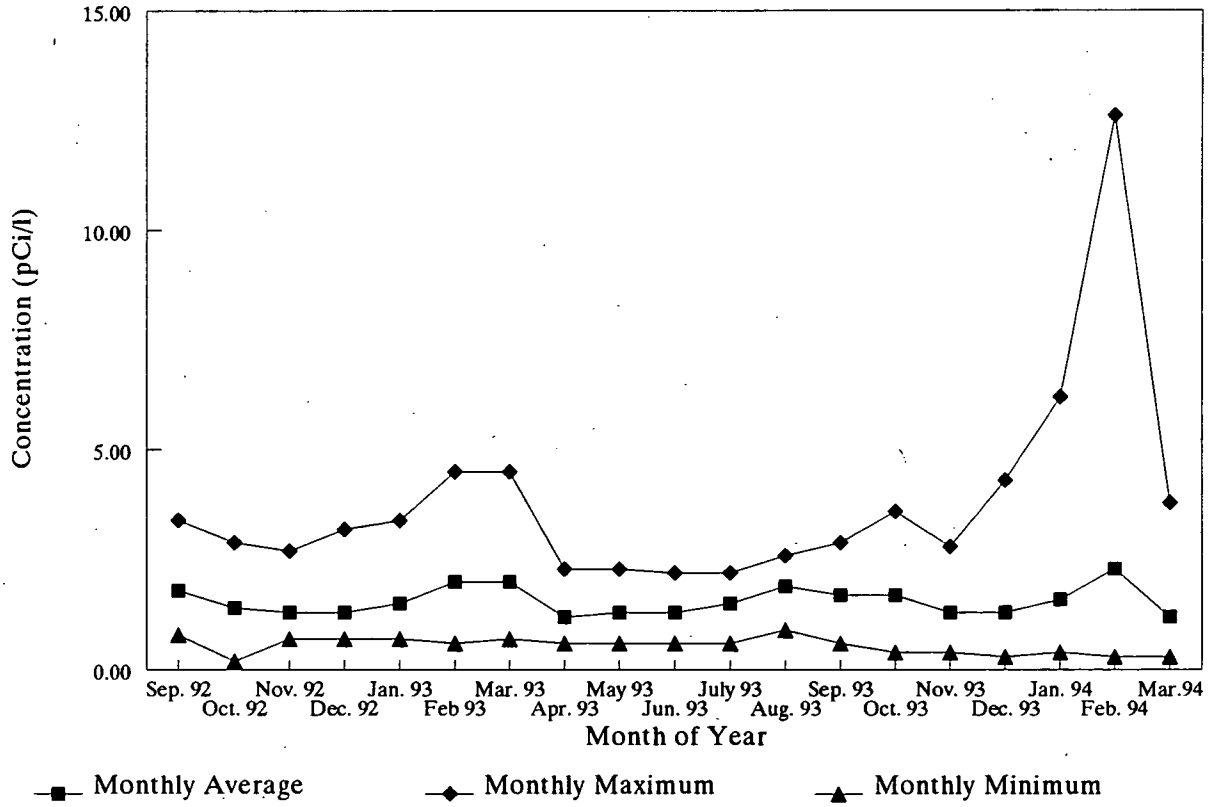


Figure A–6 Radon Concentrations at K–65 SW Exclusion Zone



5528

APPENDIX B

RADON MONITORING BEFORE AND AFTER BENTONITE PLACEMENT

APPENDIX B
TABLE OF CONTENTS

List of Tables . . . . . b-i
List of Figures . . . . . b-i

B.1 Introduction B-1

LIST OF TABLES

B-1 K-65 Exclusion Zone Monitors Radon Concentrations B-2
B-2 Air Monitoring Stations Radon Concentration B-3
B-3 Silos 1 & 2 Radon in Headspace B-4
B-4 Silos 1 & 2 Dome Surface Radiation B-5

LIST OF FIGURES

B-1 K-65 Exclusion Zone Monitors Radon Concentrations B-2
B-2 Perimeter Radiation Monitoring B-3
B-3a Silo 1 Radon in Headspace B-4
B-3b Silo 2 Radon in Headspace B-4
B-4a Silos 1 Dome Surface Radiation B-5
B-4b Silo 2 Dome Surface Radiation B-5

B.1 INTRODUCTION

Tables B-1 through B-4 present the pre- and post-bentonite placement radon concentrations monitored at the K-65 exclusion zone fenceline, nearby air monitoring stations, Silos 1 and 2 headspace, and the Silos 1 and 2 dome surface radiation levels. The following data and their graphical presentation show that radon concentration within the silos and in ambient air has been reduced after installation of bentonite to the K-65 silos. The statistical evaluation of the Silos 1 and 2 dome surface radiation level data presented in Appendix B is presented in Appendix C in an effort to demonstrate that the bentonite layer was not only effective in reducing the radon concentrations in the Silos 1 and 2 headspace, but was effective in reducing the Silos 1 and 2 dome surface radiation levels as well.

TABLE B-1
K-65 EXCLUSION ZONE MONITORS RADON CONCENTRATION (pCi/l)

Date	K-65 NW (pCi/l)	K-65 SW (pCi/l)	K-65 NE (pCi/l)	K-65 SE (pCi/l)
11/08/91	1.8	3.6	10.6	12.0
11/09/91	23.8	27.3	48.8	31.2
11/10/91	13.1	14.7	56.7	31.1
11/11/91	5.1	5.0	13.2	12.2
11/12/91	6.7	4.2	38.2	15.0
11/13/91	1.0	1.9	8.3	2.2
11/14/91	3.4	3.9	10.2	10.3
11/15/91	2.1	2.3	4.7	2.9
11/16/91	3.3	5.1	2.1	1.5
11/17/91	10.1	10.0	0.5	
11/18/91	4.5	1.9	0.9	0.5
11/19/91	0.8	0.8	0.5	0.5
11/20/91	0.5	0.9	0.6	0.9
11/21/91	201.0	11.9	12.9	9.7
11/22/91	527.2	40.8	13.3	12.1
11/23/91	483.9	22.1	26.4	11.9
11/24/91	1.3	0.7	4.9	3.0
11/25/91	166.7	3.8	15.5	14.5
11/26/91	439.9	10.5	5.0	16.1
11/27/91	70.2	10.4	2.3	2.4
11/28/91	65.9	2.7	0.8	0.9
11/29/91	0.5	0.5	0.5	0.4
11/30/91	0.4	0.5	0.7	0.7
12/01/91	0.9	1.7	0.5	0.6
12/02/91	1.9	3.4	0.6	0.6
12/03/91	0.5	0.7	2.5	1.5
12/04/91	0.5	0.6	2.4	1.5
12/05/91	0.4	0.6	1.0	0.5
12/06/91	1.3	1.3	1.4	1.2
12/07/91	0.5	0.7	0.8	0.4
12/08/91	0.4	0.4	0.5	0.3

FIGURE B-1
K-65 EXCLUSION ZONE MONITORS RADON CONCENTRATION (pCi/l)

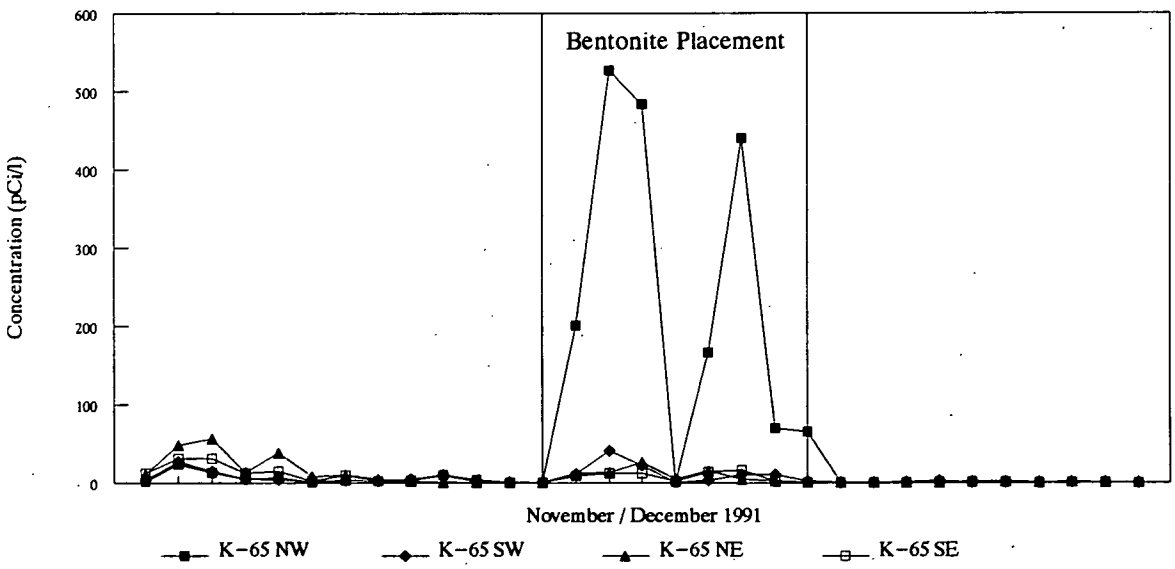


TABLE B-2
AIR MONITORING STATIONS RADON CONCENTRATION (pCi/l)

Date	AMS 5 (pCi/l)	AMS 6 (pCi/l)	AMS 7 (pCi/l)
11/08/91	1.0	0.7	0.5
11/09/91	1.9	1.5	1.4
11/10/91	2.0	1.7	1.9
11/11/91	1.2	0.9	1.3
11/12/91	1.6	1.4	1.7
11/13/91	0.6	0.5	0.7
11/14/91	2.0	1.6	2.1
11/15/91	0.9	0.7	1.1
11/16/91	1.1	0.8	0.8
11/17/91	0.8	0.8	0.5
11/18/91	0.8	0.6	0.7
11/19/91	0.4	0.4	0.4
11/20/91	0.3	0.4	0.4
11/21/91	0.7	0.7	0.6
11/22/91	1.4	1.2	1.0
11/23/91	1.5	1.2	1.4
11/24/91	0.3	0.4	0.3
11/25/91	0.9	0.7	0.8
11/26/91	1.9	1.5	2.0
11/27/91	0.7	0.7	0.9
11/28/91	0.5	0.6	0.5
11/29/91	0.3	0.3	0.3
11/30/91	0.3	0.4	0.3
12/01/91	0.4	0.4	0.4
12/02/91	0.5	0.6	0.5
12/03/91	0.4	0.4	0.4
12/04/91	0.4	0.6	0.4
12/05/91	0.3	0.4	0.3
12/06/91	0.6	0.5	0.8
12/07/91	0.3	0.4	0.4
12/08/91	0.3	0.3	0.3

FIGURE B-2
AIR MONITORING STATIONS RADON CONCENTRATION (pCi/l)

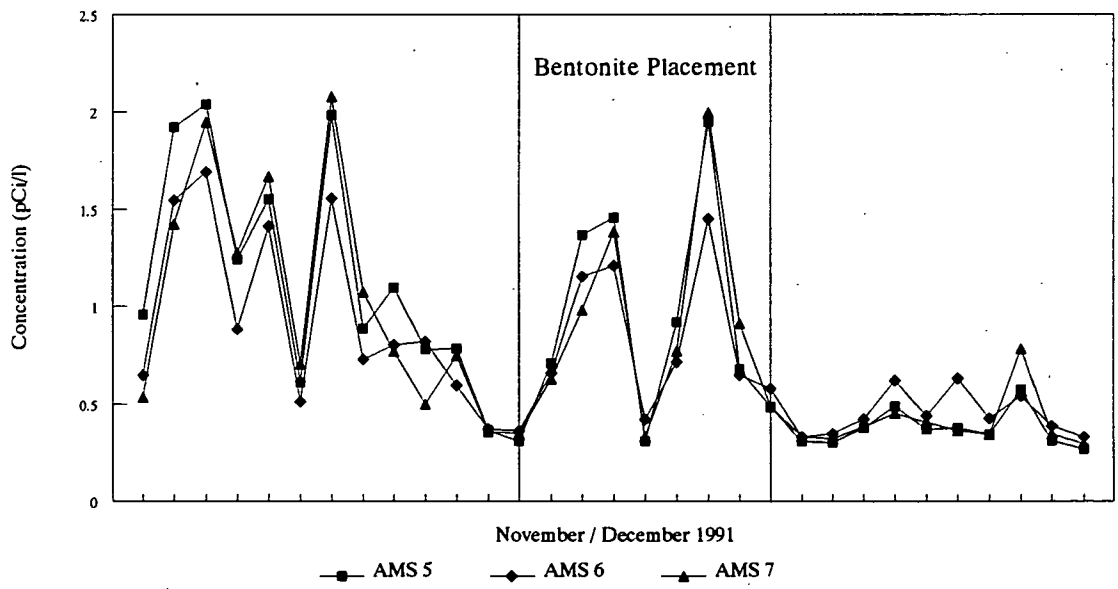


TABLE B-3
SILOS 1 & 2 – RADON IN HEADSPACE (pCi/l)

Silo 1

Date	11/8/91	12/3/91	1/6/92	2/3/92	3/5/92	4/1/92
Radon Concentration	25,000,000	188,600	158,700	149,500	155,300	129,300

Silo 2

Date	11/1/91	12/3/91	1/6/92	2/3/92	3/5/92	4/1/92
Radon Concentration	30,000,000	137,700	143,000	145,700	111,600	114,700

FIGURE B-3a SILO 1 RADON IN HEADSPACE

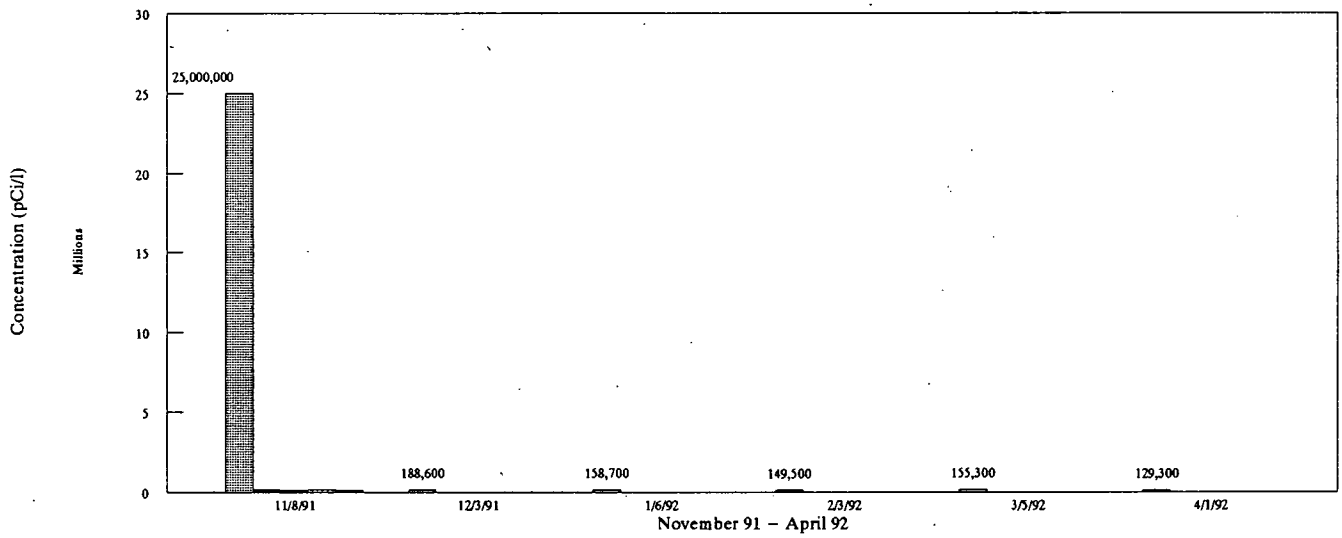


FIGURE B-3b SILO 2 RADON IN HEADSPACE

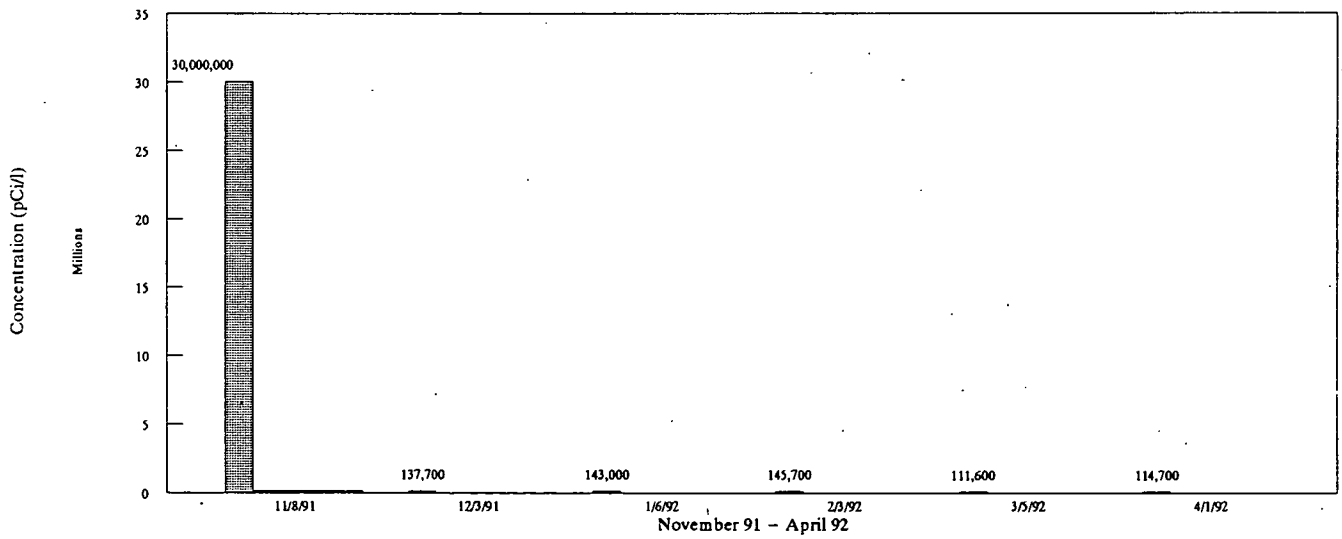


TABLE B-4
SILOS 1 & 2 DOME SURFACE RADIATION (mR/hr)

Date	SILO 1				SILO 2			
	SE	SW	NE	NW	SE	SW	NE	NW
11/8/91	135	130	140	175	200	185	215	204
12/3/91	8.4	7	6.3	6.9	15	15	10	15
1/6/92	4.3	N/A	3.9	4.5	3.2	3.1	2.7	2.3
2/9/92	3.7	N/A	3.5	4.2	3.8	3.9	3	2.7
3/8/92	9	8	7	9	4	4.8	3	3.3
4/8/92	4.2	4.3	4.6	6	3.3	3.7	2.3	2.1
5/6/92	3	3.5	3.5	4.1	3.7	4.1	3	2.2
6/8/92	2.9	3.4	3	3.6	3.6	3.7	2.8	2.4
7/8/92	3.1	3.5	3.4	3.9	7	8	4.5	3.9
9/16/92	4.3	4.3	4.2	6	11	11	10	9
10/8/92	3.6	3.7	4	4.1	10	9	9	8
11/24/92	9	9	11	7	15	13	13	12
12/7/92	5	5	6	7	16	17	15	15
1/6/93	4.4	4.5	4.7	4.7	16	16	16	15
2/8/93	6	6	7	6	16	15	15	13
3/8/93	2	2	3	2	12	12	10	11
4/5/93	3.6	3.7	3.5	4.7	12	11	10	10
5/10/93	4.5	6	5	6.5	14	14	13	10
6/8/93	3.5	5	6	4.5	12	14	13	12
7/8/93	3.5	3.5	3.5	4.5	17	17	14	14
8/6/93	4.3	4.5	4.7	5	17	17	17	16
9/8/93	7	7	6	8	21	23	20	20
10/8/93	7	7	9	10	17	18	16	16
11/4/93	6	6	8	8	18	16	17	15

FIGURE B-4a SILO 1 DOME SURFACE RADIATION (mR/hr)

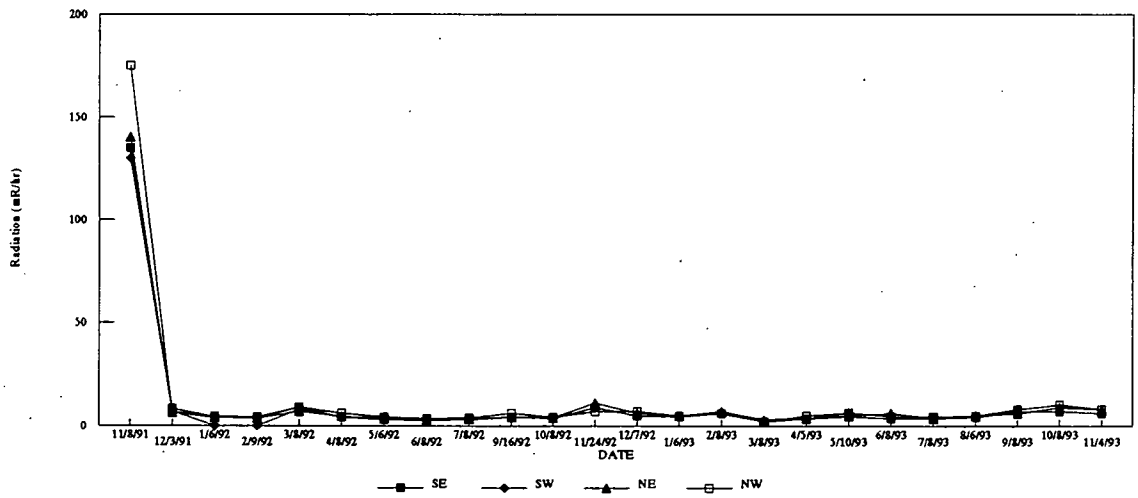
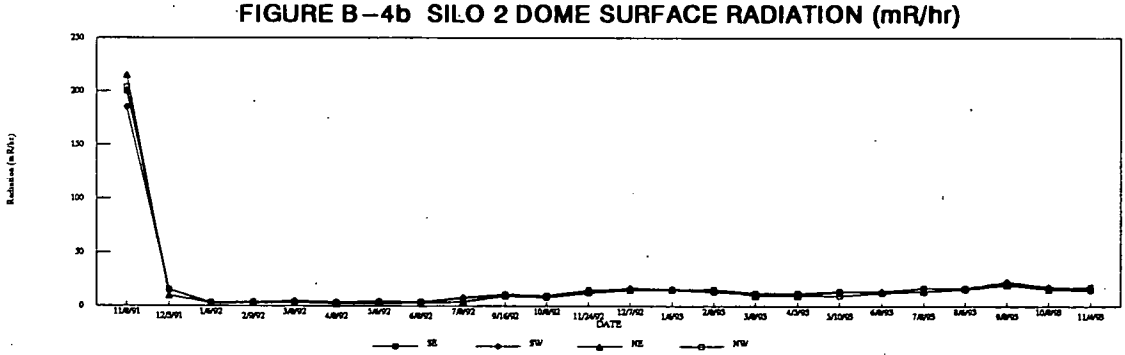


FIGURE B-4b SILO 2 DOME SURFACE RADIATION (mR/hr)



5528

APPENDIX C

STATISTICAL EVALUATION OF PRE-BENTONITE AND POST-BENTONITE PLACEMENT DATA

APPENDIX C
TABLE OF CONTENTS

List of Tables . . . . . c-i

C.1 Introduction C-1
C.2 Conclusion C-1

LIST OF TABLES

C-1 Statistical Determination Summary C-2
C-2 Silo 1 Radon Headspace Concentration Summary (pCi/l) C-4
C-3 Silo 2 Radon headspace Concentration Summary (pCi/l) C-5
C-4 Silo 1 Dome Surface Radiation (mrem/hr) C-6
C-5 Silo 2 Dome Surface Radiation (mrem/hr) C-8
C-6 Radon Concentration at K-65 Exclusion Zone Pre-Bentonite C-10
C-7 Radon Concentration at K-65 Exclusion Zone Post-Bentonite C-11

5528

C.1 INTRODUCTION

The objective of the analysis performed in this Appendix was to statistically evaluate whether the placement of the bentonite layer in Silos 1 and 2 was effective in reducing the radon levels in the headspace and at the critical receptor. In order to demonstrate the removal action's apparent success, the post-bentonite placement data presented in Appendices A and B were compared directly with pre-bentonite placement data and statistically evaluated to determine if there were any significant reductions in radon concentrations and associated radiation levels. The following is a discussion of the approach taken to evaluate the data.

In order to perform the evaluations, the pre-bentonite and post-bentonite data were tabulated (see Tables C-2 through C-7) and reviewed to determine the type of distribution the data seemed to follow in an effort to select the most appropriate statistical test. Next, all data sets were evaluated against the test hypothesis that there was a statistically significant difference in the post-bentonite radon concentration data when compared to the pre-bentonite radon concentration data. Table C-1 presents a summary of the statistical test that was run for each data set (pre-bentonite and post-bentonite) why the test was selected, the test statistic, and the p-value.

C.2 CONCLUSIONS

Based upon the statistical evaluations performed on the pre-bentonite and post-bentonite data sets, in every case it can be stated that there was a statistically significant reduction in radon concentrations at the 95 percent confidence level ($\alpha = 0.05$).

000060

TABLE C-1

STATISTICAL DETERMINATION SUMMARY

SAMPLE LOCATION	STATISTICAL TEST RUN	STATISTICAL SUMMARY
Silo 1 Headspace Radon Concentration	t-test	Data were normally distributed and the observations were assumed to be independent. Compared average of a set of values (post-bentonite) to a constant (pre-bentonite). H_o: $\mu - C \geq 0$. H_1: $\mu - C < 0$. $t = -1155.62$. $p = <0.0001$. (Refer to Table C-2 for data)
Silo 2 Headspace Radon Concentration	t-test	Data were normally distributed and the observations were assumed to be independent. Compared average of a set of values (post-bentonite) to a constant (pre-bentonite). H_o: $\mu - C \geq 0$. H_1: $\mu - C < 0$. $t = -170.195$. $p = <0.0001$. (Refer to Table C-3 for data)
Silo 1 Dome NW Surface Radiation	Unequal variance t-test	Both data sets were approximately normally distributed and the observations were assumed to be independent. Compared average (μ_1) of a set of values (pre-bentonite) to an average (μ_2) of another set of values (post-bentonite). H_o: $\mu_1 - \mu_2 \leq 0$. H_1: $\mu_1 - \mu_2 > 0$. $F = 394.99$, $p = 0.0000$; $t = 13.2947$, $p = <0.0001$. (Refer to Table C-4 for data)
Silo 1 Dome NE Surface Radiation	Median test	the post-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 6.63325$, $p = <0.0001$. (Refer to Table C-4 for data)
Silo 1 Dome SW Surface Radiation	Unequal variance t-test	Both data sets were approximately normally distributed and the observations were assumed to be independent. Compared average (μ_1) of a set of values (pre-bentonite) to an average (μ_2) of another set of values (post-bentonite). H_o: $\mu_1 - \mu_2 \leq 0$. H_1: $\mu_1 - \mu_2 > 0$. $F = 342.80$, $p = 0.0000$; $t = 13.2285$, $p = <0.0001$. (Refer to Table C-4 for data)
Silo 1 Dome SE Surface Radiation	Unequal variance t-test	Both data sets were approximately normally distributed and the observations were assumed to be independent. Compared average (μ_1) of a set of values (pre-bentonite) to an average (μ_2) of another set of values (post-bentonite). H_o: $\mu_1 - \mu_2 \leq 0$. H_1: $\mu_1 - \mu_2 > 0$. $F = 230.67$, $p = 0.0000$; $t = 13.7545$, $p = <0.0001$. (Refer to Table C-4 for data)
Silo 2 Dome NW Surface Radiation	Median test	The pre-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 6.02056$, $p = <0.0001$. (Refer to Table C-5 for data)
Silo 2 Dome NE Surface Radiation	Median test	The pre-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 6.02056$, $p = <0.0001$. (Refer to Table C-5 for data)
Silo 2 Dome SW Surface Radiation	Median test	The pre-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 5.73320$, $p = <0.0001$. (Refer to Table C-5 for data)

000061

5528

TABLE C-1

(Continued)

SAMPLE LOCATION	STATISTICAL TEST RUN	STATISTICAL SUMMARY
Silo 2 Dome SE Surface Radiation	Median test	The pre-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 5.73320$, $p = <0.0001$. (Refer to Table C-5 for data)
K-65 Silo Exclusion Zone Radon Concentration-NW	Unequal variance t-test	Both data sets were approximately normally distributed and the observations were assumed to be independent. Compared average (μ_1) of a set of values (pre-bentonite) to an average (μ_2) of another set of values (post-bentonite). H_o: $\mu_1 - \mu_2 \leq 0$. H_1: $\mu_1 - \mu_2 > 0$. $F = 10.49$, $p = 0.0000$; $t = 7.3824$, $p = <0.0001$. (Refer to Tables C-6 and C-7 for data)
K-65 Silo Exclusion Zone Radon Concentration-NE	Median test	The post-bentonite data set was non-normally distributed and the two data sets were dissimilar in distribution. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 4.09750$, $p = <0.0001$. (Refer to Tables C-6 and C-7 for data)
K-65 Silo Exclusion Zone Radon Concentration-SW	Unequal variance t-test	Both data sets were approximately normally distributed and the observations were assumed to be independent. Compared average (μ_1) of a set of values (pre-bentonite) to an average (μ_2) of another set of values (post-bentonite). H_o: $\mu_1 - \mu_2 \leq 0$. H_1: $\mu_1 - \mu_2 > 0$. $F = 42.53$, $p = 0.0000$; $t = 5.8875$, $p = <0.0001$. (Refer to Tables C-6 and C-7 for data)
K-65 Silo Exclusion Zone Radon Concentration-SE	Wilcoxon Rank Sums test	The post-bentonite data set was non-normally distributed, but both data sets had positive kurtosis and positive skewness. Compared median (med_1) of a set of values (pre-bentonite) to a median (med_2) of another set of values (post-bentonite). H_o: $med_1 - med_2 \leq 0$. H_1: $med_1 - med_2 > 0$. $Z = 4.23169$, $p = <0.0001$. (Refer to Tables C-6 and C-7 for data)

000062

5528

Table C-2

Silo 1
Radon Headspace Concentration Summary (pCi/l)

Pre-Bentonite*		Post-Bentonite	
Date	Concentration	Date	Concentration
11/8/91	25,000,000	April 1993	220,763
		May 1993	369,276
		June 1993	402,499
		July 1993	295,998
		August 1993	292,549
		September 1993	208,925
		October 1993	233,688
		November 1993	234,973
		December 1993	241,728
		January 1994	286,833
		February 1994	153,034
		March 1994	363,273

* - Only one headspace sample was taken prior to bentonite installation.

Table C-3

Silo 2
Radon Headspace Concentration Summary (pCi/l)

Pre-Bentonite*		Post-Bentonite	
Date	Concentration	Date	Concentration
11/1/91	30,000,000	April 1993	1,304,163
		May 1993	1,975,921
		June 1993	2,496,051
		July 1993	2,886,893
		August 1993	2,909,393
		September 1993	2,542,503
		October 1993	2,371,735
		November 1993	2,578,251
		December 1993	2,742,546
		January 1994	3,173,491
		February 1994	2,963,381
		March 1994	3,390,744

* - Only one headspace sample was taken prior to bentonite installation.

Table C-4

Silo 1
Dome Surface Radiation (mrem/hr)

Pre-Bentonite					Post-Bentonite				
Date	Dose (mrem/hr)				Date	Dose (mrem/hr)			
	SE	SW	NE	NW		SE	SW	NE	NW
3/20/91	100	75	110	140	12/3/91	8.4	7	6.3	6.9
7/9/91	140	125	155	195	1/6/92	4.3	NA	3.9	4.5
7/10/91	140	85	170	135	2/9/92	3.7	NA	3.5	4.2
7/19/91	110	127	180	135	3/8/92	9.0	8	7	9
7/29/91	135	137	156	170	4/8/92	4.2	4.3	4.6	6
8/2/91	110	120	120	140	5/6/92	3	3.5	3.5	4.1
8/7/91	130	130	130	165	6/8/92	2.9	3.4	3	3.6
8/9/91	98	120	111	120	7/8/92	3.1	3.5	3.4	3.9
8/12/91	105	120	120	130	9/16/92	4.3	4.3	4.2	6
8/14/91	87	114	104	112	10/8/92	3.6	3.7	4	4.1
8/16/91	71	78	90	87	11/24/92	9	9	11	7
8/19/91	100	105	120	110	12/7/92	5	5	6	7
8/21/91	76	82	90	90	1/6/93	4.4	4.5	4.7	4.7
8/23/91	81	102	95	98	2/8/93	6	6	7	6
8/25/91	73	79	88	76	3/8/93	2	2	3	2
9/19/91	125	175	174	150	4/5/93	3.6	3.7	3.5	4.7
9/23/91	100	100	100	120	5/10/93	4.5	6	5	6.5
9/24/91	40	50	50	50	6/8/93	3.5	5	6	4.5
9/25/91	50	60	50	70	7/8/93	3.5	3.5	6.5	4.5
9/26/91	50	50	60	70	8/6/93	4.3	4.5	4.7	5

000065

5528

Table C-4
(Continued)

Pre-Bentonite					Post-Bentonite				
Date	Dose (mrem/hr)				Date	Dose (mrem/hr)			
	SE	SW	NE	NW		SE	SW	NE	NW
9/27/91	50	50	70	75	9/8/93	7	7	6	8
9/29/91	90	70	70	70	10/8/93	7	7	9	10
10/1/91	70	70	70	100	11/4/93	6	6	8	8
10/2/91	60	65	70	75					
10/2/91	50	75	75	75					
10/3/91	75	75	100	75					
10/3/91	40	50	50	60					
10/5/91	50	90	75	80					
10/6/91	50	90	75	80					
10/21/91	110	105	120	150					
11/8/91	135	150	140	175					
11/11/91	93	93	90	114					
11/13/91	50	50	60	43					
11/14/91	47	59	53	60					
11/15/91	50	50	50	50					
11/16/91	50	55	65	72					
11/17/91	50	54	55	58					
11/19/91	68	79	79	80					

000066

5528

Table C-5

Silo 2
Dome Surface Radiation (mrem/hr)

Pre-Bentonite					Post-Bentonite				
Date	Dose (mrem/hr)				Date	Dose (mrem/hr)			
	SE	SW	NE	NW		SE	SW	NE	NW
3/20/91	370	360	310	330	12/3/91	15	15	10	15
7/9/91	140	135	120	120	1/6/92	3.2	3.1	2.7	2.3
7/10/91	130	140	105	120	2/9/92	3.8	3.9	3	2.7
7/11/91	111	97	89	82	3/8/92	4	4.8	3	3.3
7/14/91	95.3	98.1	76.3	85.4	4/8/92	3.3	3.7	2.3	2.1
7/15/91	95	90	100	94	5/6/92	3.7	4.1	3	2.2
7/17/91	102	104	104	108	6/8/92	3.6	3.7	2.8	2.4
7/21/91	135	130	155	148	7/8/92	7	8	4.5	3.9
7/22/91	86	81	93	96	9/16/92	11	11	10	9
7/24/91	41	74	48	67	10/8/92	10	9	9	8
7/24/91	80	103	125	115	11/24/92	15	13	13	12
7/28/91	150	160	160	160	12/7/92	16	17	15	15
7/30/91	97	90	120	116	1/6/93	16	16	16	15
8/1/91	105	102	118	112	2/8/93	16	15	15	13
8/4/91	120	110	140	125	3/8/93	12	12	10	11
9/27/91	50	50	60	50	4/5/93	12	11	10	10
9/27/91	150	175	175	175	5/10/93	14	14	13	10
9/28/91	50	55	60	60	6/8/93	12	14	13	12
9/30/91	90	80	105	100	7/8/93	17	17	14	14
10/3/91	100	100	125	100	8/6/93	17	17	17	16

000067

5528

Table C-5
(Continued)

Pre-Bentonite					Post-Bentonite				
Date	Dose (mrem/hr)				Date	Dose (mrem/hr)			
	SE	SW	NE	NW		SE	SW	NE	NW
10/4/91	100	90	125	100	9/8/93	21	23	20	20
10/5/91	50	75	60	75	10/8/93	17	18	16	16
10/6/91	100	50	50	50	11/4/93	18	16	17	15
10/7/91	70	60	50	60					
10/8/91	75	80	65	80					
10/9/91	50	50	90	80					
10/10/91	55	55	70	50					
10/14/91	100	105	100	100					
10/15/91	78	65	80	75					
10/17/91	75	75	90	90					
11/1/91	200	185	215	204					
11/13/91	100	80	70	70					
11/17/91	116	120	138	130					
11/19/91	103	100	95	108					

000068

5528

Table C-6

Radon Concentration at K-65 Exclusion Zone
Pre-Bentonite

Date	K-65 NW			K-65 SW			K-65 NE			K-65 SE		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
January 1991	6.1	17.2	2.4	3.7	14.6	0.6	9.1	25.0	0.9	err	err	err
February 1991	6.0	25.5	1.7	5.9	35.0	0.3	21.1	149.1	0.0	15.6	146.7	-.2
March 1991	4.5	18.3	0.4	4.6	27.8	0.3	4.7	26.8	0.3	5.9	26.1	.1
April 1991	4.9	23.6	0.5	6.5	23.7	0.5	9.1	29.7	0.4	6.7	31.6	0.1
May 1991	5.2	15.3	0.5	9.2	53.2	0.5	109	32.8	0.4	6.5	24.6	0.1
June 1991	2.6	5.6	0.8	4.0	9.7	1.0	7.4	39.6	0.5	3.3	19.1	0.32
July 1991	2.3	6.6	0.9	2.6	10.3	0.8	4.2	14.4	0.0	2.4	8.3	0.0
August 1991	3.8	10.8	1.4	3.4	9.8	0.8	7.0	28.5	0.0	6.6	29.1	1.0
September 1991	5.1	16.0	1.6	4.2	13.5	1.2	8.8	34.2	1.0	7.5	17.5	0.0
October 1991	6.3	17.5	1.4	8.4	23.9	2.0	15.2	65.3	0.5	22.4	75.2	0.8
November 1991	5.9	23.8	0.5	5.7	27.3	0.8	16.8	56.7	0.5	16.9	58.5	0.5

000063

5528

Table C-7

Radon Concentration at K-65 Exclusion Zone
Post-Bentonite

Date	K-65 NW			K-65 SW			K-65 NE			K-65 SE		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
September 1992	1.5	2.2	0.6	1.8	3.4	0.8	2.8	6.5	0.5	1.6	4.0	0.4
October 1992	1.6	2.7	0.7	1.4	2.9	0.2	3.0	8.0	0.6	1.5	6.0	0.5
November 1992	1.1	2.3	0.6	1.3	2.7	0.7	1.2	3.1	0.5	0.7	2.5	0.2
December 1992	1.4	3.7	0.6	1.3	3.2	0.7	1.6	5.5	0.5	1.5	4.3	0.2
January 1993	1.3	4.0	0.6	1.5	3.4	0.7	2.0	7.9	0.5	1.6	5.6	0.2
February 1993	2.0	6.8	0.7	2.0	4.5	0.6	2.9	8.8	0.4	2.3	6.1	0.6
March 1993	1.9	6.8	0.6	2.0	4.5	0.7	2.7	8.8	0.5	2.0	5.5	0.2
April 1993	1.1	2.6	0.6	1.2	2.3	0.6	1.2	4.9	0.2	1.6	5.1	0.6
May 1993	1.3	2.0	0.6	1.3	2.3	0.6	1.7	3.4	0.3	1.4	2.3	0.6
June 1993	1.3	1.9	0.7	1.3	2.2	0.6	2.5	6.3	0.8	2.0	12.3	0.7
July 1993	1.6	4.9	0.8	1.5	2.2	0.6	2.6	6.3	1.1	1.5	2.5	0.7
August 1993	1.8	2.7	1.1	1.9	2.6	0.9	3.3	7.8	1.2	2.0	2.9	0.9
September 1993	1.7	2.9	0.7	1.7	2.9	0.6	2.6	5.2	0.6	1.8	3.0	0.7
October 1993	1.8	3.5	0.8	1.7	3.6	0.4	4.0	12.0	0.6	2.4	5.6	0.9
November 1993	1.8	9.0	0.6	1.3	2.8	0.4	3.6	14.6	0.6	2.1	5.4	0.7
December 1993	1.6	4.1	0.7	1.3	4.3	0.3	2.7	12.0	0.4	1.9	6.0	0.7
January 1994	2.3	12.9	0.8	1.6	6.2	0.4	2.2	11.5	0.5	1.9	5.0	0.7
February 1994	2.8	21	0.4	2.3	12.6	0.3	13.9	135.6	0.6	5.2	39.5	0.2
March 1994	1.2	2.8	0.3	1.2	3.8	0.3	2.3	5.3	0.6	1.6	4.2	0.3

000070

5528

5528

APPENDIX D

SILOS 1 AND 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN (APRIL 1992)

5528

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

APR 21 1992

REPLY TO THE ATTENTION OF:

HRE-8J

Mr. Jack R. Craig
United States Department of Energy
Feed Materials Production Center
P.O. Box 398705
Cincinnati, Ohio 45239-8705

RE: Approval of the Revised Silo 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan

Dear Mr. Craig:

The United States Environmental Protection Agency (U.S. EPA) has completed its review of the revised Silo 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan. On April 3, 1992, U.S. EPA submitted draft responses on the Plan to the United States Department of Energy (U.S. DOE), and on April 4, 1992, U.S. DOE submitted responses to U.S. EPA comments. Comments on the Plan were further discussed on April 6 and April 8, 1992.

Based upon the above submittals and discussions U.S. EPA hereby approves the plan pending incorporation of the attached comments.

Please contact Mr. James Benetti at (312/FTS) 886-6175, or Mr. James Saric at (312/FTS) 886-0992 if you have any questions.

Sincerely,

James C Benetti

James Benetti, Chief
Radiation Section

James A. Saric
Remedial Project Manager

Enclosure

cc: Graham Mitchell, OEPA-SWDO
Pat Whitfield, U.S. DOE-HQQ

000072

Printed on Recycled Paper

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: APR 03 1992

SUBJECT: Comments on Revised Silo 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan, March 13, 1992

FROM: Larry Jensen, CHP
Regional Radiation Expert
Radiation Section

TO: James Saric, RMP
RCRA Enforcement Branch

I have reviewed the above document. My comments follow.

GENERAL COMMENTS

1. Diffusion release calculations follow the method of Borak and Colle' while free air exchange calculations follow the method of the Fernald Dosimetry Reconstruction Project (FDRP). One major observation is that while the latter uses a range for silo parameters, this monitoring plan selects a single value (from the FDRP range) but without justification for the selection. Either the specific parameter used should be justified or the most conservative parameter from each range should be used.

2. This monitoring plan includes temperature driven ventilation while the FDRP includes both temperature and wind driven ventilation. Justification should be given as to why wind driven effects are not also included in this plan, especially in terms of consistency.

SPECIFIC COMMENTS

1. It would be helpful to number the equations. Also equations which are tucked into paragraphs, but which are major culminating equations, should be separated from the text like the other equations. Specifically, this is referring to Q_{diff} on page 2 and Q_{total} on page 4.

2. For the equation $PV = nRT$ on page 3, the definitions can be improved. Specifically, (1) state units on pressure, volume, and temperature, (2) decide whether the calculation will be in °K or °R, and (3) state whether the volume is of the silo or just the headspace.

3. For the second equation on page 3, clarify the definitions also.

5528

Department of Energy
Fernald Environmental Management Project
P.O. Box 398705
Cincinnati, Ohio 45239-8705
(513) 738-6367

APR 16 1992
DOE-1382-92

Mr. James A. Saric, Remedial Project Director
U. S. Environmental Protection Agency
Region V - 5HRE-8J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

Mr. Graham E. Mitchell, Project Manager
Ohio Environmental Protection Agency
40 South Main Street
Dayton, Ohio 45402-2086

Dear Mr. Saric and Mr. Mitchell:

SILOS 1 & 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN

Enclosed for your review and approval is the subject document which has been revised to reflect all United States Environmental Protection Agency (U.S. EPA) comments received on March 31, 1992. The Comment Response Document, as previously transmitted, is also enclosed.

As you are aware, data is being input into the Model this month for transmittal of the initial results in the April 1992 Consent Agreement Report.

If you or your staff have any additional questions or comments, please contact Randi Allen at FTS-774-6158 or 513-738-6158.

Sincerely,

Jack R. Craig
Fernald Remedial Action
Project Manager

FN:Allen

Enclosures: As Stated

Recycled and Recyclable

cc w/encs.:

J. J. Fiore, EM-42, TREV
K. A. Hayes, EM-424, TREV
J. Benetti, USEPA-V, AT-18J
M. Butler, USEPA-V, 5CS-TUB-3
J. Kwasniewski, OEPA-Columbus
P. Harris, OEPA-Dayton
M. Proffitt, OEPA-Dayton
T. Schneider, OEPA-Dayton
T. W. Hahne, PRC
L. August, GeoTrans
R. L. Glenn, Parsons
D. J. Carr, WEMCO
L. S. Farmer, WEMCO
J. P. Hopper, WEMCO
J. D. Wood, ASI/IT
J. E. Razor, ASI/IT
AR Coordinator, WEMCO

Silos 1 and 2 Removal Action

Bentonite Effectiveness

Environmental Monitoring Plan

April 15, 1992

Continuous (i.e., real time) and integrated (i.e., passive) sampling for ^{222}Rn is being performed as part of the routine environmental monitoring program at the Fernald Environmental Management Project (FEMP). The recent removal action involving application of a bentonite sealant layer to the K-65 silos is expected to produce a reduction in the quantity of ^{222}Rn being emitted from the silos. Continuous measurements of ^{222}Rn in the head space of the K-65 silos will be utilized with a Gaussian plume model computer program and site specific meteorological data to determine what contribution residual radon emissions from the K-65 silos make to the offsite background radon concentration.

One of the objectives of the environmental ^{222}Rn monitoring and analysis at the FEMP is to determine whether ^{222}Rn emitted from the K-65 silos following the bentonite sealant application has been reduced to a level such that its contribution to offsite background is less than 0.015 pCi/l at the location of the maximally exposed individual at a non-FEMP location. Because the measured annual average offsite environmental radon background concentration is 0.5 ± 0.1 pCi/l, contributions to the radon background concentration equal to 0.015 pCi/l can be determined only by modeling since monitoring techniques are not sufficiently precise to reliably detect such a small change.

The Gaussian plume model computer code adopted by FEMP can predict what contribution to the offsite radon background is being produced from radon emitted by the K-65 silos. The flux of radon ($pCi/M^2/sec$) which is emitted from the silo dome by mechanisms of diffusion and air exchange (ventilation) will be used as the source term for the Gaussian plume model. This flux will be calculated from the measured concentration of radon (pCi/M^3) in the dome headspace.

Two pathways for emissions of ^{222}Rn from the silos are considered: (1) diffusion of ^{222}Rn in the K-65 silo air through the concrete dome and polyurethane foam and (2) free air exchange between the silo air and the surrounding air (ventilation).

Diffusion Releases

The calculations by Borak (1985) of diffusion releases of ^{222}Rn were based on one dimensional steady-state diffusion equations obtained from an National Bureau of Standards (NBS) summary technical report (Colle' et al. 1981).

From the concentration of ^{222}Rn in the silo air, the flux of ^{222}Rn diffusion through the concrete dome can be calculated by:

$$J = \frac{E_c \lambda_{Rn} l_c C_a}{\sinh\left(\frac{L}{l_c}\right)}$$

Where:

J_c = ^{222}Rn flux from the concrete dome surfaces to the foam (pCi/M²/sec, or similar units),
E_c = total porosity of the dome concrete,
l_c = diffusion length of ^{222}Rn in the dome concrete,
L = thickness of the dome concrete,
λ_{Rn} = decay constant of ^{222}Rn ~ $(2.1 \times 10^{-6}\ s^{-1})$[1],
C_a = concentration of ^{222}Rn in the silo air,

The diffusion release estimate will include a Monte Carlo simulation, using a computer program, with a range of inputs as defined in the Fernald Dosimetry Reconstruction Project (FDRP) for the parameters listed below:

Parameter	Range	Distribution	Source
Diffusion Length of Concrete (l_c)	6 cm to 23 cm	Uniform	FDRP
Porosity of Concrete (E_c)	0.05 to 0.265	Uniform	FDRP
Silo Dome Thickness (L)	3 in to 4 in	Uniform	FDRP
Concentration of Radon in headspace of Silo (C_a)	Using mean & standard deviation	Normal Distribution	To be Measured

There is a foam and polyurethane coating over the surface of the concrete dome on each silo. This layer is an effective radon barrier based on the laboratory measured diffusion coefficient of $4 \times 10^{-6}\ cm^2 - s^{-1}$ (TIM-8700/1). This foam layer will further attenuate the radon flux before the radon is emitted to the atmosphere. This attenuation is determined as follows:

[1]The decay constant of radon is assumed to have no uncertainty.

$$J = J_c \exp\left(\frac{-L_f}{\sqrt{D_f/\lambda_{Rn}}}\right)$$

Where:

J = ^{222}Rn flux emitted to the surrounding air (pCi/m^2-s)

Jc = ^{222}Rn flux emitted from concrete surface of the dome into the foam

L_f = thickness of the foam (10 cm)

D_f = diffusion coefficient for the foam (4 x 10 $^{-4}$ cm^2/s)

The total release rate (Q_{total}) is then the product of the ^{222}Rn flux and the surface area of the dome.

$$Q_{total} = JA \qquad (1)$$

Where:

A = the area of the dome.

Free Air Exchange (Ventilation)

Ventilation of radon from the silo is governed by the physics associated with the ideal gas law and, as such, is dependent upon the temperature and pressure changes of the gases in the silo headspace as a result in the changes in the ambient atmosphere. The rigid polyurethane foam coating, the urethane coating, and the sealing of the silo penetrations should significantly reduce the possibility of any wind induced releases of silo air to the surrounding environment. The release of silo air due to wind effects would result in a corresponding pressure change. The use of the ideal gas law, with the inclusion of temperature and pressure data would account for any significant releases as a result of meteorological conditions including wind induced effects.

The calculation of emissions of ^{222}Rn due to ventilation from the silos is, therefore, based on the expansion of the silo gases due to changes in atmospheric conditions. The ventilation of silo gases is determined from the ideal gas law using temperature and pressure data collected.

$$PV = nRT$$

Where:

P = pressure of the gases within the silo,
V = volume of the silo headspace,
n = number of moles of the gases,
R = ideal gas constant, with appropriate units, and
T = temperature, in units of an absolute scale (K or °R).

The silo gases' internal temperature and pressure has been collected and continues to be collected. This data is used to determine the release of radon due to the ventilation of silo gases.

For air exchange emissions, the assumption is made that the ^{222}Rn concentration in outside air is negligible compared to the silo concentration so that outside air does not provide a source of ^{222}Rn to the silo air. The ventilation of radon to the atmosphere is assumed to be small compared to the production of radon gases, thus the concentration of radon in the silos is assumed to be a constant which does not deviate from equilibrium. With these assumptions, the basic equation describing the rate of change in the silo air ^{222}Rn concentration can be written (NCRP 1989):

$$\frac{dC_a}{dt} = \frac{P_{Rn}}{V_0} - C_a\lambda_{eff}$$

where:

C_a = concentration of $_{222}Rn$ in the silo air,
P_{Rn} = the constrained (by the presence of the silo) rate of release of $_{222}Rn$ into the silo air (production term) from the K-65 source material (activity per time),
V_0 = volume of the air space in the silo above the K-65 material,
λ_{eff} = the effective removal rate of $_{222}Rn$ = $\lambda_{eff} = \lambda_{Rn} + \lambda_v$,
λ_{Rn} = decay constant of ^{222}Rn - (2.1×10^{-6} s^{-1}),
λ_v = The ventilation rate due to the daily atmospheric changes λ_v is the fraction of the silo air exhaled due to the atmospheric changes per some unit of time period, with the units of air changes per time. Therefore:

$$\lambda_v = \Delta n / n_0$$

where we define:

Δn = the change of number of moles of gas in silo headspace,
n_0 = the initial number of moles of gas in silo headspace

Based on the assumption of equilibrium of the radon in the headspace the following relationship is obtained:

$$P_{Rn} = C_a\lambda_{eff}V_0$$

Because the silo air space is a single compartment volume, it is assumed that the contained air will be well mixed. Thus, the air exchange release rate is simply the activity in the silo air space times the silo ventilation rate:

$$Q_{exch} = C_a\lambda_v V_0 \qquad (2)$$

where:

Q_{exch} = the rate of release of ^{222}Rn from the silo through air exchange.

then, using equations (1) and (2):

$Q_{total} = Q_{diff} + Q_{exch}$

The radon release rate (Q_{total}) from the diffusion process and air exchange process is then used as the source term input into the ISC model program. Both mechanisms of diffusion and air exchange (ventilation) will be considered in converting radon concentrations in the dome headspace to the radon release rate.

Periodic analysis of the predicted and measured offsite radon background concentration will provide information to determine the gross effectiveness of the model. Data collected from the silo headspace radon monitor will determine the relative integrity of the bentonite unrelated to changes in meteorological parameters.

The Gaussian plume model computer code, ISC version #3.4, December 1988, is currently being used to calculate what contribution ^{222}Rn emitted from the K-65 silos makes to the offsite background radon concentration. ISC is composed of two programs designed to predict the atmospheric dispersion of air emissions: ISC Short Term for predicting concentration over 1, 2, . . ., 24 hour periods and ISC Long Term for calculating quarterly, seasonal, or annual concentration. The radon monitoring data being collected at FEMP is best analyzed using ISC Long Term. Although a new version of ISC Short Term is currently available for testing, ISC Short Term will not be implemented at this time for these analyses.

Site-specific meteorological parameters and the calculated ^{222}Rn release rates are used as input to the ISC Gaussian plume model computer code to predict the radon concentration at any predetermined location relative to the K-65 silos as the source of ^{222}Rn. Predictions of the Gaussian plume model will be compared to results of actual ^{222}Rn monitoring data, although the contribution of ^{222}Rn from the K-65 silo to offsite ^{222}Rn background is expected to be very small and may not be measurable at the site boundary unless there is an unexpected release of radon due to a failure of the bentonite sealant.

The annual average offsite ^{222}Rn background is approximately 0.5 pCi/l ± 0.1 pCi/l. Therefore, it is not possible to confirm by measurements whether ^{222}Rn emitted from the K-65 silos increases the offsite radon background in excess of 0.015 pCi/l for the maximally exposed individual. However, the ISC computer model calculations, which use as a source term the ^{222}Rn concentration actually measured in the headspace of the K-65 silos, will predict how much of the offsite ^{222}Rn background is due to ^{222}Rn emissions from the K-65 silos.

Real-time ^{222}Rn monitoring data, including measurement of ^{222}Rn in the K-65 silo headspace, will be generated and recorded hourly. Permanent files of the hourly data are available on computer discs. Data from integrated radon measurements are available on a quarterly basis since samples are collected

for a three month period. For a fixed location, variations in the radon concentration are due, primarily, to changes in meteorological parameters which impact the amount of mixing and dilution experienced by the ^{222}Rn emitted from the K-65 silos. Likewise, periodic changes in ^{222}Rn flux from the K-65 silos are due to diurnal changes in certain meteorological parameters, such as, barometric pressure, wind speed, temperature and solar radiation.

Evaluation of the predicted contribution to offsite radon background, using the ISC Gaussian plume model computer code with values of the radon release rate calculated from actual headspace concentration measurements in the K-65 silos and site-specific meteorological parameters, will be accomplished by comparing the model's predictions to the actual measured results of offsite radon background using both continuous and integrated samplers. This evaluation will be performed to determine compliance with the 0.015 pCi/l limit and to provide a gross independent assessment of the model accuracy.

The Gaussian plume computer model will use hourly measurements of the radon concentration in the headspace of the K-65 silos along with site-specific meteorological parameters to predict radon concentration at any location. Sets of data will be generated to produce a weekly average concentration for all offsite monitoring locations. Analysis of the average weekly predicted radon background concentration and the actual measured average values will be reported. Although field monitoring techniques do not have the precision to detect a variation in the offsite background ^{222}Rn concentration of 0.015 pCi/l, the computer model, which uses measurements of ^{222}Rn in the K-65 silo dome headspace to predict the actual contribution to offsite ^{222}Rn background, is adequately precise to calculate these values.

REFERENCES

Borak, T. B. Calculation of radon emission, dispersion and dosimetry from K-65 Storage Tanks at the Feed Materials Production Center. (1985) in: History of FMPC radionuclide discharges. Cincinnati, OH: Westinghouse Materials Company of Ohio; FMPC-2082; 1987

Colle', R; Rubin, R. J.; Knab, L. I.; Hutchinson, J. M. R. Radon transport through and exhalation from building materials: a review and assessment. Washington, DC: National Bureau of Standards, U.S. Department of Commerce; NBS Technical Note 1139; 1981

NCRP (National Council on Radiation Protection and Measurements). Control of radon in houses. Bethesda, MD: National Council on Radiation Protection and Measurements; NCRP Report No. 103; 1989

Radiological Assessments Corporation, The Fernald Dosimetry Reconstruction Project, Tasks 2 and 3: Radionuclide Source Terms and Uncertainties - 1960 - 1962 (Draft), Submitted to the Centers for Disease Control in Partial Fulfillment of Contract No. 200-90-0803, December, 1991

Nielson, K. K., Rogers, V. C., Radon Diffusion Coefficient Measurements of Polyurethane Materials and Radon Attenuation Calculation for K-65 Silos, Technical Information Memorandum, TIM-8700/1; October 13, 1987

Response to U.S. EPA Comments
On
Revised Silos 1 and 2 Removal Action
Bentonite Effectiveness Environmental
Monitoring Plan
Dated March 13, 1992

General Comments

1. U.S EPA Comment: Diffusion release calculations follow the method of Borak and Colle' while the free air exchange calculations follow the method of the Fernald Dosimetry Reconstruction Project (FDRP). One major observation is that while the latter uses a range for silo parameters, this monitoring plan selects a single value (from the FDRP range) but without justification for the selection. Either the specific parameter used should be justified or the most conservative parameter from each range should be used.

   Response: The diffusion release estimate will include a Monte Carlo simulation, using a computer program, with a range of inputs as defined in the Fernald Dosimetry Reconstruction Project (FDRP) for the parameters listed below:

Parameter	Range	Distribution	Source
Diffusion Length of Concrete (l_c)	6 cm to 23 cm	Uniform	FDRP
Porosity of Concrete (E_c)	0.05 to 0.265	Uniform	FDRP
Silo Dome Thickness (L)	3 in to 4 in	Uniform	FDRP
Concentration of Radon in headspace of Silo (C_s)	Using mean & standard deviation	Normal Distribution	To be Measured

   The decay constant of radon is assumed to have no uncertainty.

   The thickness of the foam cover was obtained from the Project Completion Report (Grumski and Shanks 1988) and the diffusion coefficient of the foam was obtained from the Technical Information Memorandum "Radon Diffusion Coefficient Measurements of Polyurethane Materials and Radon Attenuation Calculation for K-65 Silos".

Response to U.S. EPA Comments
On
Revised Silos 1 and 2 Removal Action
Bentonite Effectiveness Environmental
Monitoring Plan

2. U.S. EPA Comment: This monitoring plan includes temperature driven ventilation while the FDRP includes both temperature and wind driven ventilation. Justification should be given as to why wind driven effects are not also included in this plan, especially in terms of consistency.

   Response: The period of assessment is different for this estimate than the FDRP. The latest period estimated in the FDRP is 1987. In 1979, the openings in the silo domes, including the gooseneck pipe and other penetrations were sealed, with gaskets installed to prevent radon emissions. (Boback 1980; Grumski 1987 as referenced in the FDRP). In December of 1987, a rigid polyurethane foam layer and urethane coating were applied to the exterior of the silo dome surfaces to weatherproof the silos (Grumski and Shanks 1988; Shanks and Vogel 1988 as referenced in the FDRP).

   The release estimates in the FDRP for the period 1980 - 1987 are based solely on the data available for the temperature effects. The wind effects were "arbitrarily assumed" to range from zero to the equivalent of the temperature related releases following a uniform distribution.

   The rigid polyurethane foam coating, the urethane coating, and the sealing of the silo penetrations should significantly reduce the possibility of any wind induced releases of silo air to the surrounding environment. The release of silo air due to wind effects would result in a corresponding pressure change. The use of the ideal gas law, with the inclusion of temperature and pressure data, currently being measured, would account for any significant releases as a result of meteorological conditions including wind induced effects.

<u>Specific Comments</u>

1. U.S EPA Comment: It would be helpful to number the equations. Also equations which are tucked into paragraphs, but which are major culminating equations, should be separated from the text like the other equations. Specifically, this is referring to Q_{air} on page 2 and Q_{air} on page 4.

   Response: Will modify.

2. U.S. EPA Comment: For the equation PV=nRT on page 3 the definitions can be improved. Specifically, (1) state units

on pressure, volume, and temperature, (2) decide whether the calculation will be in °K or °R, and (3) state whether the volume is of the silo or just the headspace.

Response:

(1) Appropriate and consistent units will be utilized in the calculations.

(2) Appropriate and consistent units will be utilized in the calcultions.

(3) V = Volume of the silo headspace.

3. U.S. EPA Comment: For the second equation on page 3, clarify the definitions also.

Response: λ_v will be clarified.

APPENDIX E

SILOS 1 AND 2 HEADSPACE CONCENTRATION CALCULATIONS

5528

APPENDIX E
TABLE OF CONTENTS

List of Tables . . . . . e-i
List of Figures . . . . . e-i
E.1 Introduction E-1
E.2 Results E-2

LIST OF TABLES

E-1 Pertinent Information used in Predicting Radon Headspace Concentration for Silo 1 and Silo 2 . . . . . E-6

LIST OF FIGURES

E-1 Radon Headspace Concentration for Silo 1 and Silo 2 which would result in an Ambient Air Concentration of 15 pCi/m^3 (Receptor #1) E-7

E-2 Radon Headspace Concentration for Silo 1 and Silo 2 which would result in an Ambient Air Concentration of 15 pCi/m^3 (Receptor #2) E-8

E-3 Headspace Concentrations Resulting in 0.015 pCi/l at the Critical Receptor E-9

5528

E.1 INTRODUCTION

Continuous (i.e., real time) and integrated (i.e., passive) sampling for radon is performed as a part of the routine environmental monitoring program at the Fernald Environmental Management Project (FEMP). The Silos 1 and 2 Removal Action has utilized continuous hourly measurements of the radon in the headspace of the K-65 Silos with a Gaussian Plume model computer program and site specific meteorological data, to determine what contribution the residual radon emissions from the K-65 Silos make to the off-site background radon concentration. This methodology and determination were completed in accordance with the U.S. EPA approved *Silos 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan (April 1992)*, see Appendix D.

The USEPA established a removal action goal to reduce radon emissions from the K-65 silos, so that their contribution to off-site radon levels is no greater than 0.015 pCi/l above background, at the location of the maximally exposed individual, at a non-FEMP location. Two potential off-site receptors were selected and evaluated as the potential maximally exposed individual. The first critical receptor is located at North 481,710': East 1,345,459' (plant coordinates South 1095': East 379') and the second resident evaluated is located at North 479,239': East 1,345,933' (plant coordinates 3552': East 920'). While the second resident is closer to the silos (1660 feet), the first resident is located in a more frequent wind direction and, in spite of a greater distance to the silos (1980 feet), has the greater potential impact from the silos.

The final step taken to demonstrate the effectiveness of the bentonite cap, involved the determination which radon headspace concentration ratios from the two silos, which when modelled, resulted in an increase radon concentration of 0.015 pCi/l above background, at the location of the maximally exposed individual, at a non-FEMP location. These values were plotted to allow rapid determination using actual data, if a given set of silo headspace concentrations exceed the 0.015 pCi/l goal (Figure E-3). The following section presents a detailed discussion regarding the calculations and assumptions, and presents graphical representation of the results.

E.2 RESULTS

Problem: Given a regulatory limit of 15 pCi/m^3 (0.015 pCi/l) at the nearest resident to Silos 1 and 2, determine the headspace concentration ratios in the two silos which will result in this target concentration. Provide a plot of these values to allow rapid determination if given a set of silo headspace concentrations exceed the target concentration (15 pCi/m^3) at the nearest resident.

References:

1. Remedial Investigation Report, Operable Unit 4, Fernald Environmental Management Project, (Final), November, 1993.

2. Silos 1 and 2 Removal Action Bentonite Effectiveness Environmental Monitoring Plan, April 1992

Given:

The nearest resident is located at Ohio State Planar Coordinates North 481,710': East 1,345,459 (Plant coordinates South 1095': East 379'). A second resident is located at North 479,239': East 1,345,933' (Plant coordinates South 3552': East 920').

The model described in Reference 1 is used to establish exposure point concentrations for the two receptors.

All other Operable Unit 4 sources (the berm fill and soil) remain constant at their current estimated rate of emission as defined in Reference 1.

Assumptions:

The breathing rate of the two silos remain constant at the value used in Reference 1.

The model is linear with respect to radon emission from the silos.

Solution:

The Industrial Source Complex Long Term 92273 (ISCLT2) model was used in Reference 1 to establish the exposure point concentrations for numerous receptors in the FEMP area. Table E-1 is a summary of values used in the model and the

5528

predicted exposure point concentration at the two receptors of interest assuming the current source-term scenario described in Reference 1.

The table presents each source separately such that based on the assumption that a change in source emission rate produces a proportioned response in the radon concentration at the receptor location, individual source influences can be calculated. This assumption is displayed mathematically as:

$$\frac{Conc_o}{Head_o} = \frac{Conc_{tl}}{Head_{tl}} \qquad (1)$$

where:

$Conc_o$ -	the concentration at the receptor for the RI scenario
$Head_o$ -	the silo headspace concentration for the RI scenario which produces $Conc_o$ at the receptor
$Conc_{tl}$ -	the concentration at the receptor for a second headspace concentration
$Head_{tl}$ -	the silo headspace concentration at a later time

By holding constant all source emission rates except one silo and solving for the required concentration to produce a total of 15 pCi/m^3 at the critical receptor, followed by the same approach for the second silo, a plot of the combination of silo headspace concentrations which will produce 15 pCi/m^3 at the critical receptor can be produced.

$$Conc_{tl} = Conc_{Silo1} + Conc_{Silo2} + Conc_{Silo3} + Conc_{K65soil} + Conc_{Silo3soil} + Conc_{Bermfill} \qquad (2)$$

where:

$Conc_{Silo1}$ -	is the concentration at the critical receptor due to emissions from Silo 1,
$Conc_{Silo2}$ -	is the concentration at the critical receptor due to emissions from Silo 2,
$Conc_{Silo3}$ -	is the concentration at the critical receptor due to emissions from Silo 3,
$Conc_{K65soil}$ -	is the concentration at the critical receptor due to emissions from the soil around Silos 1 and 2,
$Conc_{Silo3soil}$ -	is the concentration at the critical receptor due to emissions from the soil around Silo 3, and
$Conc_{Bermfill}$ -	is the concentration at the critical receptor due to emissions from the soil in the K-65 berms.

000090

5528

$$15pCi/m^3 = Conc_{Silo1} + 2.8pCi/m^3 + 0.3pCi/m^3 + 0.2pCi/m^3 + 0.03pCi/m^3 + 0.07p$$

(3)

$$Conc_{Silo1} = 11.6\ pCi/m^3 \quad (4)$$

From Equation 1:

$$Head_{Silo1} = Conc_{Silo1}\ x\ \frac{Head_o}{Conc_o} \quad (5)$$

where:

- $Head_{Silo1}$ - is the radon concentration in the headspace of Silo 1 which produces the target concentrations at the critical receptor holding at other sources constant,
- $Head_o$ - is the radon concentration in the headspace of Silo 1 which produced the baseline concentration at the critical receptor, and
- $Conc_o$ - is the baseline concentration at the critical receptor

$$Head_{Silo1} = 4.95\ x\ 10^6\ pCi/L\ x\ \frac{11.6\ pCi/m^3}{0.4\ pCi/m^3} \quad (6)$$

$$Head_{Silo1} = 1.4\ x\ 10^7\ pCi/m^3 \quad (7)$$

Holding all sources constant except Silo 2 and solving for the headspace radon concentration which would yield the target concentration at the critical receptor:

5528

$$Head_{Silo2} = 2.22 \times 10^6\ pCi/L \times \frac{14.0\ pCi/m^3}{2.8\ pCi/m^3} \quad (8)$$

$$Head_{Silo2} = 1.1 \times 10^7\ pCi/L \quad (9)$$

Using these two points, a plot of those values which would yield the target concentration at the critical receptor was prepared and is attached as Figure E-1. The equations were similarly solved for the second receptor and the associated plot is attached as Figure E-2.

If the target limit of 15 pCi/m^3 is applied only to the emissions from Silos 1 and 2, then the critical values become:

$$Head_{Silo1} = 4.95 \times 10^5\ pCi/L \times \frac{12.2\ pCi/m^3}{0.4\ pCi/m^3} \quad (10)$$

$$Head_{Silo1} = 1.5 \times 10^7\ pCi/L \quad (11)$$

$$Head_{Silo2} = 2.22 \times 10^6\ pCi/L \times \frac{14.6\ pCi/m^3}{2.8\ pCi/m^3} \quad (12)$$

$$Head_{Silo2} = 1.2 \times 10^7\ pCi/L \quad (13)$$

For this case, the target levels are plotted for the critical receptor as Figure E-3. The comparison of the actual Silos 1 and 2 headspace concentrations shown in Tables A-1 and A-2 with Figure E-3 all lie below the 0.015 pCi/l level, clearly showing that the removal action goals was achieved and has been maintained to the present.

TABLE E-1 Pertinent Information used in Predicting Radon Headspace Concentration for Silo 1 and Silo 2.
Fernald Operable Unit 4
September 1993

	Emission Flux (pCi/m^2-s)	Area of Release (m^2)	Breathing Rate (m^3/yr)	Annual Average Ground Level Concentration (pCi/m^3)	
				Discrete Receptor 1[a]	Discrete Receptor 2[b]
Silo 1	0.980E+2	467	2941	0.4151	0.4216
Silo 2	0.747E+3	467	4966	2.7961	2.6561
Silo 3	0.109E+3	---	---	0.3357	0.2898
Bermfill	0.386E+1	---	---	0.2112	0.2278
K65 Soil	0.126E+1	---	---	0.0338	0.0355
Silo 3 Soil	0.126E+1	---	---	0.0653	0.0644

a Discrete Receptor 1 is located at South 1095 ft, East 379 ft.
b Discrete Receptor 2 is located at South 3552 ft, East 920 ft.

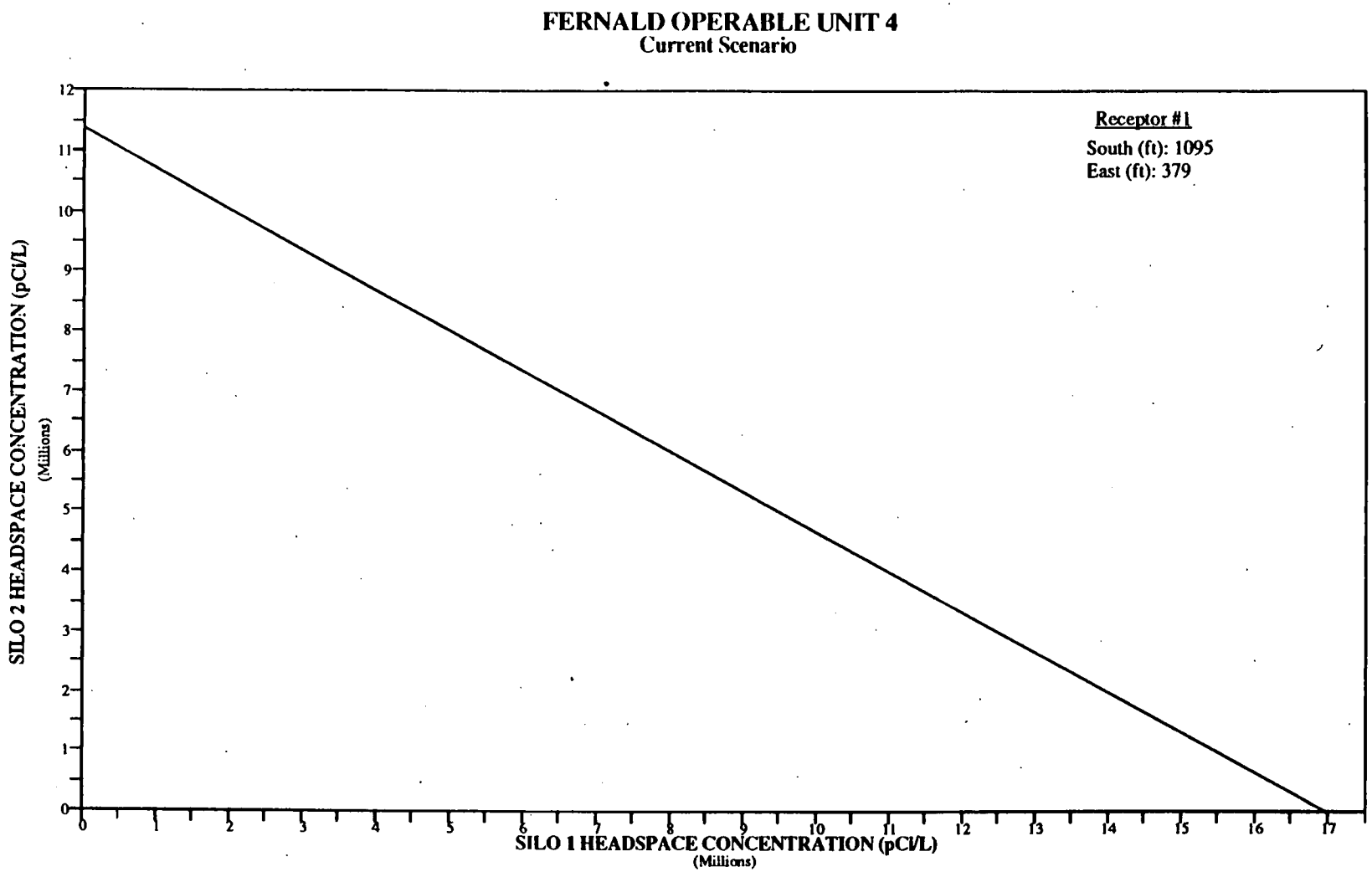


FIGURE E-1 Radon HeadSpace Concentration for Silo 1 and Silo 2 which would result in an Ambient Air Concentration of 15 pCi/m3.

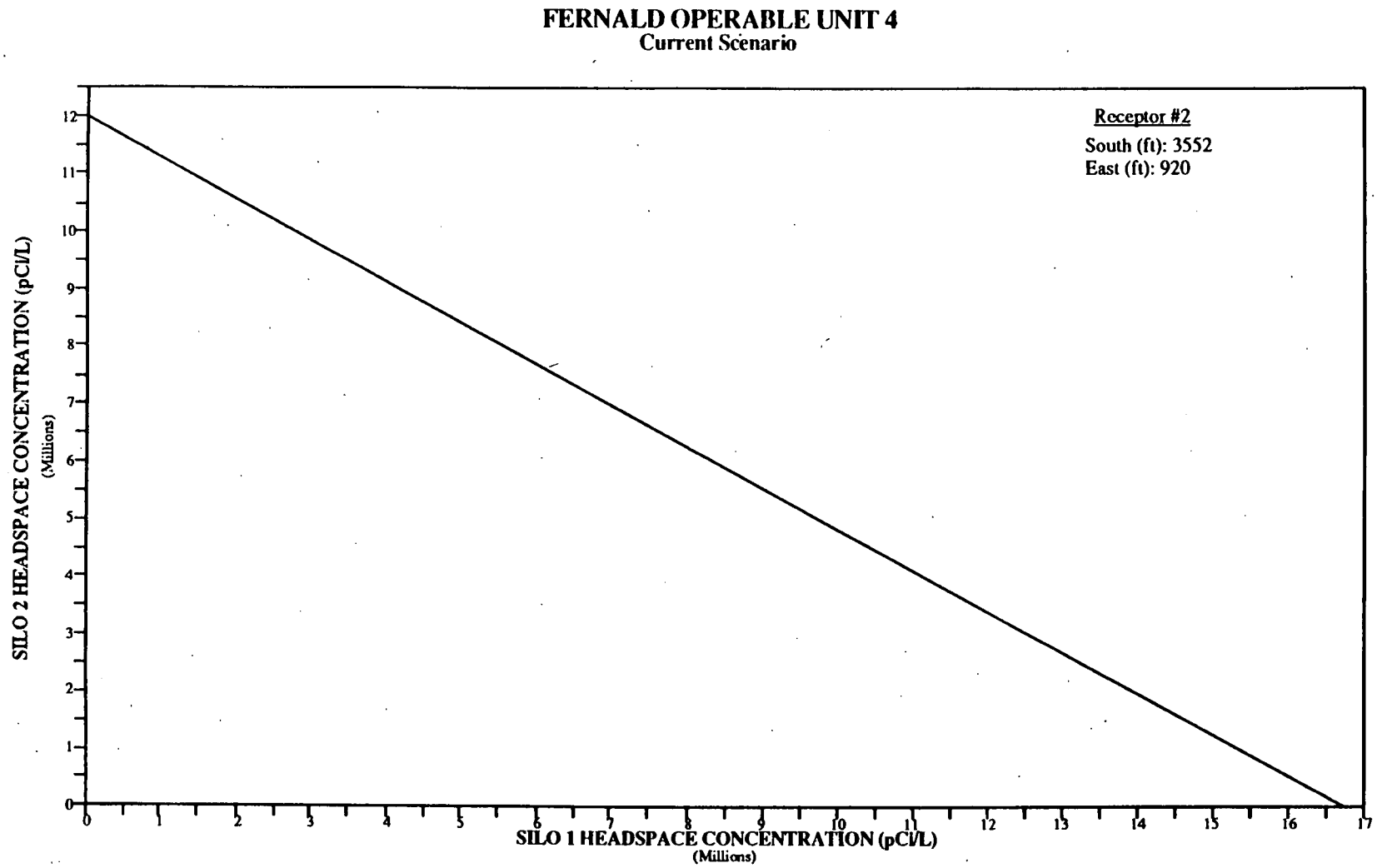
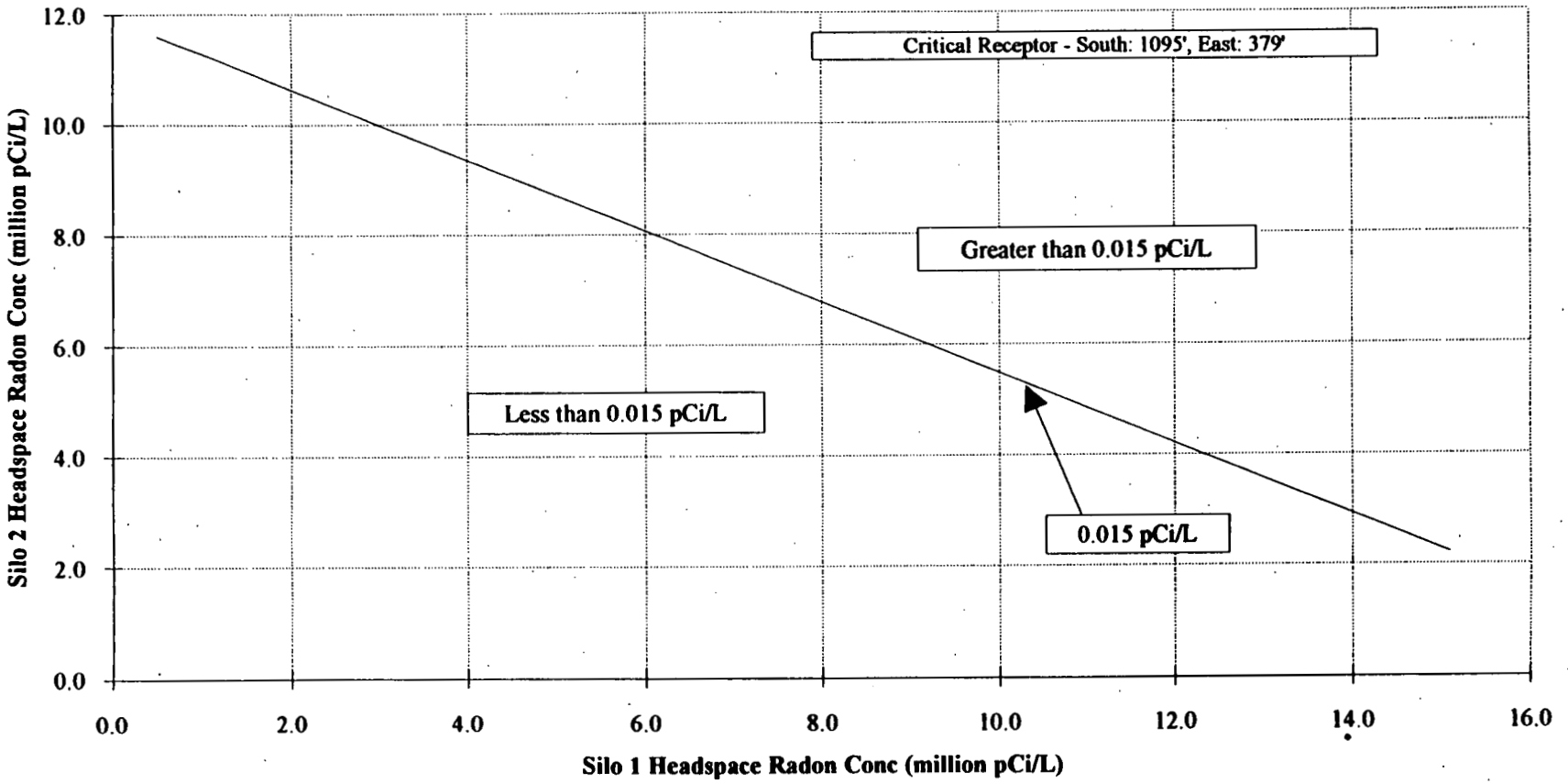


FIGURE E-2 Radon HeadSpace Concentration for Silo 1 and Silo 2 which would result in an Ambient Air Concentration of 15 pCi/m3.

000535

5528

FIGURE E-3 Headspace Concentrations Resulting in 0.015 pCi/L at the Critical Receptor



000096

APPENDIX F

K-65 SILO 2 CLOSED CIRCUIT CAMERA INSTALLATION AND BENTONITE INSPECTION WORK PLAN, REVISION 1

5528

477 7

Department of Energy
Fernald Environmental Management Project
P.O. Box 398705
Cincinnati, Ohio 45239-8705
(513) 738-6357

OCT 0 5 1993

DOE-0021-94

Mr. James A. Saric, Remedial Project Director
U.S. Environmental Protection Agency
Region V - 5HRE-8J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

Mr. Graham E. Mitchell, Project Manager
Ohio Environmental Protection Agency
40 South Main Street
Dayton, Ohio 45402-2086

Dear Mr. Saric and Mr. Mitchell:

OPERABLE UNIT 4 SILO 2 CAMERA INSTALLATION/BENTONITE INSPECTION WORK PLAN

As we discussed on Thursday, September 30, 1993, the United States Department of Energy and the Fernald Environmental Restoration Management Corporation are preparing to install two cameras in Silo 2 to view the bentonite cap in an effort to explain a recent upward trend in headspace radon concentrations in that silo. In spite of the recent concentrations in Silo 2, it is important to note that the original performance goal of the K-65 Removal Action of a radon concentration of 0.015 pci/l, above background, at the nearest resident has not been exceeded.

Enclosed for your information is a brief Work Plan which discusses the camera installation. Basically, the procedures and equipment used will be identical to those of the surface mapping project and bentonite installation in 1991.

Pending the reallocation of necessary funds to support the project, camera installation will be initiated on November 16, 1993. Therefore, if you have any questions or concerns, please call Randi Allen at 513-648-3102 prior to this date.

Sincerely,

Jack R. Craig
Fernald Remedial Action
Project Manager

FN:Allen

Enclosure: As Stated

Recycled and Recyclable

cc w/enc:

K. A. Chaney, EM-424, TREV
D. R. Kozlowski, EM-424 TREV
G. Jablonowski, USEPA-V, AT-18J
J. Kwasniewski, OEPA-Columbus
P. Harris, OEPA-Dayton
M. Proffitt, OEPA-Dayton
T. Schneider, OEPA-Dayton
J. Michaels, PRC
L. August, GeoTrans
K. L. Alkema, FERMCO
P. F. Clay, FERMCO/19
F. Bell, ATSDR
AR Coordinator, FERMCO

cc w/o enc:

R. L. Glenn, Parsons
J. W. Thiesing, FERMCO/2

5528
4777

WORK PLAN

K-65 SILO 2 CLOSED CIRCUIT CAMERA INSTALLATION
AND BENTONITE INSPECTION

FEMP

OCTOBER, 1993

REVISION 1

Prepared by:

FERMCO

For:

The United States Department of Energy

Approved by: 10/4/93
For: W. S. Pickles - CRU4 Director

Concurred by: Randi B. Allen 10-4-93
R. B. Allen - Branch Chief - DOE-FN

000100

003

477 7

TABLE OF CONTENTS

		Page
I.	INTRODUCTION	3
II.	BACKGROUND	4
	1.0 Summary of the Potential Threat	4
	2.0 Related Action	5
	3.0 Roles of the Participants	5
	4.0 Maintenance Action	5
	5.0 Integration with the Remedial Action	5
III.	SUPPORT ACTIVITIES	6
	1.0 Planning Activities	6
	2.0 Specific Design Activities	6
	3.0 Training Requirements	6
IV.	FIELD ACTIONS	6
V.	ENVIRONMENTAL MONITORING PLAN	7
VI.	HEALTH AND SAFETY PLAN	7
VII.	QUALITY ASSURANCE	8
VIII.	SCHEDULE	8

I. INTRODUCTION

The Remedial Investigation/Feasibility Study (RI/FS) identifies Operable Unit 4 at the Fernald Environmental Management Project (FEMP) as the two K-65 silos (1 and 2), the metal oxide silo (3), empty silo (4), the potentially contaminated soils surrounding the waste storage silos, any perched water encountered during remediation, and other associated facilities. In April, 1990, a Removal Site Evaluation (RSE) was generated by the Department of Energy (DOE) consistent with 40 CFR 300.410 and it was determined by the DOE, as the lead agency at the FEMP, that a non-time critical removal action was necessary. The scope of this removal action was broadly defined as the reduction of chronic radon emissions and the control of potential releases of residues from Silos 1 and 2 in event of a dome collapse, whether spontaneous or induced.

In 1991 a layer of bentonite was placed on top of the K-65 residues in Silos 1 and 2 to retard the emanation of radon gas into the space between the residues and silo domes. The layer also protects the residue in the event of dome failure. Bentonite was chosen due to its ease of application and ability to seal cracks and discontinuities in the waste surface. In addition, the bentonite maintains moisture that retards radon flow into the headspace.

Radon concentrations have remained relatively steady in both silos thru April 1993. Average head space concentration at that time were 500,000 pCi/L for Silo 1 and 2,000,000 pCi/L for Silo 2. Since that time Silo 1 readings have remained relatively steady while Silo 2 is showing an upward trend to levels approaching 4,000,000 pCi/L.

This work plan is being prepared to cover the installation of remote controlled television cameras in Silo 2 to view the interior of the silo. The bentonite layer in particular will be evaluated in an effort to determine the cause for the recent upward trend in radon concentration.

DOE Orders require that a work plan be submitted to DOE-FN for review and comment prior to implementation. This work plan satisfies that commitment. All activities performed under this maintenance action will be in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and consistent with the OSWER Directive 9360.0-03B, Superfund Removal Procedures, Rev. 3. U.S. EPA and Ohio EPA will be notified of this maintenance action prior to initiation of field activities.

II. BACKGROUND

1.0 Summary of the Potential Threat

During the early 1950's, pitchblende (high grade uranium/radium ore) from the Belgian Congo, was processed to remove uranium by the Mallinckrodt Chemical Works at St. Louis, Lake Ontario Ordinance Works and later at the FEMP site. The residue from this processing contained significant amounts of radium, which, at that time, had significant economic value. This residue was considered valuable and as part of the purchase agreement, ownership of the residue was retained by the mining company, African Metals. Ownership was subsequently transferred to the DOE from African Metals in the early 1980's.

Silos 1 and 2 were constructed in 1951 and 1952 for the purpose of storing this residue, which was called K-65 material. These silos received residues during the years between 1952 and 1958. The silos contain approximately 300 tons of residue. The radioactive constituents of concern are uranium-238 and 234, radium-226 and thorium-230. The radium bearing residues emit radiation in the form of alpha, beta, and gamma rays, as well as emitting radon gas.

Most of the radon that is generated by the K-65 residues is contained within the silos. Radon in the head space will build up until an equilibrium concentration is reached. Radioactive decay of the radon (half-life is 3.84 days) and the head space ventilation rate (due to diffusion through intact concrete and leakage through cracks) affect this equilibrium.

Independent studies by Camargo (1986) and Bechtel (1990) have been conducted on the structural integrity of the silos. The studies concluded that the silos have lost over half of their design strength and that no life expectancy could be predicted for the silo domes.

The result of a silo dome failure would be an immediate release of radon gas from the head space of the silos to the environment. There is also the potential for the K-65 residues to become airborne under tornado loading conditions.

The layer of bentonite placed on top of the K-65 residues in 1991 retards emanation of radon gas into the space between the residues and silo domes. However, due to the continuing upward trend of headspace radon concentration in Silo 2, the integrity of the bentonite cap is in question. The bentonite cap is an effective method for

attenuating radon emissions from the K-65 material as evidenced by the Silo 1 performance. Speculation is that the bentonite cap in Silo 2 has dried, cracked, or sloughed from the mounds. However, this cannot be determined or confirmed until the cap can be viewed.

2.0 Related Action

There are various ongoing activities and projects being conducted in the K-65 Silos area. These include periodic pumping of the K-65 Decant Sump, nondestructive concrete testing of all four silos, and a radon adsorption test.

3.0 Roles of the Participants

The DOE, as the lead agency for this maintenance action will coordinate and execute this action. The United States Environmental Protection Agency (U.S. EPA) and the Ohio Environmental Protection Agency (Ohio EPA) roles have been one of providing guidance and participation in the preparation of the CERCLA 120 Consent Agreement and technical information exchanges.

Fernald Environmental Restoration Management Corporation (FERMCO), as the FEMP contractor, is responsible for implementing this maintenance action in a manner consistent with applicable DOE orders and regulatory guidance.

4.0 Maintenance Action

This maintenance action is to investigate the cause of the recent upward trend in Silo 2 headspace radon concentration. The preferred method is to install two closed circuit television (CCTV) cameras in the 20 inch manways to inspect the condition of the bentonite cover. These will be the same cameras that were used to monitor the bentonite installation in 1991. Videotapes during and after bentonite installation are available and a comparison to the current condition will be made. Cracks, gaps or shifting of the bentonite along with its overall condition may explain the increase in concentration levels.

5.0 Integration with the Remedial Action

This maintenance action will not affect remedial actions.

III. SUPPORT ACTIVITIES

1.0 Planning Activities

- Activities to be undertaken prior to the actual site work are planning, training, and preparing the detailed operating procedures and Health & Safety Plan. An Operational Readiness Review (ORR) or Readiness Assessment will be conducted prior to field activities.

2.0 Specific Design Activities

The CCTV will be installed in opposing manways (180°) to better facilitate investigation of the bentonite surface. Remote viewing of the entire Silo 2 surface will be possible. Glovebags will be utilized at manways during installation and operation of the CCTV. An operations trailer at the base of the Silos will be utilized for viewing and operation of the cameras. The equipment and system was successfully demonstrated during the 1991 removal action. No new design is required.

3.0 Training Requirements

All personnel involved with field activities will be trained in accordance with the Occupational Safety and Health Administration (OSHA) standards found in 29 CFR 1910.120. In addition to this training, all personnel involved will be trained on:
1) how to handle emergency situations in the K-65 Silos area according to the FEMP K-65 Silo Numbers 1 and 2 Area Emergency Standard Operating Procedure (SOP) 65-C-201 dated March 1, 1990, and 2) applicable procedures relevant to the activities to be performed.

IV. FIELD ACTIONS

Coordination of this maintenance action along with supplying equipment, maintenance, installation, operation, dismantling and removal of the equipment/system will be performed by FERMCO personnel. Commercially available equipment and/or systems will be utilized to the extent practical.

Installation/Operation of the CCTV

Operation of the CCTV system within the silo will proceed after testing/startup proves that the system operates satisfactorily.

Installation in Silo 2 will include:

a. Installing a glovebag over the southeast or northwest manway.
b. Removing the manway cover.
c. Installing the CCTV in the manway.
d. Repeat steps a thru c for the manway 180° from first camera location.
e. Install a glovebag over one of the two remaining perimeter manways.
f. Remove the manway cover.
g. Install the light system in the manway.
h. Repeat steps e thru g for the remaining perimeter manway.
i. Inspect the condition of the bentonite cover utilizing the two remote controlled CCTV's.
j. After completion of video monitoring, remove the CCTV's and lights, reinstall the manway cover on the silo, and remove the glovebag.
k. Review videotapes to qualitatively evaluate current condition of the bentonite surface.

V. ENVIRONMENTAL MONITORING PLAN

The K-65 residues generate radon on a constant basis. The resulting radon concentration has been monitored as a part of the FEMP Environmental Monitoring Program in support of this maintenance action and the remedial action for Operable Unit 4. Also, in support of this maintenance action, additional radon monitoring may be undertaken.

1. The atmosphere within Silo 2 will continue to be measured for pressure and temperature and then compared to the pressure and temperature of the surrounding ambient air.

2. Additional radon concentration monitoring at Silo 2 may be initiated as necessary by the Radiation Work Permit (RWP).

The above mentioned radon concentration monitors, temperature sensors and pressure sensors in Items 1 and 2 have the capability to monitor on a one hour time increment. This hourly data will be collected from the chart recorders on each of the instruments. FEMP personnel will be responsible for collecting the data associated with the above items, in addition to the data currently collected as a part of the FEMP Environmental Monitoring Program.

VI. HEALTH AND SAFETY PLAN

The work will be performed consistent with the Health and Safety Plan prepared for this maintenance action. The plan

identifies, evaluates, and addresses all safety and health hazards. In addition, it provides for emergency response for hazardous operations. The plan is consistent with 29 CFR 1910.120 and the FEMP Health Plan ESH-1-1000. The plan will be released prior to initiation of any work activity.

VII. QUALITY ASSURANCE

The silo monitoring action will be conducted in accordance with the requirements of FERMCO's Quality Assurance Program Description, RM-0012 and the SCQ, as applicable. Program elements applicable for this Project Specific Plan include the SCQ requirements for developing this Project Specific Plan, deviation reporting, document and record management and corrective action using site procedures. This plan requires no environmental sampling and analysis to be performed. The objective will be to provide a viewing of the interior of Silo 2 to examine the bentonite for potential cracking or openings, which may be the cause for the upward treand of radon concentration.

VIII. SCHEDULE

ACTIVITY	DATE SCHEDULED
Transmit Work Plan to DOE-FN	September 24, 1993
Transmit Work Plan, Rev. 1, to DOE-FN	October 4, 1993
DOE Approval of the Work Plan	October 6, 1993
Notification of the Regulatory Agency	October 18 1993
Install Cameras - Inspect Bentonite	November 16, 1993
Report and Recommendation	December 7, 1993
DOE Concurrence with Recommendation	December 14, 1993

APPENDIX G

FEMP ADMINISTRATIVE RECORD REFERENCES

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-101.1 2226		K-65 AREA WEEKLY REPORT MAY 23, 1991		05/23/91	DOE-FSO USEPA	23	REPORT	RA #4 FILE
R-008-101.2 1292		K-65 AREA WEEKLY REPORT MAY 30, 1991		05/31/91		4	REPORT	RA #4 FILE
R-008-101.3 1298		K-65 AREA WEEKLY REPORT JUNE 6, 1991		06/06/91		4	REPORT	RA #4 FILE
R-008-101.4 1369		K-65 AREA WEEKLY REPORT JUNE 14, 1991		06/14/91		4	REPORT	RA #4 FILE
R-008-101.5 1564		K-65 AREA WEEKLY REPORT JUNE 21, 1991		06/21/91		7	REPORT	RA #4 FILE
R-008-101.6 1620		K-65 WEEKLY REPORT JUNE 28, 1991		06/28/91		12	REPORT	RA #4 FILE
R-008-101.7 1867	DOE-1765-91	K-65 WEEKLY REPORT		07/05/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-101.8 1741		K-65 WEEKLY REPORT JULY 19, 1991		07/19/91		10	REPORT	RA #4 FILE
R-008-101.9 1906		K-65 WEEKLY REPORT JULY 26, 1991		07/26/91		4	REPORT	RA #4 FILE

000109

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-101.10 1896		K-65 WEEKLY REPORT AUGUST 2, 1991		08/02/91		4	REPORT	RA #4 FILE
R-008-101.11 2059		K-65 WEEKLY REPORT AUGUST 9, 1991		08/09/91		4	REPORT	RA #4 FILE
R-008-101.12 1931		K-65 WEEKLY REPORT AUGUST 16, 1991		08/16/91		3	REPORT	RA #4 FILE
R-008-101.13 1999		K-65 WEEKLY REPORT AUGUST 22, 1991		08/22/91	DOE-FSO EPA	4	REPORT	RA #4 FILE
R-008-101.14 2061		K-65 WEEKLY REPORT AUGUST 30, 1991		08/30/91		4	REPORT	RA #4 FILE
R-008-101.15 2236		K-65 WEEKLY REPORT SEPTEMBER 13, 1991		09/13/91	DOE-FSO EPA	4	REPORT	RA #4 FILE
R-008-101.16 2237		K-65 WEEKLY REPORT SEPTEMBER 20, 1991		09/20/91	DOE-FSO EPA	4	REPORT	RA #4 FILE
R-008-101.17 2209		K-65 WEEKLY REPORT SEPTEMBER 27, 1991		09/27/91	DOE-FSO USEPA	7	WKLY REPORT	RA #4 FILE
R-008-101.18 2238		K-65 WEEKLY REPORT OCTOBER 4, 1991		10/04/91	DOE-FSO EPA	4	REPORT	RA #4 FILE

000140

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-101.19 2239		K-65 WEEKLY REPORT OCTOBER 11, 1991		10/11/91	DOE-FSO EPA	4	REPORT	RA #4 FILE
R-008-101.20 2314		K-65 WEEKLY REPORT OCTOBER 18, 1991		10/18/91	DOE-FSO EPA	6	REPORT	RA #4 FILE
R-008-101.21 2359		K-65 WEEKLY REPORT OCTOBER 25, 1991		10/25/91	DOE-FO EPA	4	REPORT	RA #4 FILE
R-008-101.22 2372		K-65 WEEKLY REPORT NOVEMBER 1, 1991		11/01/91	DOE-FO EPA	4	REPORT	RA #4 FILE
R-008-101.23 2402		K-65 WEEKLY REPORT NOVEMBER 8, 1991		11/08/91	DOE-FO EPA	4	REPORT	RA #4 FILE
R-008-101.24 2509		K-65 WEEKLY REPORT NOVEMBER 15, 1991		11/15/91		4	ENCLOSURE	RA #4 FILE
R-008-101.25 2516		K-65 WEEKLY REPORT NOVEMBER 22, 1991		11/22/91		4	ENCLOSURE	RA #4 FILE
R-008-101.26 2521		K-65 WEEKLY REPORT NOVEMBER 29, 1991		11/29/91		4	ENCLOSURE	RA #4 FILE
R-008-101.27 2705	DOE-750-92	THE ORIGIN OF K-65 MATERIAL		01/27/92	DOE-FO BLEECKER PUBLISHING	3	LETTER	RA #4 FILE

000111

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-105.1 695		CALCULATION OF RADON EMISSION, DISPERSION AND DOSIMETRY FROM K-65 STORAGE TANKS AT THE FEED MATERIALS PRODUCTION CENTER		10/01/85	COLORADO ST UNV WMCO	014	LETTER	RA #4 FILE
R-008-105.2 786		K-65 SILOS STUDY & EVALUATION REPORT		02/25/86	CAMARGO		REPORT	RA #4 FILE
R-008-105.3 3666		K-65 SILOS STUDY & EVALUATION CAMARGO REPORT APPENDIX A & B FEBRUARY 1986		02/01/86	DOE-FN WEMCO	500	REPORT	RA #4 FILE
R-008-105.4 3667		K-65 SILOS STUDY & EVALUATION CAMARGO REPORT APPENDIX C, D & E FEBRUARY 1986		02/01/86	DOE-FN WEMCO	500	REPORT	RA #4 FILE
R-008-105.5 3703		K-65 SILOS STUDY & EVALUATION CAMARGO REPORT APPENDIX F 1 OF 2 FEBRUARY 1986		02/01/92	DOE-FN WEMCO	500	REPORT	RA #4 FILE
R-008-105.6 3704		K-65 SILOS STUDY & EVALUATION CAMARGO REPORT APPENDIX F 2 OF 2 FEBRUARY 1986		02/01/86	DOE-FN WEMCO	500	REPORT	RA #4 FILE
R-008-105.7 167	DE-AC05-81OR20722	STUDY AND EVALUATION OF K-65 SILOS FOR THE FEED MATERIALS PRODUCTION FACILITY AT FERNALD, OHIO	0	01/01/90	BNI DOE-FMPC	50	REPORT	RA #4 FILE
R-008-105.8 168	DE-AC05-81OR20722	APPENDICES A THROUGH H: STUDY AND EVALUATION OF K-65 SILOS FOR THE FEED MATERIALS PRODUCTION CENTER AT FERNALD, OHIO	0	01/01/90	BNI DOE-FMPC	90	REPORT	RA #4 FILE
R-008-105.9 169	DE-AC05-81OR20722	APPENDIX I: STUDY AND EVALUATION OF K-65 SILOS FOR THE FEED MATERIALS PRODUCTION CENTER AT FERNALD, OHIO	0	01/01/90	BNI DOE-FMPC	482	REPORT	RA #4 FILE

000112

5529

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-105.10 1432		REVIEW OF THE K-65 SILO STUDIES FOR THE FEED MATERIALS PRODUCTION CENTER AT FERNALD OHIO APRIL 1, 1991		04/01/91		20	REPORT	RA #4 FILE
R-008-105.11 555	FMPC/SUB-02A UC-702	A PROBABILISTIC RISK ASSESSMENT FOR THE K-65 SILOS AT THE FMPC	1	10/01/90	UC DOE-FMPC	250	REPORT	RA #4 FILE
R-008-105.12 2007		A PROBABLISTIC RISK ASSESSMENT FOR THE K-65 SILOS AT THE FMPC NOVEMBER 1990		11/01/90		100	REPORT	RA #4 FILE
R-008-106.1 2703	DOE-745-92	NO TITLE SILOS 1 AND 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN		01/27/92	DOE-FO EPA	2	LETTER	RA #4 FILE
R-008-106.2 3030	DOE-1015-92	REVISED SILO 1 AND 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN		03/17/92	DOE-FO EPA	2	LETTER	RA #4 FILE
R-008-106.3 3184	DOE-1382-92	SILOS 1 & 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN		04/16/92	DOE-FN EPA	2	LETTER	RA #4 FILE
R-008-106.4 3290	DOE-1742-92	BENTONITE EFFECTIVENESS MODEL RESULT FOR JANUARY THROUGH APRIL, 1992		05/22/92	DOE-FN EPA	2	LETTER	RA #4 FILE
R-008-106.5 3512	DOE-2022-92	BENTONITE EFFECTIVENESS MODEL RESULT FOR MAY 1992		06/30/92	DOE-FN EPA	3	LETTER	RA #4 FILE
R-008-108.1 4479	NEPA DOC. 278	EVALUATION OF STRUCTURAL STABILITY OF THE K-65 SILOS AT FERNALD NEPA DOC. NO. 278		10/30/89	DOE-FN DOE-HQ	2	CAT EX	RA #4 FILE

000113

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-201.1 3047	DOE-1060-90	REMOVAL SITE EVALUATION - K-65 SILOS		05/21/90	DOE-FO WMCO	1	LETTER	RA #4 FILE
R-008-201.2 1683	DOE-159-91	SILOS 1 & 2 REMOVAL ACTION - REMOVAL ACTION MEMORANDUM		10/29/90	DOE-FSO WMCO	2	LETTER	RA #4 FILE
R-008-202.1 294		REMOVAL SITE EVALUATION K-65 SILOS		05/21/90	DOE-FMPC WMCO	5	REPORT	RA #4 FILE
R-008-203.1 444		A BASELINE RISK ASSESSMENT FOR THE K-65 SILOS USING EPA METHODOLOGY FOR APPLICABILITY TO THE EE/CA MAY 11, 1990	1	05/11/90	UC DOE-FMPC	132	REPORT	RA #4 FILE
R-008-203.2 1244	DOE-1537-90	TRANSMITTAL OF THE K-65 SILOS EE/CA - CONSENT AGREEMENT DELIVERABLE		07/31/90	DOE-FMPC USEPA & OEPA	2	LETTER	RA #4 FILE
R-008-203.3 443		ENGINEERING EVALUATION/COST ANALYSIS (EE/CA) K-65 SILOS REMOVAL ACTION AT THE FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO JULY 1990	2	07/31/90	BNI DOE	135	REPORT	RA #4 FILE
R-008-203.4 3270		ENGINEERING EVALUATION/COST ANALYSIS - ENVIRONMENTAL ASSESSMENT FOR THE K-65 SILOS REMOVAL ACTION, FERNALD ENVIRONMENTAL MANAGEMENT PROJECT, FERNALD, OHIO		11/14/91	DOE DUFFY	2	LETTER	RA #4 FILE
R-008-203.5 3271		FINDING OF NO SIGNIFICANT IMPACT ENGINEERING EVALUATION/COST ANALYSIS - ENVIRONMENTAL ASSESSEMENT K-65 SILOS REMOVAL ACTION FERNALD ENVIRONMENTAL		11/14/91	DOE	9	REPORT	RA #4 FILE
R-008-204.1 266	DOE-566-90	REVISED K-65 WORK PLAN		03/13/90	DOE-ORO DOE-FMPC	9	WORK PLAN	RA #4 FILE

600114

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-204.2 2026	DOE-118-91	REVISED PLAN FOR THE TREATABILITY SCREENING ACTIVITIES FOR OPERABLE UNIT 4		10/22/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE
R-008-204.3 2027		TREATABILITY WORK PLAN (LABORATORY SCREENING) FOR SILOS 1 AND 2 SEPTEMBER 1990		09/01/90		66	REPORT	RA #4 FILE
R-008-204.4 2336	DOE-213-91	K-65 SILOS REMOVAL ACTION WORK PLAN		11/02/90	DOE-FMPC EPA	2	LETTER	RA #4 FILE
R-008-204.5 1875		SILOS 1 AND 2 (K-65 SILOS) REMOVAL ACTION WORK PLAN NOVEMBER 1990		11/01/90		25	REPORT	RA #4 FILE
R-008-204.6 1433		SITE SPECIFIC SAFETY PLAN FOR THE K-65 VERTICAL BORING OPERATIONS		03/01/91		25	REPORT	RA #4 FILE
R-008-204.7 1561	DOE-1512-91	REMOTE SURFACE MAPPING TECHNOLOGY SUPPORT DEMONSTRATION ON FERNALD SILO 4		06/21/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-204.8 1562		FERNALD SILO #4 REMOTE SURFACE MAPPING TECHNOLOGY SUPPORT DEMONSTRATION WORK PLAN MAY 1991		05/01/91		30	ENCLOSURE	RA #4 FILE
R-008-204.9 4009	DOE-0650-93	BENTONITE EFFECTIVENESS EVALUATION FOR OPERABLE UNIT 4 AT THE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT		12/17/92	DOE-FN EPA	2	LETTER	RA #4 FILE
R-008-204.10 4010		K-65 SILO REMOVAL ACTION - BENTONITE EFFECTIVENESS EVALUATION DECEMBER 17, 1992		12/17/92	DOE-FN EPA	200	EVALUATION	RA #4 FILE

000115

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-204.11 4777	DOE-0021-94	OPERABLE UNIT 4 SILO 2 CAMERA INSTALLATION/BENTONITE INSPECTION WORK PLAN		10/05/93	DOE-FN EPA	10	WORK PLAN	RA #4 FILE
R-008-205.1 270	DOE-745-90	TASK 9.33, K-65 SILO SAMPLING		05/08/90	DOE-FMPC ASI	1	LETTER	RA #4 FILE
R-008-205.2 829		SITE SPECIFIC HAZARD ASSESSMENT FOR BORINGS 2028 AND 2033 LOCATED IN THE K-65 CONTROL AREA MARCH 27, 1990		03/27/90	ASI DOE-FMPC	40	REPORT	RA #4 FILE
R-008-205.3 276	90L02298.HLW	K-65 SILO RE-SAMPLING OPERATING PROCEDURES		03/29/90	ASI DOE-FMPC	52	PROCEDURE	RA #4 FILE
R-008-205.4 1776	WMCO:EC:90-0204	PERMIT TO INSTALL/PERMIT TO OPERATE DETERMINATION ON GLOVE BOX		06/14/90	WMCO DOE-FMPC	2	LETTER	RA #4 FILE
R-008-205.5 1777	DOE-1372-90	PERMIT REQUIREMENTS FOR GLOVE BOX USE IN TREATABILITY TESTING FOR K-65 SILO RESIDUES		07/06/90	DOE-FMPC WMCO	2	LETTER	RA #4 FILE
R-008-205.6 1276	DOE-1758-90	K-65 SAMPLING PROJECT		08/24/90	DOE-FMPC ASI	1	LETTER	RA #4 FILE
R-008-205.7 1831	DOE-277-91	K-65 SILOS SAMPLING AND ANALYSIS		11/15/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE
R-008-205.8 1995	DOE-285-91	REVISED K-65 SILO SUBSOILS SAMPLING AND ANALYSIS PLAN		11/16/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE

000116
55298

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-205.9 1996		RI/FS WORK PLAN ADDENDUM: K-65 SILO SUBSOILS SAMPLING AND ANALYSIS PLAN NOVEMBER 13, 1990		11/13/90		14	REPORT	RA #4 FILE
R-008-205.10 1006	WMCO:EMT:90-869	APPROVAL FOR RUST FORCE ACCOUNT TO COMPLETE THE SILOS 1 AND 2 REMOVAL ACTION		12/18/90	WMCO DOE-FMPC	3	LETTER	RA #4 FILE
R-008-205.11 2430		RI/FS WORK PLAN ADDENDUM: K-65 SILO BERM VERTICAL BORING SAMPLING AND ANALYSIS PLAN WITH SITE SPECIFIC HEALTH AND SAFETY PLAN DECEMBER 1990		12/01/90	DOE-FO EPA	50	ADDENDUM	RA #4 FILE
R-008-205.12 1374	DOE-1511-91	ADDITIONAL REVISIONS TO THE K-65 RESIDUE SAMPLING AND ANALYSIS PLAN		06/13/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-205.13 1300		RESIDUE SAMPLING FOR K-65 SILOS SAMPLING AND ANALYSIS PLAN U.S. DEPARTMENT OF ENERGY FEED MATERIALS PRODUCTION CENTER FERNALD, OHIO MAY 28, 1991		05/28/91		200	REPORT	RA #4 FILE
R-008-205.14 1865	DOE-1802-91	REVISIONS TO K-65 SILO SUBSOILS SAMPLING AND ANALYSIS PLAN		07/10/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-205.15 1866		RI/FS WORK PLAN ADDENDUM K-65 SILO SUBSOILS AND PERCHED GROUNDWATER SAMPLING AND ANALYSIS PLAN JUNE 27, 1991		06/27/91		30	ENCLOSURE	RA #4 FILE
R-008-205.16 1744	DOE-1882-91	REVISED SAMPLING AND ANALYSIS PLAN FOR THE K-65 SILOS RESIDUE SAMPLING PROJECT		07/25/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-205.17 1745		RESIDUE SAMPLING FOR K-65 SILOS SAMPLING AND ANALYSIS PLAN JULY 15, 1991		07/15/91		400	ENCLOSURE	RA #4 FILE

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-205.18 3015	WEMCO:ER:92-158	TIGER TEAM COMMITMENT NO. TT:89:0243 (TTA#611) - INTERIM STABILIZATION (FFCA) AND COMPLETE CHARACTERIZATION REQUIRED (K-65 SILOS)		03/17/92	WEMCO DOE-FO	2	LETTER	RA #4 FILE
R-008-205.19 3016	WEMCO:ER:92-161	K-65 SILOS DATA VALIDATION AND CHARACTERIZATION		03/17/92	WEMCO DOE-FO	2	LETTER	RA #4 FILE
R-008-205.20 4452	DCR 65A	K-65 SILO BERM VERTICAL BORING SAMPLING AND ANALYSIS PLAN RI/FS WORK PLAN ADDEDNDUM MARCH 1991		03/01/91		7	DCR 65A	RA #4 FILE
R-008-206.1 344		TRANSMITTAL OF ANALYTICAL DATA		05/18/90	ASI DOE-FMPC	250	DATA	RA #4 FILE
R-008-206.2 246	303317.24.05.20	CERTIFICATE OF ANALYSIS - PROJECT NUMBER 482331 JOB NUMBER 303317.24.05.20 - SILO MATERIAL		03/22/90	IT WMCO	33	CERTIFICATE	RA #4 FILE
R-008-206.3 2830		CHARACTERISTICS OF FERNALD'S K-65 RESIDUE BEFORE, DURING AND AFTER VITRIFICATION FEBRUARY 1991		02/01/91		60	REPORT	RA #4 FILE
R-008-206.4 3101	WEMCO:ER:92-191	CHARACTERIZATION OF K-65 SILO CONTENTS		03/31/92	WEMCO DOE-FN	2	LETTER	RA #4 FILE
R-008-206.5 3601	DOE-2349-92	RESULTS OF GRAB SAMPLES AND CONTINUOUS PYLON MONITORS FOR SILOS 1 AND 2		08/07/92	DOE-FN EPA	2	LETTER	RA #4 FILE
R-008-206.6 4749	C:OP:93-1284	K-65 SILOS - HEADSPACE RADON CONCENTRATION		09/09/93	FERMCO DOE-FN	4	LETTER	RA #4 FILE

000118

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-207.1 3329		NO TITLE COMMENTS ON K-65 INTERIM STABILIZATION PROJECT		10/09/87	OEPA DOE-FMPC	2	LETTER	RA #4 FILE
R-008-207.2 3440		NO TITLE USEPA REVIEW OF K-65 SILOS INTERIM STABILIZATION PROJECT		10/19/87	USEPA DOE-FN	3	LETTER	RA #4 FILE
R-008-207.3 469	5HR-12	SILO SAMPLING U.S. DOE FERNALD OH6 890 008 976		05/25/89	OEPA DOE-FMPC	1	LETTER	RA #4 FILE
R-008-207.4 1049		SILO SAMPLING U.S. DOE - FERNALD OH6 890 008 976		05/25/89	OEPA DOE-FMPC	1	LETTER	RA #4 FILE
R-008-207.5 1755		K-65 SAMPLING		07/26/90	OEPA DOE-FMPC	1	LETTER	RA #4 FILE
R-008-207.6 1277		K-65 SAMPLING OU#4 U.S. DOE - FERNALD OH6 890 008 976		08/15/90	USEPA DOE-FMPC	8	LETTER	RA #4 FILE
R-008-207.7 2456		OU#4-REMOVAL #4 K-65 BORINGS U.S. DOE FERNALD OHD 890 008 976		08/27/90	USEPA DOE-FSO	3	LETTER	RA #4 FILE
R-008-207.8 547		EE/CA K-65 REMOVAL #4 U.S. DOE FERNALD OH6 890 008 976		09/04/90	USEPA DOE-FMPC	3	LETTER	RA #4 FILE
R-008-207.9 1711		K-65 EE/CA		09/05/90	OEPA DOE-FMPC	2	LETTER	RA #4 FILE

000119

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-207.10 2450		NO TITLE OEPA MAKES THE FOLLOWING STIPULATION REGARDING THE INSTALLATION AND OPERATION OF THE GLOVE BOX		09/27/90	OEPA DOE-FSO	2	LETTER	RA #4 FILE
R-008-207.11 1879		EE/CA K-65 REMOVAL #4 U.S. DOE FERNALD OH6 890 008 976		10/18/90	USEPA DOE-FMPC	2	LETTER	RA #4 FILE
R-008-207.12 919		REMOVAL #4 WORK PLAN U.S. DOE FERNALD OH6 890 008 976		11/30/90	USEPA DOE-FMPC	2	LETTER	RA #4 FILE
R-008-207.13 1794		CONDITIONAL APPROVAL OF K-65 REMOVAL WORK PLAN		12/05/90	OEPA DOE-FMPC	1	LETTER	RA #4 FILE
R-008-207.14 2460		OU#4 EXTERNAL SAMPLING U.S. DOE FERNALD OH6 890 008 976		12/13/90	USEPA DOE-FSO	2	LETTER	RA #4 FILE
R-008-207.15 3345		FURTHER CLARIFICATION RELATIVE TO DISPOSAL OF THE K-65 RESIDUES AT THE FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO		01/10/91	USEPA USEPA		MEMORANDUM	RA #4 FILE
R-008-207.16 2804		NO TITLE BACKGROUND INFORMATION ON HOW TARGET RADON CONCENTRATION WAS DERIVED		01/29/92	USEPA DOE-FO	2	LETTER	RA #4 FILE
R-008-207.17 1816		CONDITIONAL APPROVAL K-65 SILO VERTICAL BORING SAMPLING PLAN		02/07/91	OEPA DOE-FMPC	2	LETTER	RA #4 FILE
R-008-207.18 1743		OU #4: K-65 SILO RESIDUE SAMPLING AND ANALYSIS PLAN		07/01/91	USEPA DOE-FMPC	3	LETTER	RA #4 FILE

000120
5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-207.19 2453		APPROVAL - REMOTE SURFACE SURFACE MAPPING TECHNOLOGY SUPPORT DEMONSTRATION ON FERNALD SILO 4 WORK PLAN		07/25/91	OEPA DOE-FSO	1	LETTER	RA #4 FILE
R-008-207.20 2121		APPROVAL OF K-65 SILO CONTENT SAMPLING PLAN	0	09/10/91	USEPA DOE-FSO	2	LETTER	RA #4 FILE
R-008-207.21 2903		DISAPPROVAL OF THE SILO 1 AND 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN		02/19/92	USEPA DOE-FO	1	LETTER	RA #4 FILE
R-008-207.22 3168		APPROVAL OF THE REVISED SILO 1 AND 2 REMOVAL ACTION BENTONITE EFFECTIVENESS ENVIRONMENTAL MONITORING PLAN		04/21/92	USEPA DOE-FN	1	LETTER	RA #4 FILE
R-008-207.23 4129		DISAPPROVAL OF THE BENTONITE EFFECTIVENESS EVALUATION FOR OU 4		02/12/93	USEPA DOE-FN	25	LETTER	RA #4 FILE
R-008-208.1 3358	DOE-873-89	NOTIFICATION OF SAMPLING OF K-65 SILOS AT THE U.S. DOE FEED MATERIALS PRODUCTION CENTER		04/06/89	DOE-FN SOAPCA	2	LETTER	RA #4 FILE
R-008-208.2 1997		COMMENT RESPONSE TO U.S. EPA COMMENTS ON: THE RI/FS WORK PLAN ADDENDUM: K-65 SILO EMBANKMENT AND SUBSOILS SAMPLING AND ANALYSIS PLAN JULY 1990		07/01/90		8	REPORT	RA #4 FILE
R-008-208.3 1275	DOE-1711-90	K-65 SAMPLING PROCEDURES		08/10/90	DOE-FMPC USEPA	2	LETTER	RA #4 FILE
R-008-208.4 1805	DOE-1722-90	INFORMATION SUBMITTAL UNDER PARAGRAPH XIII (B) OF THE 1990 CERCLA CONSENT AGREEMENT - GLOVE BOX TREATABILITY TESTING		08/14/90	DOE-FSO EPA	4	LETTER	RA #4 FILE

000121

35528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

ndex Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
ı-008-208.5 557	072131	K-65 SILOS REMOVAL ACTION ENGINEERING EVALUATION/COST ANALYSIS RESPONSIVENESS SUMMARY		10/17/90	BECHTEL DOE-FMPC	14	REPORT	RA #4 FILE
ı-008-208.6 2028		FMPC RI/FS REPORT OPERABLE UNIT 4 LABORATORY SCREENING WORK PLAN		09/01/90		11	COMMENTS	RA #4 FILE
ı-008-208.7 1680	DOE-1904-90	EXTENSION OF PUBLIC COMMENT PERIOD FOR THE K-65 EE/CA		09/11/90	DOE-FSO EPA	2	LETTER	RA #4 FILE
ı-008-208.8 1921	DOE-1937-90	K-65 RESIDUE SAMPLING - RESPONSE TO U.S. EPA COMMENTS ON SAMPLING PROCEDURES		09/19/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE
ı-008-208.9 1732	DOE-1870-90	K-65 SILOS REMOVAL ACTION		09/27/90	DOE-FSO EPA	2	LETTER	RA #4 FILE
ı-008-208.10 2426		FMPC RI/FS PROJECT K-65 SILOS SAMPLING AND ANALYSIS PLAN RESPONSE TO OEPA COMMENTS		10/02/90	DOE-FO OEPA	2	ENCLOSURE	RA #4 FILE
R-008-208.11 1908	DOE-19-91	K-65 SILOS REMOVAL ACTION - INFORMAL DISPUTE RESOLUTION		10/04/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE
R-008-208.12 1933	DOE-35-91	K-65 REMOVAL ACTION - STATEMENT OF DISPUTE		10/11/90	DOE-FSO USEPA	3	LETTER	RA #4 FILE
R-008-208.13 1842	DOE-60-91	K-65 SAMPLING		10/11/90	DOE-FSO USEPA	2	LETTER	RA #4 FILE

000122

5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-208.14 1932	DOE-131-91	K-65 REMOVAL ACTION		10/22/90	DOE-FSO USEPA	3	LETTER	RA #4 FILE
R-008-208.15 2428	DOE-23-91	RESPONSE TO OEPA STIPULATIONS FOR INSTALLATION AND OPERATION OF THE GLOVE BOX FOR TREATABILITY TESTING		11/06/91	DOE-FO OEPA	2	LETTER	RA #4 FILE
R-008-208.16 911	DOE-413-91	INFORMATION SUBMITTAL UNDER PARAGRAPH XIII (B) OF THE 1990 CERCLA CONSENT AGREEMENT - ORGANIC EXTRACTION - K-65 SILO RESIDUE SAMPLE ANALYSES		12/11/90	DOE-FMPC EPA	3	LETTER	RA #4 FILE
R-008-208.17 1910		RESPONSE TO U.S. EPA COMMENTS		/ /		4	REPORT	RA #4 FILE
R-008-208.18 1911		RESPONSE TO OHIO EPA COMMENTS		/ /		12	REPORT	RA #4 FILE
R-008-208.19 1836	DOE-579-91	K-65 SILOS BERM SAMPLING WORK PLAN		01/14/91	DOE-FSO USEPA	1	LETTER	RA #4 FILE
R-008-208.20 1157		RESPONSES TO OEPA COMMENTS ON THE K-65 SILO BERM VERTICAL BORING SAMPLING PLAN		01/01/91		2	RESPONSE	RA #4 FILE
R-008-208.21 2182	DOE-1023-91	K-65 SILOS WORKING GROUP STATUS REPORT		03/28/91	DOE-FSO K-65 SR. COMMITTEE	1	LETTER	RA #4 FILE
R-008-208.22 2979	DOE-1186-91	MAJOR POINTS AND ISSUES RESULTING FROM THE APRIL 10, 1991 MEETING		04/22/91	DOE-FO EPA	7	LETTER	RA #4 FILE

000123
5528

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-208.23 1502	DOE-1344-91	K-65 REMOVAL ACTION ADVISORY COMMITTEE		05/15/91	DOE-FSO USEPA	2	LETTER	RA #4 FILE
R-008-208.24 1287	DOE-1359-91	MAJOR POINTS OF DISCUSSION		05/17/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-208.25 1366	DOE-1508-91	K-65 TABLETOP EXERCISE		06/11/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-208.26 1874	DOE-1803-91	K-65 CONTENTS RESAMPLING		07/10/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-208.27 1871	DOE-1886-91	K-65 SLANT BORING #2		07/24/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-208.28 2069	DOE-2195-91	COMPLETION OF OPERABLE UNIT 4 SAMPLING ACTIVITIES		09/10/91	DOE-FSO EPA	2	LETTER	RA #4 FILE
R-008-208.29 2515	DOE-382-92	NO TITLE DELAY OF THE INITIATION OF THE INSTALLATION OF THE BENTONITE IN SILOS 1 AND 2		11/20/91	DOE-FO EPA	2	LETTER	RA #4 FILE
R-008-208.30 3344		NO TITLE REQUESTING A MEETING CONCERNING THE APPLICATION OF EPA STANDARDS FOR THE MANAGEMENT AND DISPOSAL OF HIGH-LEVEL		03/23/92	DOE-WASHINGTON, D.C3 USEPA		LETTER	RA #4 FILE
R-008-208.31 3343	DOE-1944-92	OPERABLE UNIT (OU) ARARs		06/18/92	DOE-FN USEPA	2	LETTER	RA #4 FILE

000124

000128

FEMP ADMINISTRATIVE RECORD
REMOVAL ACTION #4 -- K-65 SILOS 1 AND 2

Index Number	Document Number	Document Title	Rev. #	Document Date	From To	# of Pages	Type of Document	Location Number
R-008-209.1 4374	DOE-871-88	COMPLETION REPORT FOR THE EXTERIOR FOAM APPLICATION/ RADON TREATMENT SYSTEM OPERATION OF THE K-65 INTERIM STABILIZATION PROJECT - FEED MATERIALS PRODUCTION		05/23/88	DOE USEPA	50	REPORT	RA #4 FILE
R-008-1003.1 447		THE USDOE ANNOUNCES THE AVAILABILITY FOR PUBLIC REVIEW OF THE ENGINEERING EVALUATION/COST ANALYSIS FOR THE K-65 SILOS (SILOS 1 AND 2) REMOVAL ACTION AT THE DOE's		08/01/90	DOE-FMPC PUBLIC	2	NOTICE	RA #4 FILE
R-008-1003.2 305		THE USDOE ANNOUNCES THE AVAILABILITY OF THE ADMINISTRATIVE RECORD FILE FOR THE K-65 SILOS (SILOS 1 & 2) REMOVAL ACTION AT THE DOE'S FMPC AT FERNALD, OH		05/07/90	WMCO PUBLIC	1	NOTICE	RA #4 FILE
R-008-1004.1 4068		K-65 SILOS REMOVAL ACTION COMMUNITY WORKSHOP AND SITE SPECIFIC PLAN PRESENTATION AUGUST 16, 1990		08/16/90	DOE-FN	150	REPORT	RA #4 FILE

000125

5298

5528

APPENDIX H - DRAFT ARARs

APPENDIX H
TABLE OF CONTENTS

Attachment 1 Potential Contaminant-Specific ARARs and TBCs
Attachment 2 Potential Location-Specific ARARs and TBCs
Attachment 3 Potential Action-Specific ARARs and TBCs

ATTACHMENT 1

POTENTIAL CONTAMINANT-SPECIFIC ARARs and TBCs

1. Resource Conservation and Recovery Act (RCRA), Subtitle C, Standards for Hazardous Waste Management (40 CFR, Parts 260-279).

   Establishes criteria and standards for identification, management, and permitting of hazardous waste and hazardous waste treatment, storage, and disposal facilities. Part 268 contains treatment standards for wastes restricted from land disposal. These standards are not applicable to the K-65 residues, because the residues are not hazardous wastes.

2. Safe Drinking Water Act (40 CFR Parts 141-149)
   (a) Maximum Concentration Levels (MCLs)
   (b) Maximum Concentration Level Goals (MCLGs)

   Establishes MCLs, which are enforceable standards for chemicals in public drinking water supply streams. MCLGs are nonenforceable guidelines that do not consider the technical feasibility of contaminant removal. The SWDA also authorizes: The Underground Injection Control (UIC) Program; The Sole-Source Aquifer Program; The Wellhead Protection Program.

   Remedial actions under CERCLA and RCRA generally use MCLs as groundwater quality restoration goals. MCLGs are considered in

CERCLA remedial action planning, pursuant to CERCLA Section 121(d)(2)(a)(ii).

3. Clean Water Act (CWA) (40 CFR Parts 104 -140) and Federal Ambient Water Quality Criteria (AWQC) (45 CFR Part 231).

CWA governs point-source discharges through the National Pollutant Discharge Elimination System (NPDES), dredge and fill activities that may degrade or disturb wetlands or other aquatic habitats, discharges of dredged or fill materials, and oil and hazardous spills into United States waters. The AWQC are used as guidelines in accessing the impact of contaminants on water quality in remedial action analyses.

4. Environmental Radiation Standards for Nuclear Power Operations (40 CFR 190) (EPA).

Establishes standards for the radiation doses received by members of the public in the general environment, and to radioactive materials introduced into the environment as the result of operations that are part of a nuclear fuel cycle. Milling and chemical conversion of uranium ore are defined as parts of the uranium fuel cycle.

Requires that the annual dose equivalent not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public, as a result of exposures to

planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations.

Limits the total quantity of radioactive materials entering the general environment from the entire uranium fuel cycle, per gigawatt-year of electrical energy produced, to 50,000 Ci of ^{85}Kr, 5 mCi of ^{129}I, and 0.5 mCi combined of ^{239}Pu and other alpha-emitting transuranic radionuclides with half-lives greater than 1 year.

These standards are targeted at nuclear power facilities and spent fuel reprocessing operations, and are not applicable to mining operations and waste disposal sites. The terms "general public" and "general environment" refer to locations outside the facility. They are, however, relevant or appropriate, to the extent that the K-65 residues are derived from the milling of uranium ore and the chemical conversion of uranium. The standards for annual dose equivalent (e.g., 25 mrem) can serve as guidelines for protection of off-site populations during and after the removal action.

5. Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings (40 CFR 192) (EPA).

Applies to the control of residual radioactive material at designated processing or repository sites under Section 108 of the Uranium Mill Tailings Radiation Control Act of 1978, and to restoration of such sites following any use of subsurface minerals under Section 104 (h).

The standards have subparts applicable to:

A. Control of Residual Radioactive Materials from Inactive Uranium Processing Sites

B. Cleanup of Land and Buildings Contaminated with Residual Radioactive Materials from Inactive Uranium Processing Sites

C. Implementation provisions

D. Management of Uranium Byproduct Materials Pursuant to Section 84 of the Atomic Energy Act of 1954, as amended

E. Management of Thorium Byproduct Material pursuant to Section 84 of the Atomic Energy Act of 1954, as amended

Of these subparts, D and E appear to be relevant or appropriate to the K-65 silos. Subparts A and B are not applicable, because the FMPC is an active site.

Subpart D largely places controls on the groundwater discharges, as well as delineate liner requirements for surface impoundments. Standards applicable after closure are established:

- Closure design should meet 40 CFR 264.111, except for radon emission

- The design should provide reasonable assurance of effectiveness for 1000 years (to extent reasonably achievable), and 200 years in any case

- Limit releases of ^{222}Rn to the atmosphere to less than an average release rate of 20 pCi/m^2-sec.

Subpart E applies the same standards promulgated for uranium tailings. It requires that standards for ^{222}Rn and ^{226}Ra also apply to ^{220}Rn and ^{228}Ra, respectively. It additionally requires that the annual dose equivalent to members of the public arising from the planned discharge of radioactive materials, ^{222}Rn and its daughters excepted, not exceed 25 mrem/y (whole body), 75 mrem/y (thyroid), and 25 mrem/y (any other organ).

6. Clean Air Act (CAA) (42 USC 4701)

National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61)

There are two key subparts applicable to facilities owned or operated by DOE:

(1) Subpart H - National Emission Standards for Emissions of Radionuclides other than radon from Department of Energy Facilities.

This requires that emissions of radionuclides other than ^{222}Rn and ^{220}Rn not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/y.

The standard does not apply to disposal at facilities subject to 40 CFR 191, Subpart B, or to 40 CFR 192 (Uranium and Thorium Mill Tailings).

(2) Subpart Q - National Emission Standards for Radon Emissions from Department of Energy Facilities.

These standards are applicable to the design and operation of all storage and disposal facilities for radium - containing material [i.e., byproduct material under the Atomic Energy Act, as amended, Section 11 e (2)]; the Feed Materials Production Center, Fernald, Ohio is one of the DOE facilities explicitly

cited in the regulation. The standard requires that no source at a DOE facility emit more than 20 pCi/m^2-s of ^{222}Rn as an average for the entire source, into the air. It also specifies that this requirement will be part of any Federal Facility Compliance Agreement reached between DOE and EPA.

Designated facilities are exempt from the reporting requirements specified in 40 CFR 61.10.

7. Ohio General Radiation Protection Standards (OAC 3701-38-01 through -39)

These standards establish registration, performance, monitoring, reporting, and disposal requirements to users of radiation sources that are not subject to regulation by the AEC. By current usage, reference to the AEC is taken to mean the Nuclear Regulatory Commission. As a general matter, however, the Atomic Energy Act, as amended, precludes regulation of wastes subject to the Act by state or local law or regulation.

The standards are basically intended to control sources of radiation used for medical or scientific purposes. It establishes performance standards for a number of radioactive materials for worker exposure within restricted areas, and for general public exposure in unrestricted areas. The standard for ^{222}Rn for worker exposure is 1 x 10^{-7} uCi/mL (air) for a 40-

hour period over a 7-day week; the standard for the public is 3×10^{-9} uCi/mL.

While these standards are not applicable to the K-65 silo removal section, they may be relevant or appropriate.

8. Ohio Standards for Radiation Handling, General Provisions (OAC 3701-70-01 through -06)

These standards establish record keeping and inspection requirements for users of radiation-generating equipment. They are explicitly not applicable to the Federal government or any of its agencies. The standards are designed to ensure that radiation-generating and emitting equipment used in medical, veterinary and scientific facilities is properly inspected by qualified technical specialists. The rule does not place performance standards on these devices. It is not an ARAR for the K-65 silo removal action.

9. Ohio Ambient Air Quality Standards OAC 3745-17-02

These rules establish ambient air quality standards for particulate matter and require emission testing for various new and existing sources, such as coke oven batteries. Fugitive dust emission standards are also included. Most of the standards focused on stationary sources emitting particulate

matter from heat or power generation. The fugitive dust control standards require "reasonably available control" measures, and are targeted at dust suppression for roads and bulk material transfer operations (e.g., grain).

These standards are not applicable to the K-65 removal action, but the fugitive dust control requirements should be considered if removal of the K-65 residues from the silos is contemplated.

ATTACHMENT 2

POTENTIAL LOCATION-SPECIFIC ARARs and TBCs

1. Regulation of Activities Affecting Waters of the United States (Army Corps of Engineers) (33 CFR 320-329); and Wetlands and Navigable Waterways Protection (Ohio OAC 3742-32).

   These regulations are applicable to activities in wetlands and navigable waters. Some actions may require water quality certifications under Section 401 of CWA. Activities, such as 401 Certifications, which are under the jurisdiction of COE, are reviewed by the Ohio Department of National Resources under OAC 3742-32.

2. EPA's Groundwater Protection Strategy.

   Establishes EPA's policy (not a promulgated regulatory standard) that groundwater should be protected for its highest present or potential beneficial use. The policy is intended to be incorporated into future regulations for EPA programs affecting groundwater quality. The strategy designated three categories of groundwater (I, II, III a, b). The classification influences the level of remedial response.

3. Endangered Species Act of 1978 (16 USC 1531).

Provides for consideration of the impacts of remedial actions on endangered and threatened species, should any be located within, or affected by, the area of influence of the project.

4. Fish and Wildlife Improvement Act of 1978 (16 USC 742), Fish and Wildlife Coordination Act (16 USC 661).

   Provides for consideration of the impacts of remedial actions on wetlands and protected habitats.

5. Executive Order 11990 (42 FR 15123) - Protection of Wetlands.

   Establishes policies for the Federal Government concerning wetland protection.

6. Rivers and Harbors Act of 1899 (33 CFR 320-327).

   Establishes general standards for water quality.

7. Ohio Location Standards (OAC) 3745-54-18).

   Places restrictions on hazardous waste treatment, storage, and disposal facilities in areas subject to seismic activity and in floodplains.

ATTACHMENT 3

POTENTIAL ACTION-SPECIFIC ARARs and TBCs

1. OSHA Requirements (29 CFR Parts 1910, 1926, and 1904).

   Establishes standards for protection of workers engaged in on-site remedial activities. Applicable to private sector employers. Public sector employers (e.g. DOE) may adopt similar requirements as a matter of policy.

2. Nuclear Regulatory Commission's Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61)

   Establish criteria for the land disposal of radioactive wastes received from other persons. They are not applicable to high level, uranium, or thorium tailings or wastes (by-products) in quantities greater than 10,000 kilograms and containing more than 5 mCi of ^{226}Ra, or as subject to 10 CFR 20.

   The Department of Energy is not subject to these standards, to the extent that Section 202 of the Energy Reorganization Act of 1974 excludes it.

Concentrations of radioactive materials released from land disposal facilities to groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of any member of the public.

Also establishes substantial design and operational criteria for land disposal facilities.

3. Federal Compliance with Pollution Control Standards. Executive Order 12088 (43 FR 47707).

Requires that all federal facilities and activities comply with applicable pollution control standards.

4. The Atomic Energy Act of 1954, as amended (42 USC 2011).

As amended, the Act establishes the overall scope and framework for many DOE operations and authority. Section 11 provides definitions for various classes of radioactive wastes pertinent to establishing remediation standards for the K-65 wastes. In particular, it establishes that K-65 wastes are byproduct material because they are tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.

5. Department of Energy Orders.

a) General Environmental Protection Requirements (5400.1). Establishes general requirements for the environmental compliance procedures for DOE facilities

b) Environmental Compliance Issue Coordination (5400.2). Establish DOE requirements for coordination of significant environmental compliance issues.

c) Radiological Effluent Monitoring and Environmental Surveillance (5400.xy).

Describes requirements and provides guidance for monitoring effluent and conducting environmental surveillance.

d) CERCLA Program (5400.4)

Establishes general requirements for hazardous waste cleanup and notification.

f) DOE Order 5400.5 - Radiation Protection of the Public and the Environment

This order, effective 5/8/90, establishes limits on public exposure to radiation. It also directs that potential exposure to the public be as far below these limits as is reasonably achievable (ALARA). It requires that DOE facilities have the capability to monitor routine and non-routine releases, and to asses doses to the public DOE installations and DOE contractors must comply with the order.

000141

Field Office Managers are directed to either certify (in early April) that their facilities are in compliance , or request an exemption for areas of non-compliance along with a plan for achieving compliance.

The order replaces DOE order 6480.1A, Chapter XI. It adopts and implements radiation protection dose standards consistent with the 1977 recommendations of the International Commission on Radiological Protection (ICRP). To the extent required by the Clean Air Act, exposure of the public to radioactive materials released to the atmosphere must not exceed an effective dose equivalent of 10 mrem per year. The order also directs that DOE installations comply with the requirements of NRC and EPA regulations found in 10 CFR Parts 60 an 72 and 40 CFR Parts 61, 191, and 192.

It establishes a primary standard of 100 mrem effective dose equivalent per year to members of the public as a consequence of all routine DOE activities, as well as remedial actions. This is five times less than the previous primary limit. The higher 500 mrem effective dose equivalent per year can be authorized for a limited period if justified by unusual operating conditions. DOE operators are required to report DOE-related effective dose equivalent contributions of 10 mrem per year or more to DOE Headquarters.

Liquid radioactive waste streams are to be treated to the "best available technology" (BAT) level. Normally, waste steams exceeding the "Derived Concentration Guide" (DCG) reference values at the point of discharge will require BAT treatment.

It prescribes the use of 3 EPA models to evaluate potential doses from airborne releases; these are: AIRDOS/RADRISK;

CAP-88, and AIRDOS-PC. It also prescribes the use of specific dose conversion factors and derived concentrations needed to make dose evaluations. Doses to the public must be evaluated to assess compliance with dose limits, as well as to assess exposures from unplanned events.

The Order presents derived concentration guides (DCG) for a comprehensive list of radioisotopes. The air immersion (annual average for on and off site) value for ^{220}Rn, as well as ^{222}Rn, is 3×10^{-9} µCi/mL. The instantaneous ^{222}Rn concentration should not exceed 100×10^{-9} µCi/mL Values for inhaled air for radium species are:

^{223}Ra	2×10^{-12} µCi/mL
^{224}Ra	4×10^{-12} µCi/mL
^{225}Ra	2×10^{-12} µCi/mL
^{226}Ra	1×10^{-12} µCi/mL
^{227}Ra	4×10^{-8} µCi/mL
^{228}Ra	3×10^{-12} µCi/mL

Values for thorium and uranium are:

^{230}Th	4×10^{-14} µCi/mL
^{238}U	1×10^{-13} µCi/mL

Air immersion DCGs were calculated for a continuous, nonshielded exposure via immersion in a semi-infinite atmospheric cloud. The air inhalation values are based on the assumption of inhalation of 8,400 cubic meters of air, 24 hours per day, 365 days per year.

000143

g) National Environmental Policy Act (5440.1c).

Establishes DOE's policy for implementation of the National Environmental Policy Act of 1969 (PL 91-90).

h) Environmental Safety and Health Program for DOE Operations. (5480.1B)

Establishes an overall framework of program requirements for safety, environmental, and health protection, including criteria for radiation exposure and radioactive effluent releases for operating facilities and sites.

i) Environmental, Safety, and Health Protection Standards. (5480.4)

Identifies mandatory and references environmental, safety and health standards.

j) Radiation Protection for Occupational Workers (5480.11)

Establishes radiation protection standards and program requirements for workers at DOE facilities.

k) Environmental, Safety, and Health Appraisal Program. (5482.1B)

Establishes an environmental, safety, and health appraisal program for DOE.

l) Environmental Protection, Safety, and Health Protection Information Reporting Requirements. (5484.1)

000144

Establishes requirements and procedures for reporting and investigating matters of environmental protection, safety, and health protection significant to DOE operations.

m) Quality Assurance (5700.6B).

Establishes DOE's quality assurance program.

n) Radioactive Waste management (5820.2A) and in particular, Chapter III: Management of Low-Level Waste.

Establishes performance objectives for management of low-level wastes and mixed radioactive wastes. external exposure to waste and releases to surface water, groundwater, soil, plants, and animals are not to exceed an effective dose equivalent of 25 mrem/y to any member of the public.

Releases to the atmosphere shall meet the requirements of 40 CFR Part 61. ALARA principles should be followed.

Committed effective dose equivalents received by individuals who inadvertently intrude into the facility after loss of active institutional control (100 years) should not exceed 100 mrem/y for continuous exposure or 500 mrem for a single acute exposure.

Groundwater resources should be protected in a manner consistent with federal, state and local requirements.

Performance assessments, including monitoring, should be prepared and maintained, to show compliance with performance objectives.

- These are not promulgated standards, and do not meet the strict definition of ARARs. However, they are mandatory at DOE facilities, under DOE policy. They meet the definition of 'To Be Considered' policies.